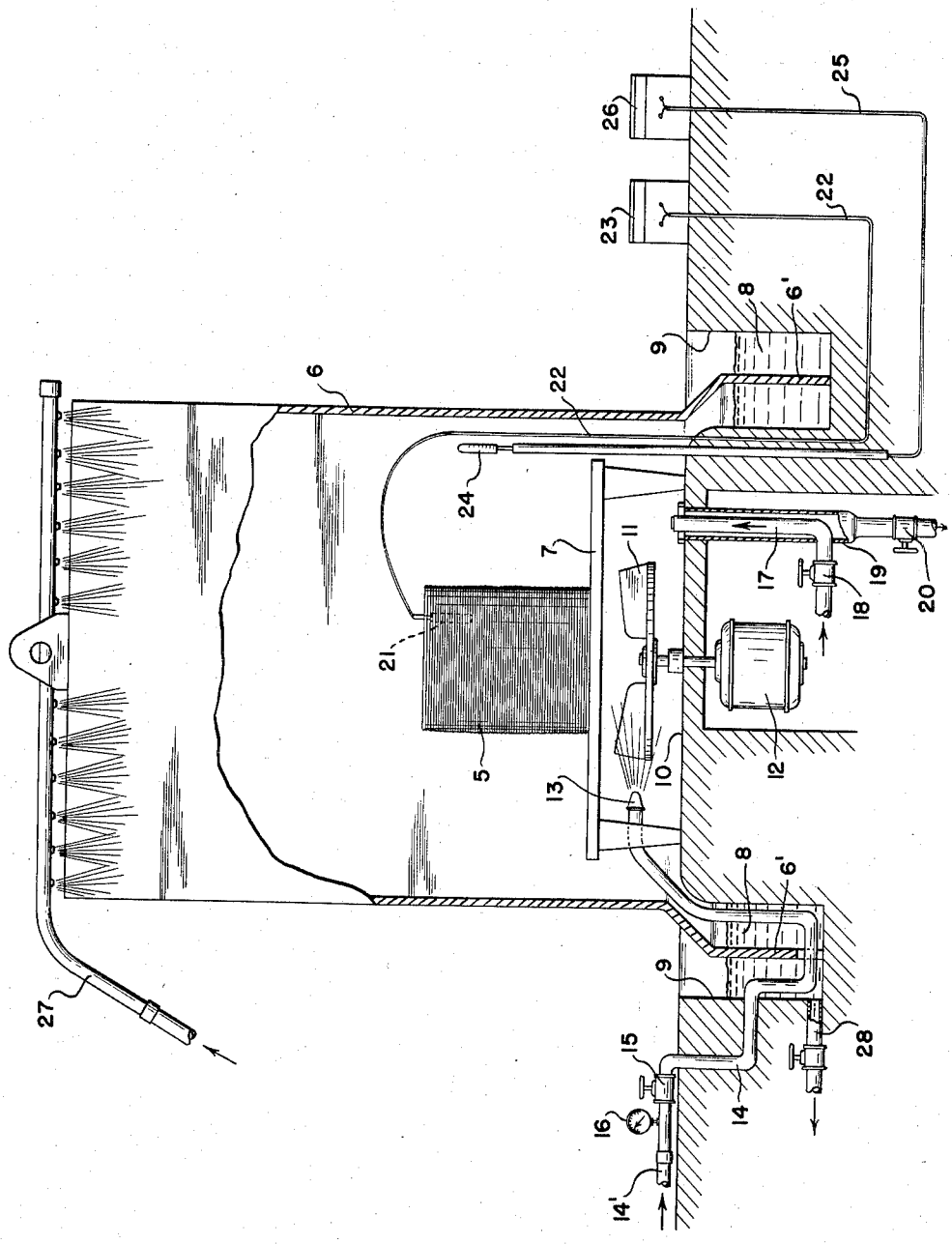
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METHOD AND APPARATUS FOR HEAT TREATING METAL STOCK

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METHOD AND APPARATUS FOR HEAT TREATING METAL STOCK

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The invention relates to furnaces and more particularly to annealing furnaces of the bell or retort type. The invention aims to provide an improved method of, and instrumentalities for, the cooling of annealed or heat-treated metal stock within the bell or retort.

