Sept. 5, 1967 H. E. MÖBIUS ETAL 3,339,373

PROCESS AND DEVICE FOR COOLING WIRE COILS

Filed Dec. 21, 1965 8 Sheets-Sheet 1

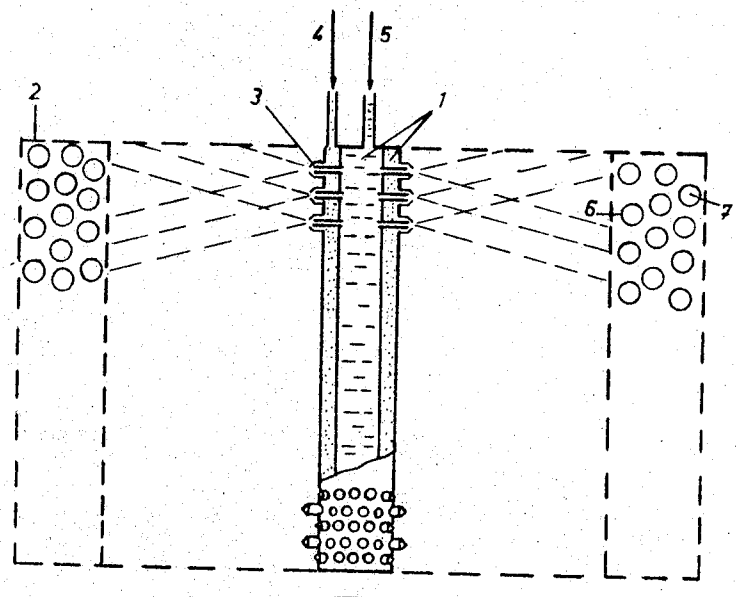


Fig. 1

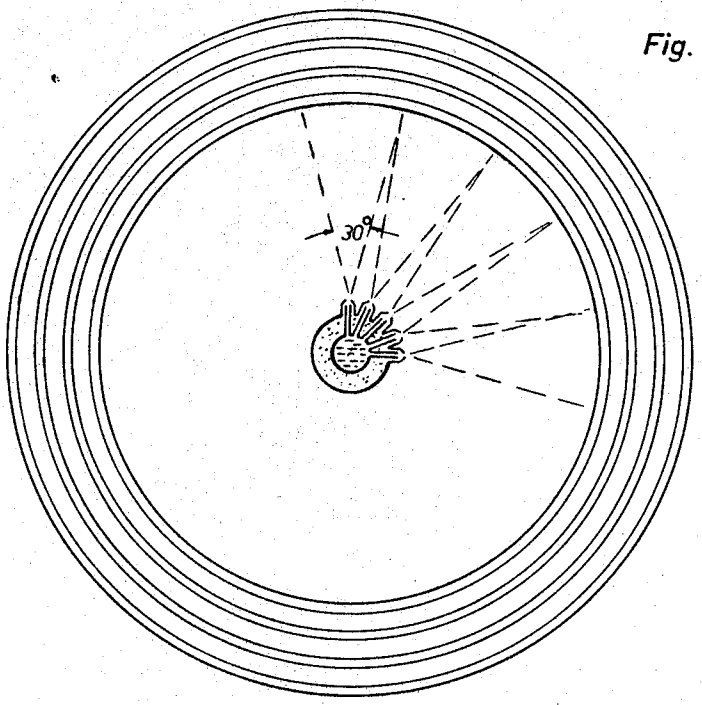


Fig. 2

PROCESS AND DEVICE FOR COOLING WIRE COILS

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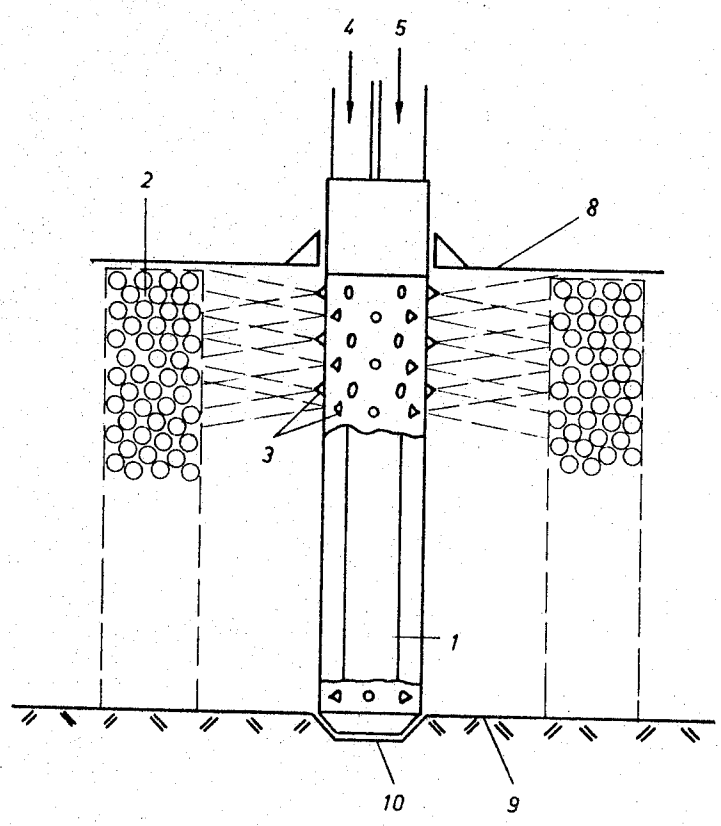


