Feb. 7, 1967 J. A. SCHARBROUGH 3,302,939

INDUSTRIAL FURNACE COOLING SYSTEM

Filed May 19, 1964 2 Sheets-Sheet 1

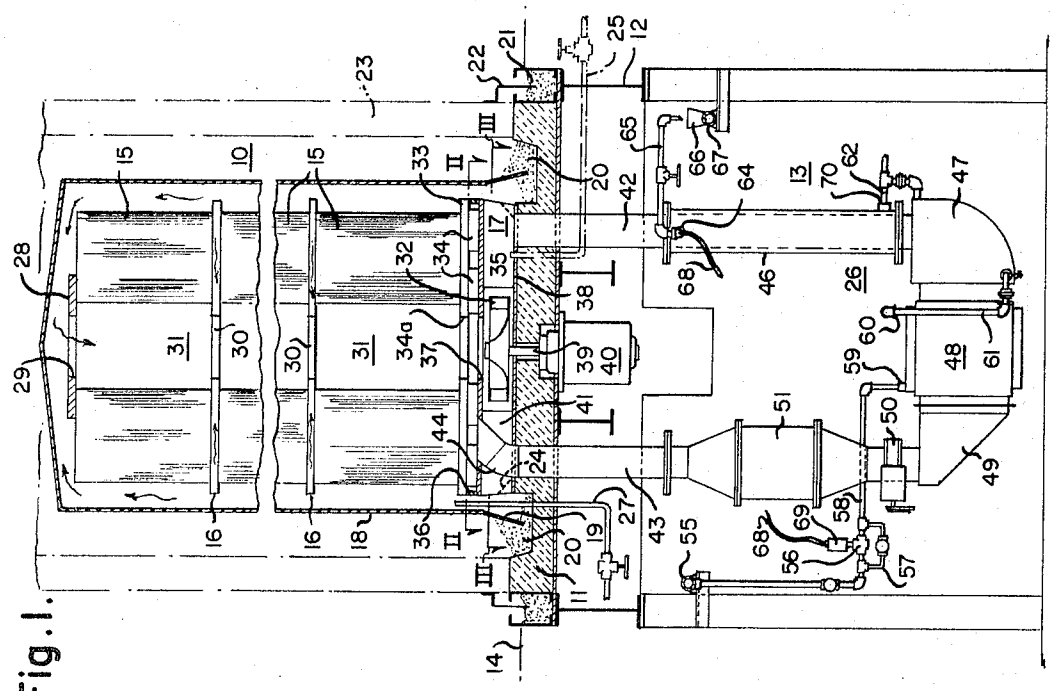


Fig. 1.

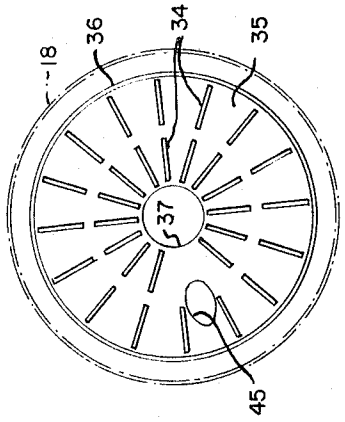


Fig. 2.

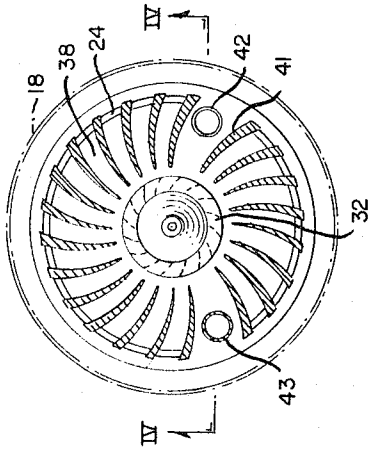


Fig. 3.