The bell furnace may be either circular or rectangular and is customarily provided with a motor-driven fan for heating and cooling by forced convection currents. Such furnaces are used for the annealing or heat-treatment of coiled metal strip (e. g., steel, copper, brass, etc.), wire in coils or on spools, sheet and bar stock, miscellaneous parts loaded in baskets, and the like. The metal stock to be heat-treated is loaded on a platform or the like and covered by the bell or retort. The furnace or heating element is then lowered over the bell and the heating cycle begins. At the completion of the heating cycle, the heating element is removed and the heat-treated metal stock is permitted to cool within the bell in a controlled circulating atmosphere. Three or more bases or bell stations are ordinarily required for each heating element to provide for loading (and unloading), heating and cooling.

In the heretofore customary practice of annealing copper and brass in a bell furnace, the heating cycle has been about 5 hours and the cooling cycle about 17 hours. Since the cooling cycle is more than three times as long as the heating cycle, 5 bases or bell stations are provided for a single furnace. Due to the extended cooling time, little incentive has existed to decrease the annealing time.

The present invention effects a very substantial reduction in the time required for cooling heat-treated metal stock in a bell furnace. In accordance with the invention, a spray of water is directed against the rotating fan blades within the bell, after the heating cycle has been completed and the heating element has been removed. Due to the high temperature within the bell, the water of the spray is immediately vaporized. Simultaneously, an inert gas is introduced and circulates within the bell, and inert gas and water vapor (resulting from vaporization of the water spray) are exhausted from within the bell. When the temperature of the metal stock undergoing cooling has fallen until its residual heat is only slightly greater than required to vaporize water, say to a temperature within the range of about 110° C. and about 125° C., the water spray is discontinued while continuing the introduction and exhaustion of the inert gas until water vapor has been substantially completely exhausted from within the bell, and the temperature of the metal stock is sufficiently low to permit exposure to the atmosphere. The bell is then removed and the cooled metal stock is exposed to the atmosphere for unloading from the furnace. By practice of the invention, copper and brass stocks annealed at a temperature of 400° to 500° C. in a heating cycle of about 5 hours have been cooled to atmospheric temperatures in from 4 to 5 hours with metal stock loads varying from 13,000 to 22,000 pounds. The combined heating and cooling cycle is thus reduced from 22 to 9–10 hours, a time saving of 12–13 hours.

The invention will be better understood from the following description taken in conjunction with the accompanying drawing in which the single figure is a diagrammatic elevation, partly in section, of a bell furnace with the heating element removed.

As illustrated in the drawing, the bell furnace is ready for cooling the heat-treated metal stock **5**, which may be a coil of wire or the like. The heating element has been removed and, hence, is not shown in the drawing. As well understood by those skilled in the art, the heating element, lowered by a crane or the like, encloses and covers the bell **6** during the heating cycle, and upon completion of the heating cycle is raised from the bell and moved to another bell station. The heating element is provided with any suitable type of heating means, such as gas or oil fuel, electric heating elements, etc. The bell **6** is thus externally heated, as in a retort or muffle furnace, and heat is conveyed from the hot wall of the bell to the metal stock by convection currents within the bell. A controlled inert atmosphere is usually maintained within the bell during the heating cycle and circulation of this atmosphere by the fan assures rapidly-moving convection currents.

With both the heating element and the bell raised, the metal stock **5** to be heat-treated is loaded upon a platform or bottom plate **7**. The bell **6** is then lowered, e. g., by a crane, and its lower edge or apron **6'** dips well beneath the surface of a body of water **8** in a sealing pit or moat **9** surrounding the base **10** supporting the platform **7**. The platform is spaced from the base sufficiently to accommodate the blades **11** of a fan driven by a motor **12** suitably mounted in the base. The heating element is then lowered over the bell, the heating cycle is carried to completion, the heating element is removed, and the hot heat-treated metal stock is cooled by the improved method of the invention.

In accordance with the invention, a nozzle **13** is positioned beneath the platform **7** to direct a spray of water against the rotating fan blades **11**. The nozzle is adapted to be connected by a pipe **14** and flexible hose **14'** to a suitable source of water under pressure. The pipe **14** is provided with a conveniently located valve **15** and pressure gauge **16**.

A gas inlet pipe **17** extends through the base **10** into the space between the base and the platform **7** and is provided with a control valve **18**. The gas pipe **17** is surrounded by an exhaust gas pipe **19**, also terminating in the space between the base **10** and platform **7** and provided with a control valve **20**. A thermo-couple **21**, or other suitable temperature-responsive means, is thermally associated with the metal stock **5** and is operatively connected by a cable **22** to a temperature-indicating instrument **23** conveniently located outside the furnace. A second thermo-couple **24**, or other suitable temperature-responsive device, is positioned within the bell **6** remote from the stock **5** in a location fairly indicative of the average air or atmosphere temperature within the bell. The thermo-couple **24** is connected by a cable **25** to a temperature-indicating instrument **26** also conveniently positioned outside the furnace.