Fig. 3

PROCESS AND DEVICE FOR COOLING WIRE COILS

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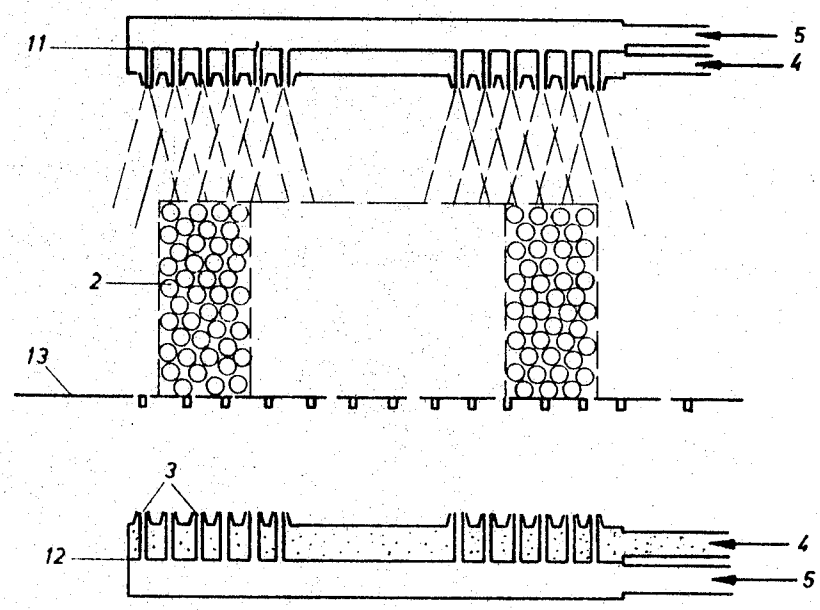


Fig. 4

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PROCESS AND DEVICE FOR COOLING WIRE COILS

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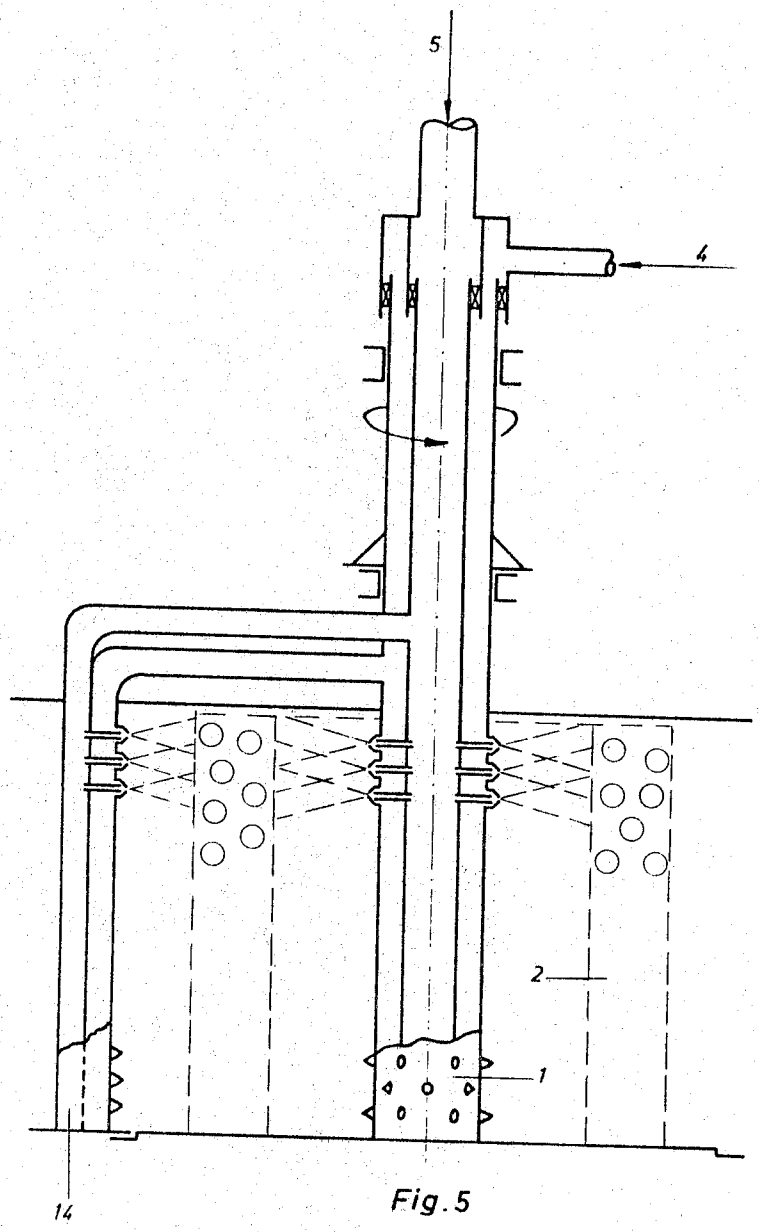


