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ROTATING MACHINE STRUCTURE WITH RECYCLING COOLING CIRCUIT

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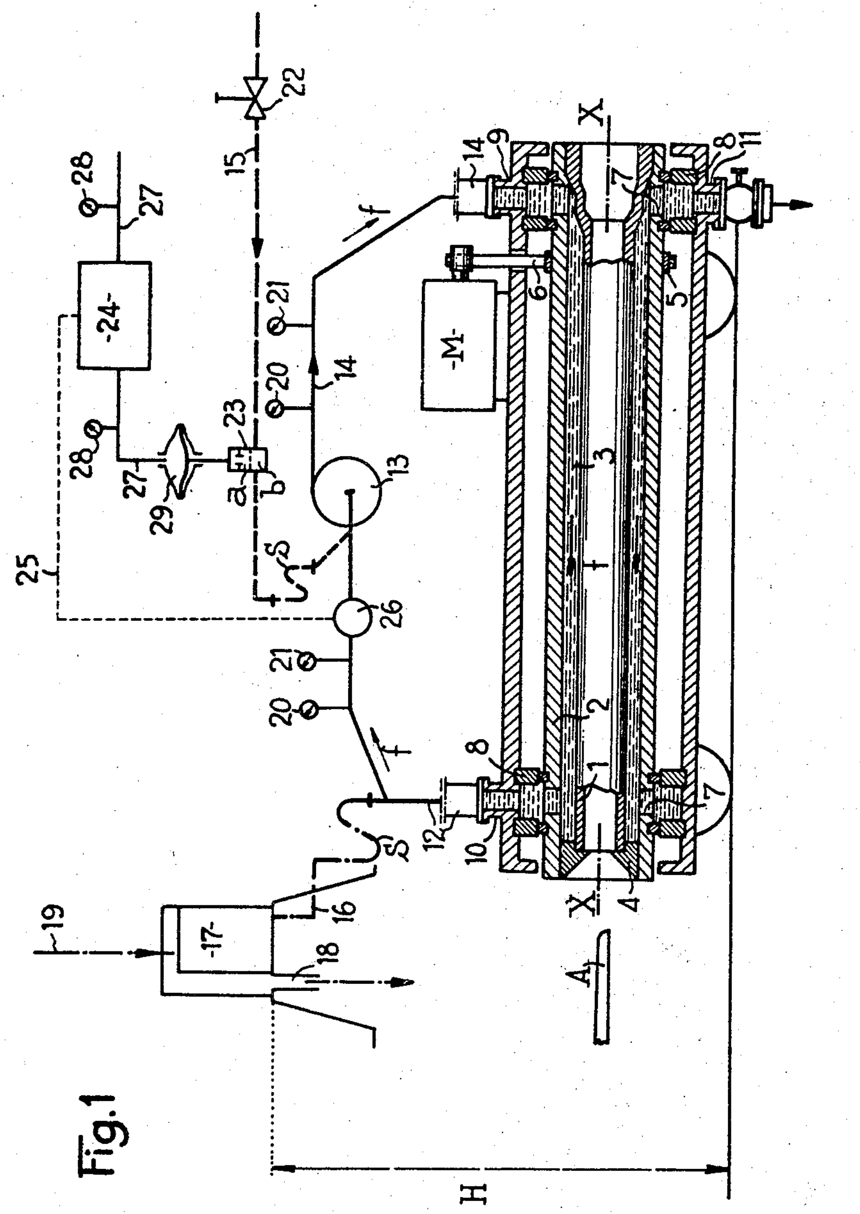