It has heretofore been customary to artifically cool the bell **6** by water supplied near the top of the bell from an overhead pipe **27**, which may be permanently positioned at the bell station or may be portable and placed in operative position with respect to the bell when the heating element has been removed. Even with cooling water so supplied, the dissipation of heat from within the bell is so slow that metal stock heat-treated to a temperature around 400° C. cannot be cooled to a sufficiently safe temperature for exposure to the atmosphere in less than about 17 hours.

In accordance with the present invention, the nozzle **13** directs a spray of water against the rotating fan blades

11. This causes an extremely rapid drop in the temperature within the bell. In conjunction with the heretofore customary overhead sprinkler system **27**, the invention permits lowering of the air or atmosphere temperature within the bell (as indicated by instrument **26**) at least 200° C. in approximately ½ hour.

Vaporization of the water sprayed against the rotating fan blades **11** extracts heat from within the bell and circulation of the resulting water vapor or steam rapidly cools the mass of metal stock undergoing cooling on the platform **7**. The platform **7** is itself a large mass of metal and is normally the hottest part within the bell. Since the water spray is directed at the rotating fan blades **11** under the platform **7**, this large mass of metal is quickly cooled.

During the spraying of water against the rotating fan blades **11**, an inert gas, such as illuminating gas, nitrogen, or the like, is introduced within the bell **6** through the pipe **17**, and the inert gas along with water vapor formed by vaporization of the water spray are exhausted from the bell through the pipe **19**, whereby during the cooling cycle a controlled inert atmosphere is maintained within the bell. When the temperature of the metal stock **5** has fallen until its residual heat is only slightly greater than required to vaporize water, say a temperature of about 110° C. to about 125° C., as indicated by the instrument **23**, the water spray is discontinued by closing the valve **15**, without interrupting the supply and exhaustion of the inert gas. The continued circulation of the inert gas within the bell exhausts all of the remaining water vapor and eliminates any possibility of water-staining the heat-treated stock. When the temperature of the metal stock **5** has fallen to about atmospheric temperature, as indicated by the instrument **23**, or in the case of some metal stocks to a somewhat higher temperature, e. g. 50° to 85° C., the valves **18** and **20** are closed, water is drained from the pit **9** through a valved drain pipe **28**, the bell **6** is raised or pulled, and the cooled metal stock is unloaded from the platform **7**.

When the heating cycle has been completed, the gas supply valve **18** and gas exhaust valve **20** are turned on full, the heating element is removed, and the inside water spray valve **15** is slowly and gradually opened until the water pressure is raised to about 70 pounds per square inch (p. s. i.). Simultaneously, the overhead sprinkler **27** is slowly and gradually turned on. When the temperature of the metal stock has fallen to around 110° to 125° C., the overhead sprinkler is turned off and the valve **15** is closed. When the metal stock temperature has fallen to around 80–90° C., with the gas supply and exhaust valves **18** and **20** still open, the valve in the drain pipe **28** is opened and water is drained from the pit until the water seal is broken, the valves **18** and **20** in the meantime being closed. The bell may then be raised.

The following examples illustrate practices of the invention on copper alloys following an annealing heating cycle of about 5 hours at temperatures of 320° to 425° C.

Example I.—Metal stock load of about 13,000 pounds

Time	Bell temp. by Inst. 26, °C.	Remarks
0	450	Gas valve 18 turned on full and exhaust valve 20 opened.
1 minute	450	Heating element removed.
2 minutes	460	Valve 15 opened, water pressure 42 p. s. i.
9 minutes	320	
11 minutes		Overhead sprinkler 27 turned on.
20 minutes	270	Water spray pressure increased to 55 p. s. i.
30 minutes	240	
1 hour	165	
1½ hours	135	
2 hours	105	
3½ hours	60	Overhead sprinkler 27 off.
4 hours	50	Valve 15 closed.
	48	Water pit drained; valve 18 closed, bell raised.