Fig. 5

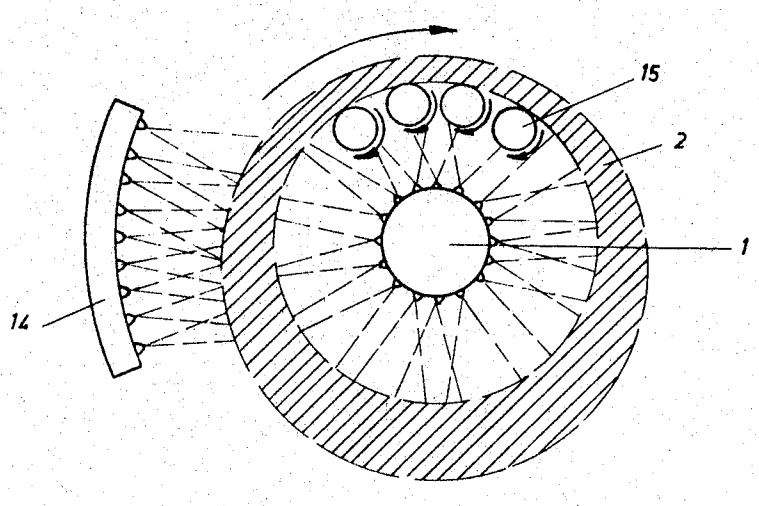


Fig. 6

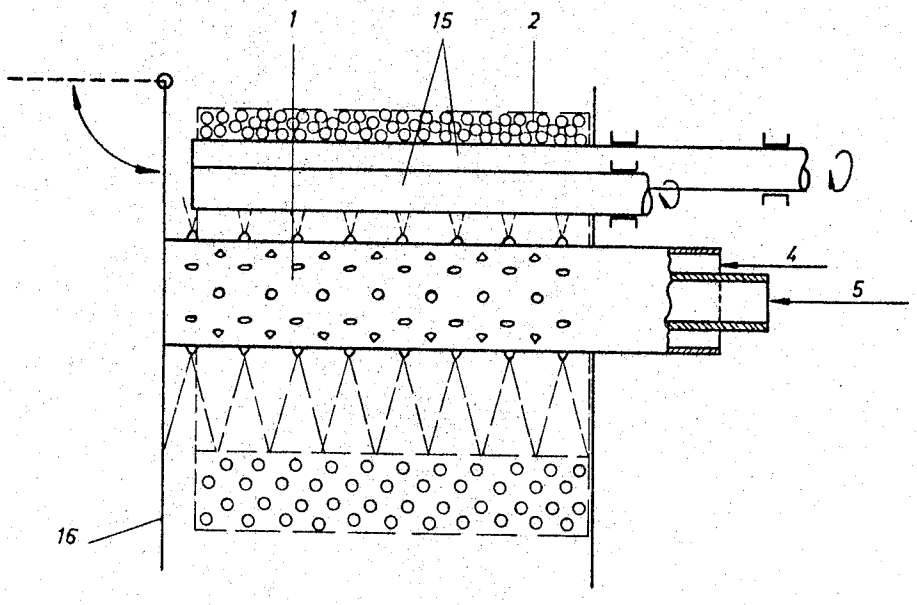


Fig. 7

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PROCESS AND DEVICE FOR COOLING WIRE COILS