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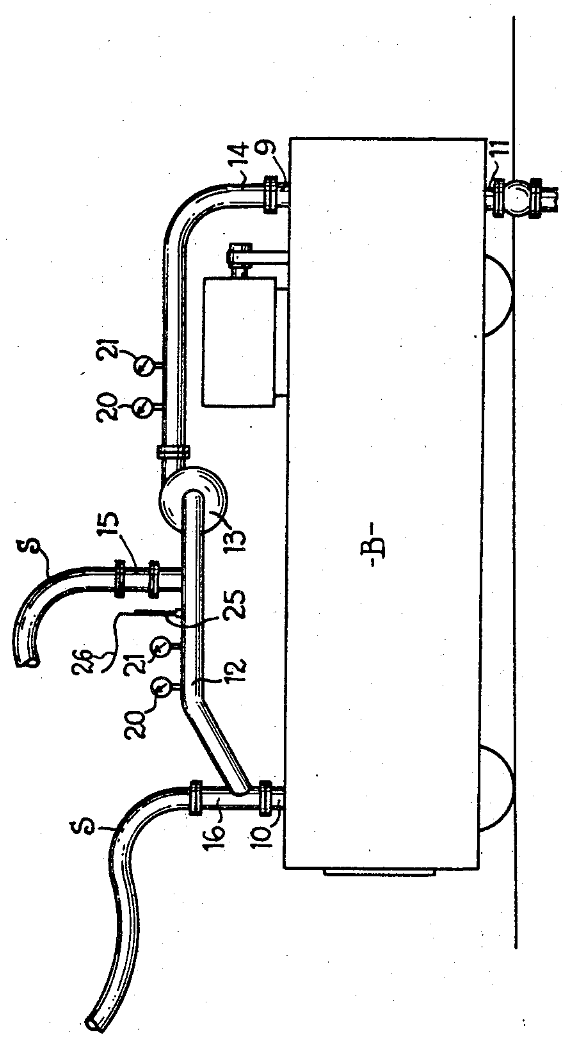
Filed Oct. 14, 1966 2 Sheets-Sheet 2

Fig.2

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# ROTATING MACHINE STRUCTURE WITH RECYCLING COOLING CIRCUIT

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## ABSTRACT OF THE DISCLOSURE

A machine which has a rotating part surrounded by water in a water jacket, the machine being movable in translation, and a unit for cooling the jacket water. This unit comprises a cooling water recycling circuit connected to the jacket, means for cooling the recycled water in accordance with regulating means, a recycling pump in the recycling circuit, the pump and the recycling circuit being carried by the machine. A water tank is fixed on the ground and located above the water jacket and connected to the recycling circuit whereby the water in the tank creates a pressure head in the recycling circuit.

The present invention relates to the water cooling of machines movable in translation and having a rotating part, and in particular but not exclusively to the type of machines for centrifugally casting metal pipes and especially iron pipes having a socket in which a metal mould or shell is driven in rotation and cooled externally by a bath of water.

The invention is more particularly applicable to machines of this type in which the mould is mounted within a coaxial sleeve which forms an annular space in which the cooling water circulates and thus constitutes a water jacket surrounding the mould.

Open-circuit cooling units for such machines are already known. The water is supplied at very high pressure so as to achieve an efficient cooling of the mould. Consequently, it is necessary to employ a high-powered and large pump which must be secured to the ground. Further, the pipes for the circulation of the cooling water must include telescopic joints and rotatable couplings owing to the fact that the machine moves in translation with respect to the fixed pump. These joints and couplings result in high pressure drops and are another reason for employing a high-powered pump.

In these units the cold water enters at one end at a temperature varying between 0 and 20° C. and issues from the other end at a temperature varying between 40 and 60° C. depending on the time of the year. The temperature difference between the two ends of the water jacket of the mould, and more generally between the cooling water inlet and outlet is therefore relatively great. Moreover, after a long interruption of iron casting the temperature of the cooling water is often too low so that when casting is resumed the temperature of the water jacket only resumes the desired value for production at the end of the relatively long period of time. Consequently the shell is subjected to thermic shock or stress. Generally speaking, stopping the operation of a rotating machine breaks the thermic equilibrium between the water jacket and the rotating part.

Closed-circuit cooling units are also known in which the temperature difference between the cooling water input zone and output zone does not exceed 5–10° C. The temperature of the centrifugal casting mould is therefore regulated in a much more uniform manner than in the case of the open-circuit unit. However closed-circuit cooling units of known type are mounted on the ground and connected to the movable machine as in the foregoing case by telescopic joints and rotatable couplings and large pressure drops occur. In order to compensate the inevitable leakages through the rotatable couplings between the jacket surrounding the mould and the housing of the machine, a powerful pump is also necessary and this pump must be secured to the ground. Further, owing to leakages which occur in the rotatable joints, above all owing to wear, stopping the casting for a few minutes is sufficient to empty the circuit of the cooling water without replenishing this water. Consequently, when the machine is once more started up and the casting of the iron is resumed, the amount of cooling water in the circuit has diminished so that this water assumes an excessively high temperature owing to the large amount of heat given off by the iron. Therefore, the regulation of the temperature of the mould is effected in a very imperfect manner. Moreover, this system does not operate well during the rotation of the mould since the centrifugal force to which the cooling water jacket is subjected separates the water from the wall of the mould to be cooled.