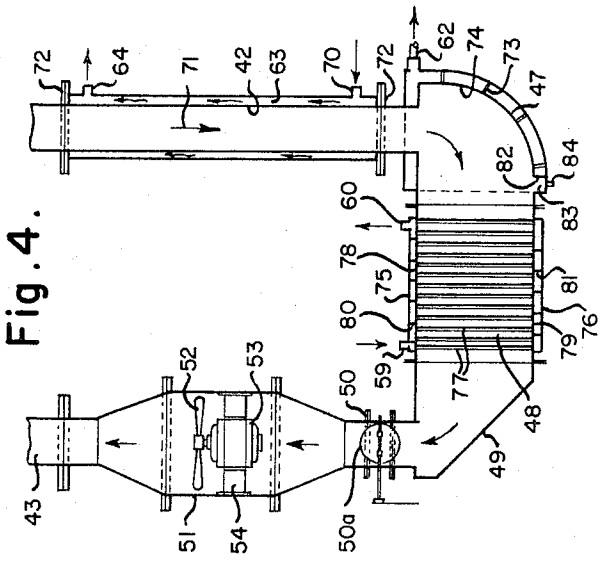


Fig. 4.

INVENTOR

James A. Scharbrough

By Hoppey, Leonard & Bull

his attorneys

Feb. 7, 1967 J. A. SCHARBROUGH 3,302,939

INDUSTRIAL FURNACE COOLING SYSTEM

Filed May 19, 1964 2 Sheets-Sheet 2

Fig. 6.

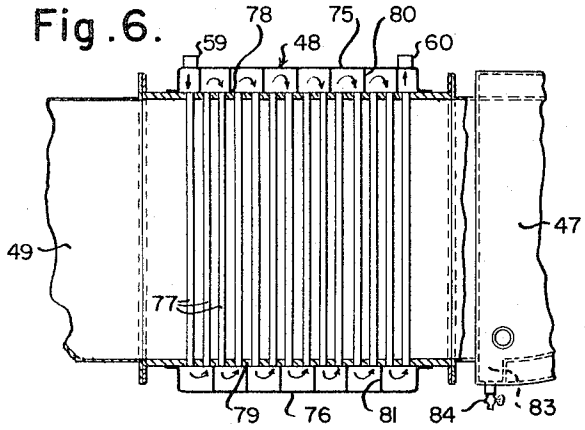


Fig. 5.

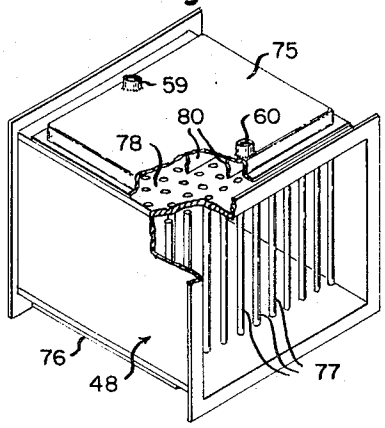


Fig. 7.

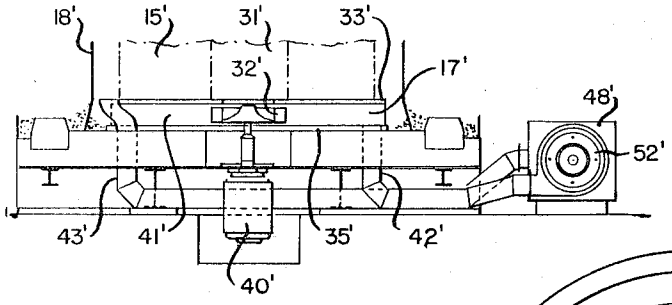


Fig. 8.

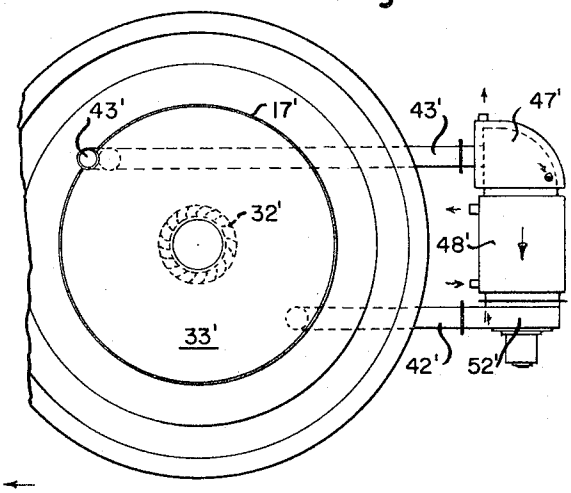


Fig. 9.