Filed Dec. 21, 1965 8 Sheets-Sheet 6

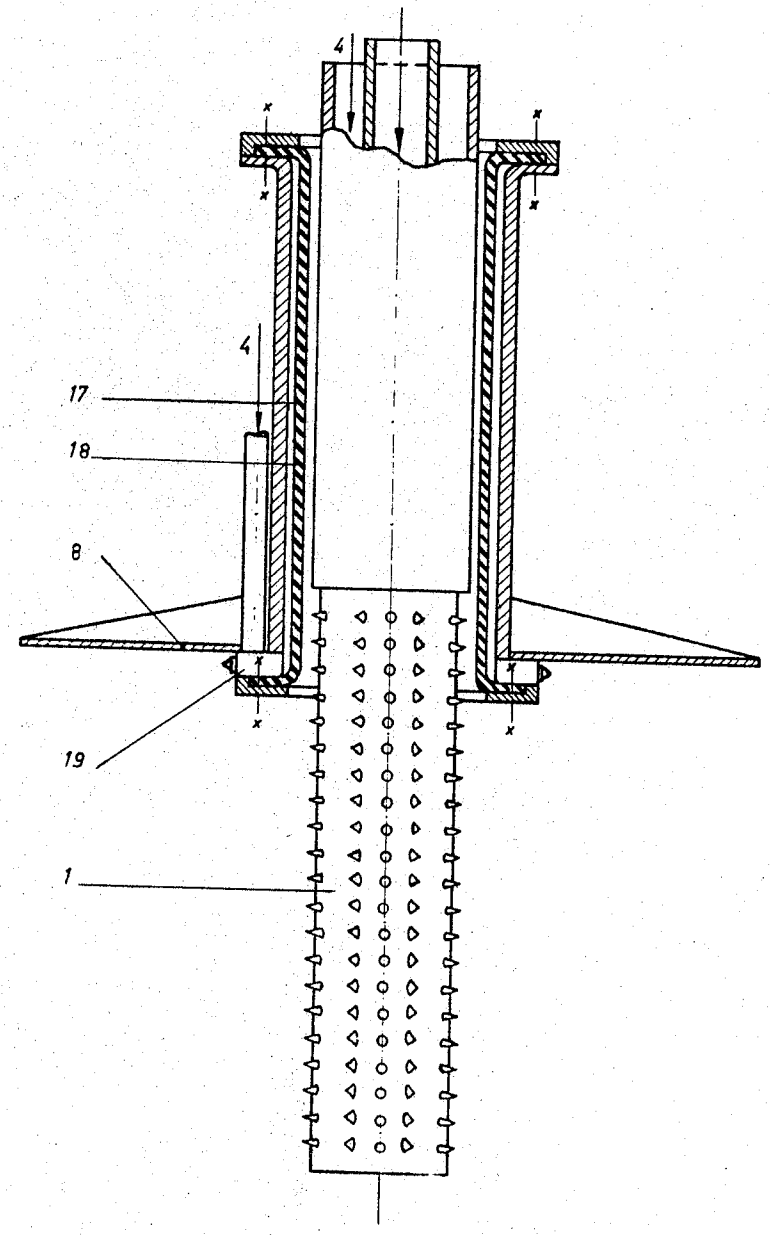


Fig. 8

PROCESS AND DEVICE FOR COOLING WIRE COILS

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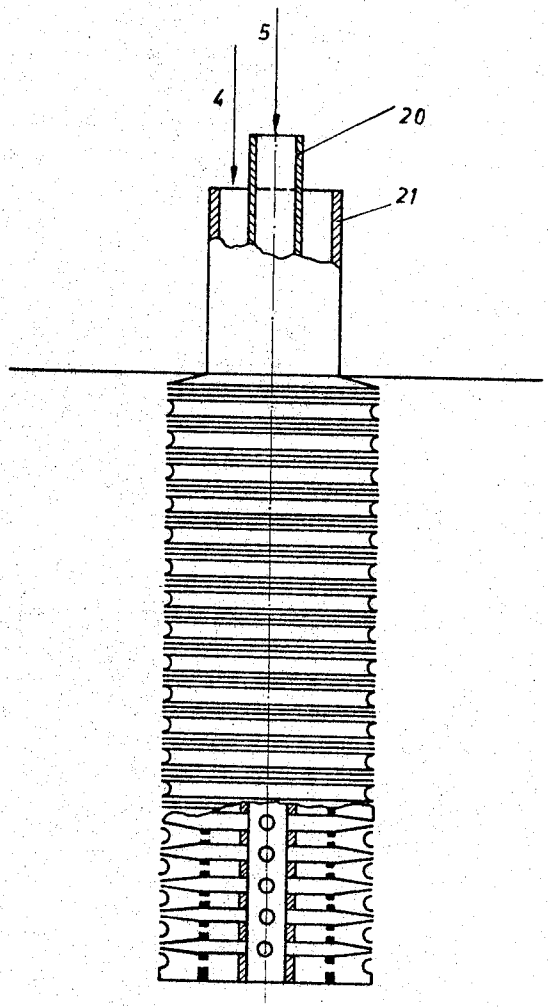