The object of the invention is to provide a water cooling unit for a machine movable in translation and having a rotating part, said unit being of the type having a closed-circuit cooling water circulation which has none of the aforementioned drawbacks but, on the contrary, the essential advantage of affording a uniform and constant cooling of the rotating part throughout the length of the latter if it concerns a centrifugal casting mould, even if the operation of the machine included periods of inoperation and consequently periods in which the supply of heat is interrupted which would normally disturb the thermic equilibrium between the rotating part and the water jacket.

The water cooling unit according to the invention comprises a cooling water recycling circuit and a recycling pump both carried by the machine itself, a water tank placed in a fixed position at a given height above said machine, and a connection connecting the tank to the recycling circuit.

Owing to the location of the water tank at a suitable height above the machine, sufficient pressure is maintained in the water jacket to ensure a permanent contact between the water jacket and the rotating part regardless of the speed of rotation of the latter. Further, possible leakages in the rotating joints are compensated by the tank of water which creates a pressure head so that a constant volume of water jacket is always maintained around the rotating part of the machine. Consequently a thermic equilibrium is advantageously maintained between the rotating part and the water jacket.

According to another feature of the invention, the fixed tank placed at a suitable height above the machine contains hot water and a cold water supply is also connected to the recycling circuit.

Owing to this feature, the heat regulation can be easily and rapidly achieved without being affected by the temperature of the atmosphere surrounding the machine.

Another object of the invention is to provide a structure comprising a machine having a rotating part, and in particular a centrifugal casting machine, in combination with the aforementioned cooling unit.

Further features and advantages of the invention will be apparent from the ensuing description with reference to the accompanying drawings.

In the drawings:

FIG. 1 is a diagrammatic view of a cooling unit according to the invention for a centrifugal casting machine, and

FIG. 2 is a diagrammatic view of a centrifugal casting machine equipped with a cooling unit according to the invention.

According to the structure shown in FIGS. 1 and 2, the invention is embodied in a machine for casting iron pipes having a socket for example in accordance with the "de LAVAUD" method. Shown in the drawing diagrammatically are the iron casting trough or spout A and the carriage B of the machine, which carries a centrifugal casting mould or shell 1 which has an axis X—X and undergoes a longitudinal movement so as to cause the trough A to enter the mould 1 during the poring stage. This mould 1 is mounted within a sleeve 2 which is coaxial and rigid with the mould as concerns rotation and forms therewith an annular space 3. The ends of the latter are closed by an iron-cutting ring 4 adjacent the smooth or male end of the pipe to be cast and by the socket or enlarged end of the mould 1 surrounding the socket region of the pipe. The sleeve 2 carries a pulley 5 for driving the sleeve in rotation by means of a motor M through a belt 6. The pulley 5 is preferably located adjacent the socket end of the mould 1. In the known manner the sleeve 2 has at its ends ports 7 arranged on its periphery for the passage of the cooling water. Rotatable joints or seals 8 are mounted axially on each side of said ports 7 in the annular space between the sleeve 2 and the carriage B. A connection 9 for the inlet of cooling water and a connection 10 for the outlet of the water are provided at the ends of the carriage B in alignment with the ports 7 and cooling water inlet and outlet passages are formed by the rotatable joints 8. As can be seen, the joints 8 mounted between the fixed inner face of the carriage B and the rotating outer face of the sleeve 2 partition off water circulation passages between the annular space 3 and the inlet 9 and outlet 10.

Formed in the carriage B adjacent the socket, in alignment with the inlet 9, is a cooling water drain aperture 11 provided for renewing the water.

The cooling unit also comprises water conduits and apparatuses for measuring and regulating the temperature and flow the circulation of water. FIG. 1 represents the conduits by different lines according to the type and quality of the fluids contained thereby, namely:

- a heavy full line for the conduits recycling the cooling water;
- a dotted line for a cold water conduit;
- a dot-dash line for a hot water conduit;
- a thin full line for a compressed air conduit; and
- a thin dotted line for an electric transmission line for actuating an apparatus measuring the temperature of water.