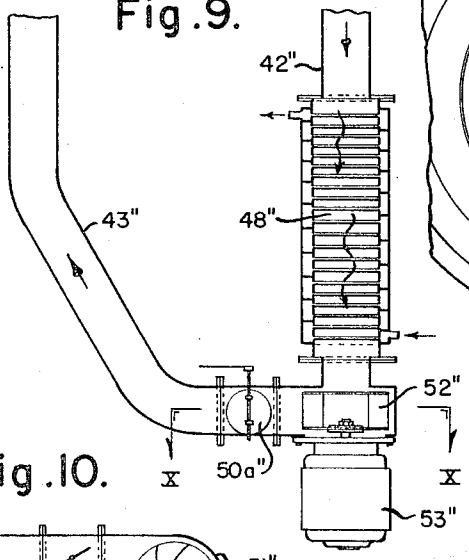
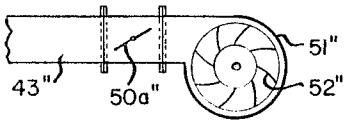


Fig. 10.



INVENTOR
James A. Scharbrough
By Hoopes, Howard & Buell
his Attorneys

United States Patent Office

3,302,939
Patented Feb. 7, 1967

3,302,939

INDUSTRIAL FURNACE COOLING SYSTEM

James A. Scharbrough, Mount Lebanon Township, Allegheny County, Pa., assignor to Salem-Brosius, Inc., Carnegie, Pa., a corporation of Pennsylvania

Filed May 19, 1964, Ser. No. 368,584
7 Claims. (Cl. 266—5)

This invention relates to a cooling system for industrial furnaces such, for example, as batch annealing furnaces for a stack of metal coils, or other articles, to be heat treated and then cooled. More particularly, this invention pertains to cooling circuit means for cooling work protecting atmosphere gas at least during the cooling phase of an operation cycle in such a furnace, preferably to reduce the cooling time to a length less than the heating period covering the heating, or heating and soaking phases.

Accelerated cooling has attracted much interest because of the long period usually required to cool down a stack of heat treated metal coils in a protective atmosphere, e.g., from a temperature in the neighborhood of 1200° F. or above, to a temperature below 300° F. in order to avoid undue oxidation and scaling of the heat treated work. Recently, means disclosed in British Patent No. 930,063 have effected a practical reduction in that country of the cooling period which, however, cannot achieve results demanded by the steel industry in this country in which heavier charges of work are common with greater equipment and labor costs.

On the other hand, in cooling system embodiments of this invention, even under American practice conditions, it has been possible to reduce the cooling time by as much as 50% over conventional times, a result which is a remarkable achievement and which yields marked economic and other advantages. Further, by reducing such cooling portion of the cycle to less than the heating and soaking time, if desired, a single heat treating furnace hood, the outer cover, can be used with each pair of stack stands and, thereby increase the tons per hour output of heat-treated and cooled metal work. Moreover, under this invention, cooling can be flexibly regulated, in summer or in winter, as by setting the outlet temperature of the water at a preselected value and varying the quantity thereof used for cooling to maintain such value. Further, the amount of regulation obtainable in the atmosphere cooling circuit of the invention may utilize both control of the flow of liquid coolant therethrough and a separate fan. The heat exchanger utilized herein has a desired relatively low pressure drop even with the higher circulation velocity usually found in American practice. And, the instant invention may be embodied in a surface installation when there is no basement or available space below grade adjacent the furnace.