Fig. 9

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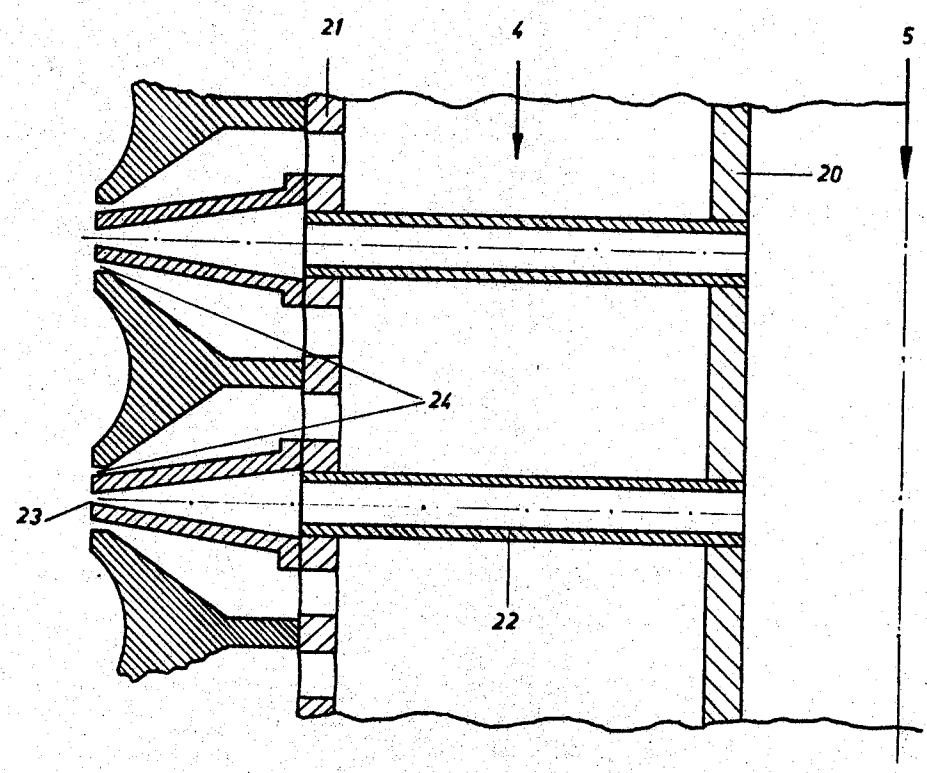


Fig.10

United States Patent Office

3,339,373

Patented Sept. 5, 1967

3,339,373

PROCESS AND DEVICE FOR COOLING WIRE COILS

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Filed Dec. 21, 1965, Ser. No. 515,329
Claims priority, application Germany, Dec. 21, 1964, R 39,509; July 30, 1965, R 41,199
7 Claims. (Cl. 62—64)

This invention relates to a process and device for cooling wire coils.

Wire, which is rolled at high temperatures and reeled into wire coils, cools irregularly in air. The outer rings of the coil cool more rapidly and the inner rings more slowly. This irregular cooling results in variations in the structure and thus in the mechanical properties of the wire. This deficiency can be avoided by the use of cooling facilities of known design, for example, by spreading out the individual rings on a cooling bed. Such known methods, however, all have the disadvantage that they occupy a great deal of space and are expensive insofar as the required equipment.

Cooling of a closed wire coil outside the reel was considered to be unfeasible prior to the present invention, since, in any event, it seemed to preclude a uniform cooling of all rings of the coil. This invention, however, illustrates a possible means of cooling a closed wire coil which neither needs to be loosened, opened or separated into its individual rings.

In accordance with the present invention, a coolant is blown through the wire coil adversely to the temperature gradient and, in the preferred embodiment, from the inside or center of the coil to the outside thereof. The coolant used is, for example, finely dispersed water, the size of the droplets being regulated by the atomizing nozzles to such an extent that they are, on the one hand, small enough to remain fluidized as they pass through and around the individual rings of the wire coil and, on the other hand, large enough, despite constant vaporization, to reach in part even the outermost rings of the wire coil. Because of this requirement, the water droplets must have in the case of a wire coil with a temperature of approximately 1000° C., for example, a diameter of 0.1 to 100 μm. and preferably 1 to 20 μm. Compounds which are known to favour the cooling effect, such as NaCl or NaOH, can be added to the water. Instead of water, it is also possible to use other coolants, such as oil, oil emulsions or such coolants, to which additions are made which retard vaporization or increase the latent heat of vaporization.