The water contained in the annular space 3 is recycled by way of an upstream conduit 12 connected to the outlet 10 and communicating with the input of a pump 13 which discharges into a downstream conduit 14. The latter is connected to the water inlet 9 of the machine. The conduits 12 and 14 are rigid and carried by the carriage B together with the pump 13.

Connected to the conduit 12, which is upstream of the pump 13, is the cold water supply conduit 15 which is connected adjacent the pump 13. Thus cold water supplied by the conduit 15 is mixed with the water of the circuit (12–14–3) in the pump 13 so that the temperature in the cooling circuit is rapidly rendered uniform. In the conduit 15 the water is at a pressure much higher than that of the cooling circuit (12–14–3).

Connected to the conduit 12 on the upstream side of the connection of conduit 15 is also a conduit 16 for hot water coming from a constant-level tank 17. The latter is mounted above the carriage B so as to create a pressure head H from the ground on the order of several metres. The higher tank 17 creates a static pressure in the water jacket of the mould 1. It contains a volume (V) for hot water at a temperature exceeding the regulation temperature of the circuit (12–14–3). The excess of hot water can be discharged to the drain by way of a drain pipe 18. However, water can also be added by way of conduit 19 if the level in the tank 17 is insufficient.



The conduits 15 and 16 are partly flexible so as to maintain the connection between the fixed cold and hot water supply devices and the water jacket of the mould 1 during the movement of the carriage B. The flexible parts of these conduits are shown diagrammatically in FIG. 1 by the loop portions S.

The regulating and measuring apparatuses of the unit are as follows:

Pressure gauges 20 measuring the pressure of the water in the cooling water recycling conduits 12 and 14.

Thermometers 21 mounted in the vicinity of the pressure gauges 20 and measuring the temperature of the water in these conduits.

A cock 22 and a slide valve 23 having two positions, namely an open position *a* and a closed postion *b* of the conduit 15 controlling the supply of cold water through this conduit. The slide valve 23 is under the control of a temperature regulating apparatus.

This temperature regulating apparatus 24 is connected by an electric transmission line 25 to a temperature responsive means or pyrometer element 26 mounted in the upstream water recycling conduit 12 of the downstream side of the thermometer 21 and therefore receives the signals from said pyrometer. It controls the supply of compressed air from a conduit 27 to the slide valve 23 for actuating the latter. The conduit 27 is connected to a source of compressed air (not shown) the pressure of which is measured by a pressure gauge 28 and connects the temperature regulator 24 to a membrane valve 29 which actuates the slide of the valve 23 through a rigid rod.

For reasons of simplification, the pipes and bleed cocks, bypass conduits and cocks for overhauling the measuring apparatuses have not been shown.

The unit according to the invention operates in the following manner:

When the temperature of the water jacket is normal the water pumped by the pump 13 flows in the direction of arrow *f* in the closed circuit consisting of the conduits 12 and 14 and the annular space 3 in passing through the ports 7 and filling the spaces between the rotatable joints 8. This flow of water does not cease during the movements of the carriage B, nor during rotation of the sleeve 2 and mould 1, nor when this rotation stops.

When the mould 1 and sleeve 2 are rotated together, the water jacket contained in the annular space 3 is subjected to a centrifugal force which is the higher as the speed of rotation is higher. Thus it would have a tendency to come away from the wall of the mould 1. However, in accordance with the invention, the tank 17 having a pressure head of H ensures by way of the conduit 16 that a sufficiently high water pressure is maintained in the annular space 3 to prevent this water from coming away from the mould wall so that there is constantly a perfect contact between the water jacket and the outer face of the mould 1. Further, leakages of water through the rotatable joints 8 are compensated in the closed circuit (conduits 12–14 and space 3) due to the supply of water from the tank 17 by way of the conduit 16.