Example II.—Metal stock load of about 19,000 pounds

Time	Bell temp. by Inst. 26, °C.	Metal stock temp. by Inst. 23, °C.	Remarks
0	445	420	Heating element removed; gas and exhaust on.
4 min	400	415	Valve 15 opened at 70 p. s. i.
8 min			Overhead sprinkler on.
30 min	200	398	
1 hour	150	355	
1½ hours	115	305	
2 hours	95	265	
2½ hours	75	220	
3 hours	60	190	
5 hours	25	100	Overhead sprinkler off; valve 15 closed; water pit drained; Valve 18 closed; bell raised.

Example III.—Metal stock load of about 14,000 pounds

Time	Bell temp. by Inst. 26, °C.	Metal stock temp. by Inst. 23, °C.	Remarks
0	430	425	Heating element removed; gas and exhaust on. Overhead sprinkler on lightly.
6 min	380	420	Valve 15 opened partially.
10 min	350	410	Valve 15 opened at 70 p. s. i.
20 min	280	390	Overhead sprinkler on full.
30 min	240	370	
1 hour	160	300	
1½ hours	130	240	
2 hours	95	190	
2½ hours	70	150	
3 hours	50	120	
3½ hours	35	85	Valve 15 closed, overhead sprinkler off.
	30	80	Bell kept over metal stock for 20 minutes.

Example IV.—Metal stock load of 22,000 pounds

Time	Bell temp. by Inst. 26, °C.	Metal stock temp. by Inst. 23, °C.	Remarks
0	400	320	Heating element removed; gas and exhaust on.
5 min	340	310	Overhead sprinkler on lightly.
10 min	265	310	Valve 15 opened partially.
15 min	235	305	Valve 15 opened at 70 p. s. i.
30 min	160	290	Overhead sprinkler on full.
1 hour	115	260	
1½ hours	100	235	
2 hours	80	200	
2½ hours	65	175	
3 hours	55	155	
3½ hours	50	140	
4 hours	35	120	
5 hours	20	85	Overhead sprinkler off; valve 15 closed, water pit drained.
5½ hours			Valve 18 closed, bell raised.

With only the overhead sprinkler **27** turned on, the duration of the cooling cycle in each of the foregoing examples would have been about 17 hours. By the practice of the invention, this cooling time is decreased to 4 to 5 hours. As a result, the annealed metal can be put back in the production line more rapidly than heretofore possible. Furthermore, the invention permits the use of an additional heating element with the five bell stations presently required for a single heating element, thus increasing production. And finally, the invention provides an incentive to decrease the time of the heating or annealing cycle.

I claim:

1. In the heat-treatment of metal stock in a bell furnace having a motor-driven fan for providing forced convection currents within the bell and around the stock as it is heated and subsequently cooled, the improvement in cooling the heat-treated stock which comprises directing a spray of water against the rotating blades of the fan, continuously introducing within the bell a stream of

inert gas while simultaneously exhausting from within the bell said gas together with water vapor formed by vaporization of the water spray, and discontinuing said water spray when the temperature of the metal stock has been lowered to within the range of about 110° C. and about 125° C. while continuing said introduction and exhaustion of said gas until substantially all water vapor within the bell has been exhausted.

2. The improvement of claim 1 in which the bell is additionally externally cooled by a water spray directed against the bell near its top.

3. The improvement of claim 2 in which the atmosphere temperature within the bell is lowered at least 200° C. in about one-half hour by the cumulative effect of said inside and outside water sprays.

4. In the heat-treatment of metal stock in a bell furnace having a motor-driven fan for providing forced convection currents within the bell and around the stock as it is heated and subsequently cooled, the improvement in cooling the heat-treated stock which comprises directing a spray of water against the rotating fan until the residual heat of the metal stock is only slightly greater than required to vaporize the spray of water and simultaneously introducing within the bell a stream of inert gas and exhausting from within the bell said gas along

with water vapor formed by vaporization of said water spray, continuing said introduction and exhaustion of said gas until substantially all water vapor within the bell has been exhausted, and removing the bell to expose the cooled stock for unloading.

5. In a bell furnace in which metal objects are heated and subsequently cooled with the cooling being obtained at least in part by heat absorbed during the evaporation of atomized water, a platform for supporting the metal objects, a water atomizing device comprising a motor-driven fan beneath said platform, a nozzle placed so as to direct a spray of liquid water against the blades of said fan, a source of liquid water under pressure, said nozzle being connected to said source, whereby liquid water may be directed against the blades of said fan for atomization thereby and subsequent vaporation in said furnace, means for introducing a gas into the bell, means through which gas within the bell may be withdrawn, and a coltrol valve for each of said means.

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