In further elaboration of this invention, a preferred device for performing the process consists, for example, of a double-walled tube which is inserted in the middle of the red-hot coil and is provided with compressed air nozzles of known design over the height of the wire coil as far as is necessary to achieve uniform spraying of the wire coil. If, for instance, the orifice angle of the conical stream is 30°, 12 or more nozzles are arranged at equal intervals around the tube's circumference. Along the tube's axis the nozzles can be staggered at half the angle of division. Uniform spraying can also be achieved by rotating the cooling device. The nozzles are supplied with water through the inner tube and with compressed air through the intervening space between the inner and outer tube. In place of the compressed air nozzles, other nozzles can also be used, provided that they disperse the coolant in such a way that droplets of the stated size are produced.

Thus, with the foregoing in mind, it is, therefore, an object of the present invention to overcome the difficulties and deficiencies associated with the prior art and to provide instead, a new and improved method and means for controlling the cooling rate of coiled hot wire to assure that such wire will cool uniformly, thereby achieving the desired metallurgical properties in such wire.

Another object of the present invention is to provide a method and apparatus for accomplishing controlled cooling of hot wire through the utilization of an atomized mist.

Another object of the present invention is to provide an atomized mist of coolant for passage through coiled convolutions of hot wire, with the size of the droplets in such mist being small enough to pass substantially completely through said convolutions while still being large enough to assure that such droplets remain fluidized as they pass through said convolutions.

Other objects, advantages and salient features of the present invention will become apparent from the following detailed description, which, taken in conjunction with the annexed drawings, discloses preferred embodiments thereof.

Referring to the drawings:

FIGURE 1 is a partial vertical sectional view of a preferred embodiment of the present invention;

FIGURE 2 is a horizontal sectional view thereof;

FIGURES 3, 4 and 5 are partial vertical sectional views of modified embodiments of the present invention;

FIGURE 6 is an end view, partly in section, of a further embodiment of the present invention;

FIGURE 7 is a front elevational view thereof;

FIGURE 8 is a partial elevational view of a modified portion of the present invention;

FIGURE 9 is an elevational view of a further modified portion of the present invention; and,

FIGURE 10 is an enlarged fragmentary sectional view of the modification of FIGURE 9.

The double-walled tube **1**, provided with the nozzles **3** over the height of the wire coil **2**, is arranged vertically in the middle of the horizontal red-hot wire coil. The nozzles **3** are staggered along the tube's axis and air or other compressed gas **4** passes through the outer tube to the nozzles while water or other liquid coolant **5** passes through the inner tube, then through radially extending small pipes to the nozzles **3**. The inner turns or convolutions of the coil are designated by the number **6** and the outer turns or convolutions by the number **7**.

The cooling device in accordance with this invention was used to cool wire coils weighing 1000 kilograms in plain carbon and alloy steels from a temperature of about 1000° C. The coolant used was water without chemical additions and had a temperature of 20° C. The surface of the inner rings facing the nozzles was cooled to 600° C. and the cooling operation then discontinued. The following cooling times and maximum temperature differences were measured in the coil:

Wire Grade	Wire Diameter, mm.	Cooling Time from 1,000 to 600° C., sec.	Max. Temperature Difference in Coil, ° C.
Basic Bessemer	8	51	225
Do	24	164	112

The stated difference in temperature is the difference between the surface temperature of an inner ring facing the nozzle and the core temperature of an outer ring when the temperature of the inner ring is 600° C. The water pressure was 2000 millimeters water-column and the

air pressure 2 atmospheres. 90% of all the droplets were smaller than 30 μm.

It has been shown further that the cooling effect is dependent on the size of the droplets chosen at a definite temperature. Cooling takes place more rapidly when larger droplets within the above-mentioned size range are selected at high wire temperatures and smaller droplets at low wire temperatures. Utilizing this expedient, to achieve an optimal cooling effect, this invention foresees the selection of droplets which become increasingly smaller as the temperature decreases.

The following cooling rates were measured on wire coils of 100 kilograms and 8 and 24 millimeters wire diameter with only slight modifications of the droplet diameters:

Wire Diameter, mm.	Droplet Diameter, μm.	Water Pressure, mm. WC	Air Pressure, atm.	Cooling Rate, ° C./sec.	
				At 900° C.	At 600° C.
8	18	−500	0.5	5.0	1.3
	13	−500	3.0	3.8	2.2
24	18	−500	0.5	3.6	0.8
	13	−500	3.0	2.2	0.9

Approximately 80% of all droplets had a smaller diameter and approximately 20% a larger diameter than that stated.