However, the temperature of the inner face of the mould 1 has a tendency to vary, depending on whether the mould is filled with liquid iron, or iron in course of solidifying during and after the pouring stage or, on the contrary, is empty during the stoppage of the machine and the stage before pouring. The purpose of the water jacket is to discharge rapidly and constantly the heat brought in by the pouring of liquid iron and to supply heat to the mould 1 during periods when pouring is interrupted. Consequently, the temperature of the water has a tendency to vary; it rises in the course of the pouring whereas it should remain sufficiently low to cool the mould in an effective manner. On the other hand, it drops at the end of a long period in which there is no pouring since no more heat is supplied to the inner face of the mould **1** and there is a risk of the latter being too cold when the pouring is resumed.

In actual fact, the temperature of the water jacket must be maintained within limits that are as narrow as possible so as to maintain the mould **1** at uniform and constant temperature. This is the object of the invention.

There will now be examined in succession the operation of the cooling unit in the course of pouring and during a period in which pouring is stopped.

In the course of pouring iron into the mould **1**, the temperature of the cooling water circuit, consisting of the water jacket **3** and the conduits **12–14**, tends to rise. If a temperature rise is read off the thermometers **21** in the conduits **12** and **14** and is automatically detected by the pyrometer element **26**, the latter transmits signals by way of line **25** to the temperature regulator **24**. The latter allows through compressed air in the conduit **27** to the membrane valve **29**. The latter opens the slide of the valve **23** (position *a*) and, owing to the fact that the pressure of cold water in the conduit **15** is much higher than that in the circuit **12–14–3**, this causes cold water to flow from the conduit **15** to the upstream conduit **12**. But it is at the same time necessary to discharge a corresponding amount of hot water so as to avoid an excessive increase in the pressure of the water, read off the pressure gauges **20**, and also achieve a more rapid cooling of the water by the introduction of cold water and the withdrawal of hot water. The withdrawal of excess hot water is effected automatically by way of the conduit **16** and the overflow **18** of the tank **7**. In this way a rapid regulation of the temperature of the water is achieved in response to an excessively high temperature.

If the temperature of the water jacket in the sleeve **3** increases excessively and exceeds for example 100° C. and pockets of steam form in the upper part of the water jacket, they escape on their own by way of the ports **7**, the port **10** and the conduit **16** and are condensed in the tank **17**.

Cold water is supplied and hot water discharged under the same conditions, as explained above.

As soon as the temperature of the water in the circuit comprising the water jacket **3** and the conduits **12–14** has resumed a normal value, the pyrometer element **26** transmits appropriate signals to the regulator **24** which closes off the compressed air in the conduit **27**. As the membrane valve **29** is no longer fed with compressed air, it allows the slide valve **23** to be closed by a return spring (not shown; position *b*). The supply of cold water from the conduit **15** to the conduit **12** then ceases and the cooling water resumes its circulation in a closed circuit.

Upon and during a long stoppage of the machine and in the absence of a pouring of iron, if the temperature of the water jacket is too low, the pyrometer **26**, which is responsive to this temperature, continues, in accordance with the aforementioned procedure, to close off the cold water supply in the conduit **15**. On the other hand, on account of inevitable leakages of water through the joints **8**, the level in the tank **17** tends to drop and the carriage B could be emptied of its water. Hot water is then admitted by way of the conduit **19** to the tank **17** and from the latter to the annular space **3** by way of the conduit **16** and thus compensates the losses and maintains a sufficient static pressure in the annular space **3**.

When pouring is resumed, the mould **1**, which is immersed in a sufficiently hot water jacket, can once more receive the liquid iron without being subjected to excessive thermic shocks.

To take a numerical example, a mould **1** is immersed in a water jacket at a temperature between 30 and 80° C. with a very small difference of only 5–10° C. between the inlet adjacent the socket of the pipe and the outlet adjacent the smooth end of the pipe. The water flows at a speed of several metres per second. The volume of the water jacket in the space **3** must be sufficient to regularize the temperature. The height H of the tank **17** above the ground must be such as to achieve sufficient static pressure in the water jacket, for example on the order of 0.6 bar, at the highest speeds of rotation of the mould **1** so as to maintain the water in contact with the latter in opposition to the effect of centrifugal force.

The volume (V) of the tank **17** depends on the diameters of the mould **1** and sleeve **2** and must be sufficient to maintain the annular space **3** full of water in compensating leakages through the joints **8**. It is for example on the order of 1 cu. m. The power of the pump is on the order of 15 H.P. which ensures an output or flow of around 250–300 cu. m. per hour for a speed of passage of the water in the space **3** on the order of 1.5 m. per second.

The water of the tank **17** is for example at a temperature of 60° C. if the temperature of the circuit (**12–14–3**), read off the thermometers **21**, is 50° C.

The unit according to the invention has the following advantages:

Owing to the fact of mounting the recycling conduits **12** and **14** and the pump **13** directly on the carriage B, the cooling water circuit has a short length and the number of bends or elbows is reduced to a minimum so that the pressure drops are very low. This makes it possible to employ a pump **13** of low power and consequently of small size and mount it on the carriage B instead of on the ground. The recycling conduits **12–14** can be connected through simple flexible conduits to the fixed cold water and hot water supply means without using telescopic joints or rotatable couplings.

Owing to the short length of the cooling water closed circuit (conduits **12–14** and space **3**), after a long period which there is no pouring, for example upon resuming production in the morning after having left the casting machine inactive overnight, it is sufficient—even in winter time in cold regions—to effect two or three castings to bring the water of the circuit (**12–14–3**) to the correct temperature of 30°–80° C. since the volume of water recycled by the pump **13** is relatively small and rapidly heated.

Owing to the tank **17**, the annular space **3** is always filled with water regardless of the speed of rotation of the mould **1** since sufficient pressure is maintained in opposition to the effect of centrifugal force. Consequently, the heat exchanges between the water and the mould occur under the best conditions since contact is always maintained.

Further, owing to the tank **17**, the leakages through the joints **8**, above all as a result of wear, are compensated by the supply of water by way of the conduit **16**. This permits maintaining the annular space **3** full of water in a permanent manner and consequently maintaining the mould **1** at sufficient temperature even after a long interruption of the pouring so that when casting is resumed the mould **1** is subjected to only a very attenuated thermic shock.

Filling the tank **17** with hot water facilitates bringing the cooling water circuit to the required temperature since both a source of hot water and a source of cold water are available and the regulation system described hereinbefore permits metering at least the supply of cold water. In particular, the hot water attenuates the thermic stresses when resuming the casting of the iron after a long interruption. This advantage is particularly noticeable when the tank **17** is common to a plurality of cooling circuits of different centrifugal casting machines. When, at the start of casting, the first machine has caused the water in the tank **17** to assume the required temperature, the heated water of this tank is then available for the cooling circuits of the other machines which can thus be started up with only weak thermic shocks to their moulds.

Briefly, owing to this cooling unit and this temperature regulation, the centrifugal casting moulds **1** are maintained at a temperature which varies within only reasonable limits between the periods of pouring liquid metal and the periods when pouring is interrupted and the mould 1 is at room temperature. Consequently, the thermic shocks undergone by the mould are attenuated and the life of the mould 1 is substantially prolonged.

Although a specific embodiment of the invention has been described, many modifications and changes may be made therein without departing from the scope of the invention as defined in the appended claims.

Thus the cold water can be supplied by the conduit 15 not to the upstream side of the pump 13 but to the downstream side thereof by way of the conduit 14.

Further, the height of the tank 17 can be varied in accordance with the speed of rotation of the mould so as to modify the water pressure in the annular space 3.

Having now described my invention what I claim as new and desire to secure by Letters Patent is:

1. In a structure comprising a machine which is movable bodily on a support and has a housing containing a rotating part and a water jacket containing water which surrounds and is in contact with said rotating part and rotating seals between the ends of said jacket and said housing; a unit for cooling said water in said jacket, said unit comprising in combination a cooling water recycling closed circuit, fixed pipe connections connecting said recycling circuit to said housing for supplying cooling water to said jacket, means for cooling the water in said recycling circuit, temperature responsive means placed in said recycling circuit for controlling said means cooling the recycled water, a recycling pump in said circuit, said recycling circuit and said pump being carried by said machine, a water tank mounted on said support in a fixed position and at a given height above said water jacket, and a connection allowing bodily movement of said machine connecting the recycling circuit to said tank, whereby the water in said tank creates a pressure head in said recycling circuit and in said water jacket for compensating leakage of water through said seals and applying the water in said jacket against said rotating part in opposition to the effect of centrifugal force on the water in said jacket due to rotation of said rotating part.