It has been further shown that spraying the coolant from the nozzles of the double tube results in a better mist formation when the upper and lower ends of the double tube are covered by a closed plate. The mist is more uniform and results in more uniform cooling of the coil. However, these cover plates must be kept dry in order to prevent a more rapid cooling of those rings of the coil which are directly adjacent to the plates. This effect is easily accomplished by fitting air nozzles, which, as compared to the compressed air nozzles, cause the air to be emitted at a lower flow rate, on the double tube directly beneath the upper plate and above the lower plate. The air from these air nozzles keeps the coolant mist away from the cover plates and thus prevents the latter from becoming moistened with the coolant.

Uniform cooling of a wire coil requires, in addition to uniform formation of the mist, uniform permeability of the coil to the coolant. For a uniform radial permeation of the coil convolutions by the coolant emitted from the nozzles, a further elaboration of this invention therefore proposes that the delivery pipe which guides the wire and pours it into the rotating reel be swivelled back and forth around a vertical axis during the reeling operation in such a way that the entire width of the coiling space is covered by the opening of the delivery pipe. The frequency of the delivery pipe's swivel must be greater than once and less than twice the rotative speed of the reel.

Since it is not possible for cooling of the wire coil to be uniform when there are substantial temperature variations within the coil due to rolling mill conditions and since the beginning of the wire coil is usually colder than the end after coiling is completed, the invention also proposes either to fit the double tube with fewer nozzles in its lower section and a gradually increasing number of nozzles towards the upper end or to fit it with nozzles spaced at regular intervals, but to make the orifices of the lower nozzles smaller and gradually increase their size towards the upper end of the tube in order that the quantity of coolant sprayed onto the coil may correspond to the given temperature range.

In the case of low coil permeability in the radial direction, it is also possible to spray the coolant from the nozzles through the coil in the axial direction if, instead of the double tube, a double wall with nozzles is used which is perpendicular to the axis of the wire coil to be cooled. In such an arrangement the given temperature difference between the lower and upper rings of the coil and the temperature difference arising during cooling between those rings located in the vicinity of the nozzles and those located at a distance from the nozzles is offset either by turning the coil or cooling it with two double walls. The double wall is advantageously provided with nozzles in annular formation and corresponds to the dimensions of the coil as regards the inner and outer diameters.

FIGS. 3 and 4 show exemplary equipment for accomplishing the processes mentioned hereinabove.

In FIG. 3 the double tube **1** provided with the nozzles **3** is closed off at both ends by means of the plates **8** and **9**. The upper plate **8** is vertically adjustable and rests on the wire coil **2** when the double tube **1** is inserted into the wire coil from above. The lower plate **9** is arranged in a fixed position and has a depression **10** in the middle which serves to centre the double tube.

In FIG. 4 a first double tube **11** and a second double tube **12** are provided. The wire coil **2** rests on a grid **13**. The dotted areas **4** mark the sections of the double walls through which air is conducted and the dashed areas **5** the sections through which water is conducted. In the embodiment shown, the coolant is being sprayed from the upper double wall **11**. The coolant is sprayed from the nozzles **3** of the two walls alternately.

In this arrangement the double walls **11** and **12** spray the coolant through the wire coil in the axial direction. If, in this type of cooling, the wire coil is relatively impermeable and is greater in height than twice the difference between its inner and outer radius, axial spraying can no longer be practised.

In order that wire coils of the latter type may also be cooled satisfactorily, the invention also proposes that the coils be cooled from within by means of a double tube with nozzles and from without by means of an annular double wall with nozzles, with these two coolant sources spraying the wire coil alternately and without pause. In this case, the coolant permeates the wire coil radially and is suppled both from within and without. Usually, the quantity of coolant emitted from the inner double tube is kept greater than that emitted from the outer annular double wall. However, applications are also possible where approximately the same amount of coolant is sprayed from both sources.

Under certain circumstances it may prove convenient to use a shell (elbow) with nozzles instead of an annular double wall. The shell has a curvature of about 30° to 40° and revolves either together with the double tube or alone at such a rate that uniform cooling of the wire coil over its circumference is guaranteed when the coolant is emitted incessantly from both sources. In this process there is no constant starting and stopping or reversing of the two coolant sources and the water vapour created during cooling can be more effectively removed. Approximately 10 revolutions are necessary during the cooling time of a wire coil to obtain uniform cooling. At a cooling time of 100 seconds the shell should thus complete at least one revolution in 10 seconds.

FIG. 5 illustrates a shell (elbow) **14** designed as a double wall which in this case revolves with the double tube **1** around the common axis of the wire coil **2** and the double tube. The portion of the double tube **1** facing

the shell need not be fitted with nozzles. The double tube **1** can also be placed in a fixed position in this arrangement, so that the shell **14** revolves around the coil alone.

The arrangement shown in FIG. 5, in which the wire coil axis is vertical, can be advantageously modified in such a way that the axis of the wire coil is horizontal. In this case the coil is borne and turned by one or more horizontal rollers which rotate in the same direction and the envelopment of which corresponds to the inner circle of the coil. It is expedient when these rollers are not absolutely parallel to one another; the axes of adjacent rollers should form an angle of less than 20°. By means of this inclined position of the rollers the wire coil is elongated in the direction of its axis and its permeability to the radially applied coolant is improved. In FIGS. 6 and 7 such a cooling unit is illustrated. Four horizontal rollers **15** bear the wire coil **2**. The coolant sources, which are in this case in a fixed position, are in the form of a double tube **1** with nozzles, which is supplied with compressed air **4** and water **5**, and a doubled-walled shell **14**, also provided with nozzles. The swivel cover plate **16** makes it possible to cover the double tube and shell-shaped double wall after the wire coil has been inserted, so that the emission of the coolant is sufficiently uniform.

If the rolling program includes coils which vary in weight and, thus, in height, it may be useful to adapt the effective height of the double tube to the height of the coil. FIG. 8 shows a double tube **1** which is equipped with a cylinder **17** having a rubber membrane **18**. The cylinder **17** is adjustable along the axis of the double tube **1**. The space between the cylinder **17** and the rubber membrane **18** is filled with compressed air or compressed water when the cylinder is in the desired position, whereby the membrane presses against the facing nozzle and closes the nozzle orifices. The nozzles **19** shown in FIG. 8 are air nozzles which serve to keep the plate **8** dry during the cooling operation.

In the case of heavy wire coils it has been shown that, even when the compressed air nozzles are arranged more densely on the double tube, the amount of coolant emitted per unit of time may, under certain circumstances, be insufficient. In this case an arrangement of slit-type nozzles in ring form over the entire length of the double tube is more effective (cf. FIG. 9). One design of these slit-type nozzles is shown in FIG. 10. The water is conducted in the central tube **20** and the annular section between the central tube and the outer tube **21** conducts the air. The slit-type nozzles are formed by rings which, for example, are screwed onto the outer tube **21** and sealed. The slit-type nozzles are supplied with water by means of the radial tube **22**. The water is emitted from the central orifice **23** and the air from the outer orifices **24**. With this arrangement it is possible to spray about 5 to 10 times as much coolant as in the case of a double tube fitted with individual nozzles. In the same way, the annular double wall or shell can also be provided with slit-type nozzles which cool the wire coil from without.

After reading the foregoing detailed description, it should be apparent that the objectives set forth at the outset hereof have been successfully achieved by the present invention.

The invention claimed is:

1. In a process for cooling hot metallic wire at a predetermined rate to alter the metallurgical properties of the wire in accordance with the cooling rate, said hot wire being configured in an annular coil formed of a plurality of convolutions, the improvement for controlling the cooling rate to assure that all of said convolutions are uniformly cooled, which comprises simultaneously generating a coolant liquid and a gas which are intimately mixed through a plurality of atomizing nozzles to create an atomized mist, spraying the atomized mist against the coil, and adjusting the size of the droplets in said mist so that they are small enough to enable said mist to permeate substantially through said convolutions, but large enough to remain fluidized as they pass through said convolutions.

2. The improvement defined in claim **1** further comprising the step of gradually decreasing the size of said droplets as the temperature gradient across said convolutions gradually equalizes.

3. The improvement defined in claim **1** wherein said convolutions are generated about a central axis and wherein said spraying is directed radially through said convolutions.

4. The improvement defined in claim **3** wherein said spraying includes directing a first atomized mist radially outward from said central axis toward the interior of said annular coil and further includes directing a second atomized mist radially inwardly toward said central axis to impinge upon the exterior of said annular coil.

5. The improvement defined in claim **1** wherein said convolutions are generated about a central axis and wherein said spraying is directed through said convolutions axially of said central axis.

6. The improvement defined in claim **1** wherein the size of said droplets is between 0.1 and 100 μm.

7. The improvement defined in claim **1** wherein said coolant includes a chemical additive which retards vaporization of said atomized mist.

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