2. In a structure comprising a machine which is movable bodily on a support and has housing containing a rotary mould and a water jacket containing water which surrounds and is in contact with said rotary mould and rotating seals between the ends of said jacket and said housing; a unit for cooling said water in said jacket, said unit comprising in combination a cooling water recycling closed circuit, fixed pipe connections connecting said recycling circuit to said housing for passing cooling water through said jacket, means for cooling the water in said recycling circuit, temperature responsive means placed in said recycling circuit for controlling said means cooling the recycled water, a recycling pump in said circuit, said recycling circuit and said pump being fixed to said machine, a water tank mounted on said support in a fixed position and at a given height above said water jacket, and a flexible pipe connection connecting the recycling circuit to said tank, whereby the water in said tank creates a pressure head in said recycling circuit and in said water jacket for compensating leakage of water through said seals and applying the water in said jacket against said rotary mould in opposition to the effect of centrifugal force on the water in said jacket due to rotation of said rotary mould.

3. On a structure comprising a support and a machine which has a housing containing a rotating part and a water jacket contining water which surrounds said rotating part, said housing having ports communicating with said water jacket through rotating seal means, said machine being movable in translation on said support; a unit for cooling said water in said jacket, said unit comprising in combination a cooling water recycling closed circuit, fixed pipe connections connecting said circuit to said housing ports, a recycling pump in said circuit, said



recycling circuit and said pump being fixed to said machine, a cold water supplemental supply conduit connected to said recycling circuit, temperature responsive means in said recycling circuit for controlling the amount of water supplied by said cold water supply conduit, a water tank mounted on said support in a fixed position in plan above said water jacket, and a flexible pipe connection connecting the recycling circuit to said tank, whereby the water is said tank creates a pressure head in said recycling circuit and in said water jacket for compensating leakage of water through said seal means and applying the water in said jacket against said rotating part in opposition to the effect to centrifugal force on the water in said iacket due to rotation of said rotating part.

4. A unit as claimed in claim 3, further comprising a regulatable hot fresh water supply means communicating with said tank.

5. A structure comprising in combination: a machine which has a rotating part and a water jacket containing water which surrounds said rotating part, said machine being movable in translation, a unit for cooling said water in said jacket, said unit comprising a cooling water recycling circuit, a recycling pump in said circuit, said recycling circuit and said pump being carried by said machine, a cold water supplemental supply conduit connected to said recycling circuit, temperature responsive means in said recycling circuit for controlling the amount of water supplied by said cold water supply conduit, a water tank placed in a fixed position in plan above said water jacket, and a connection connecting the recycling circuit to said tank, whereby the water in said tank creates a pressure head in said recycling circuit and in said water jacket for compensating leakage of water and applying the water in said jacket against said rotating part in opposition to the effect of centrifugal force on the water in said jacket due to rotation of said rotating part, a pyrometer element being disposed in the cooling water recycling circuit and valve means being disposed in said cold water supply conduit and controlled by said pyrometer element for regulating the supply of said cold water to said recycling circuit and consequently the temperature of the water in said recycling circuit.

6. A structure comprising in combination: a machine which has a rotating part and a water jacket surrounding the rotating part and containing water in contact with the rotating part, said machine being movable in translation, said unit comprising a cooling water recycling circuit connected to said jacket, a recycling pump in said circuit, said recycling circuit and said pump being carried by said machine, a water tank placed in a fixed position at a given height above said rotating part, a connection connecting the recycling circuit to said tank whereby this water in said tank creates a pressure head in said recycling circuit and in said jacket, a cold water supply conduit connected to the recycling circuit in the immediate vicinity of the pump on the upstream side of the pump, a hot water supply conduit connected to the recycling circuit upstream of the pump and upstream of the connection of the cold water conduit and adjacent the outlet region of the cooling water of the machine, a pyrometer element mounted in the recycling circuit between the connections of the hot water conduit and cold water conduit, a temperature regulator connected to the pyrometer element to be controlled by the pyrometer element, a valve controlling the cold water supply from said cold water conduit, a compressed air circuit actuating said valve, said temperature regulator being connected to said pyrometer element to be controlled thereby and associated with said compressed air circuit to control the latter, whereby cold water is supplied when the temperature of the cooling water in said recycling circuit is too low.

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