Other objects, features and advantages of this invention will be apparent from the following description and the accompanying drawings, which are illustrative only, in which

FIGURE 1 is a view in elevation end section of a batch annealing furnace utilizing one embodiment of the cooling system of this invention;

FIGURE 2 is a view taken generally along line II—II of FIGURE 1;

FIGURE 3 is a view in section taken generally along line III—III of FIGURE 1;

FIGURE 4 is a view in elevation showing a section of such cooling system taken generally along line IV—IV of FIGURE 3;

FIGURE 5 is a perspective view, with a portion broken away, of the relatively low-pressure-drop, high thermal transfer heat exchanger used in such embodiment;

FIGURE 6 is a view in side elevation, with parts broken away, of such heat exchanger and adjoining parts of the atmosphere cooling circuit;

FIGURES 7 and 8 are respectively side elevation and plan views of a modified "surface installation" embodiment of a cooling system of this invention;

FIGURE 9 is a view in side elevation and section of a further modification of a cooling system of this invention; and

FIGURE 10 is a detail view in section taken along line X—X of FIGURE 9.

Referring to FIGURES 1 to 6, inclusive, of the drawings, a circular batch annealing furnace **10** is shown therein on a refractory hearth stand **11** supported by the suitable frame members **12** which are in a basement **13** below a plant floor **14**. Stand **11** may be a single stand as shown or may be one of a greater number on a multiple position stand. In operation, a superposed stack of metal coils **15**, of strip or sheet metal, separated by connector plate coil separators **16** having gas passages therethrough between the inner and outer peripheries thereof, are supported at the bottom by a base **17** which in turn rests on stand **11**. Such coils **15** when of ferrous and other metals are enclosed by a cylindrical inner cover **18** of steel or alloy metal having a cylindrical wall, either plain or corrugated. The foot **19** of inner cover **18** stands in a reasonably gas-tight sealing material, such as sand, in a circular trough around stand **11**. An outer concentric trough having sand **21** therein is adapted to be engaged by a depending skirt **22** of an outer cover **23** during the heating and any soaking phase performed on coils **15** in furnace **10**. Such heating may be accomplished by many means, one of them by the use of gas-fired radiant tubes (not shown) fastened to the inside of cover **23**.

A gaseous protective or treatment atmosphere for the particular metal work in furnace **10** may be introduced through a pipe **25** until the entire space inside inner cover **18** and a cooling circuit **26** filled with such atmosphere, a vent pipe **27** being used until all of such interior space is so filled by such atmosphere whereupon a valve in pipe **27** is closed. Additional atmosphere may be supplied through pipe **25** during an operation to make up for any loss. The stack of coils **15** may be surmounted by a plate **28** which preferably has a central opening **29** therein, although it may be a solid disc. The opening **29** is in vertical alignment with the inner peripheral openings **30** of the coil separators **16** and the eyes **31** of the respective coils **15**, all together forming a vertical central opening extending down to base **17** in coaxial relation therewith. Circulation of atmosphere inside inner cover **18** is laterally outwardly through base **17** during at least the heating phase of the heating and any soaking cycle, upwardly between the exterior of the coils **15** and the interior of inner cover **18**, and downwardly through such central opening into the base **17** due to the influence of a centrifugal fan **32** positioned at the bottom to effect such atmosphere circulation in the space within the inner cover.

Base **17** comprises an annular support plate **33** having a central opening **34** coaxial with the vertical central opening of the stack. Support plate **33** in turn is directly supported on bars **34** which are radially and angularly spaced for circulation of atmosphere in an upper base chamber over the entire undersurface of support plate **33**. Such bars **34** are affixed to an intermediate support plate **35** having an upstanding solid rim **36** extending to the outer edge of the upper plate **33**. Intermediate plate **35** is also provided with a central opening **37** in alignment with the central opening **34***a* adjacent the rotor of fan **32**. A bottom plate **38** on base **17** is pierced for the gas-tight passage of a rotary shaft **39**

supporting the rotor 32 at its upper end, the lower end of shaft 39 being affixed to a drive motor 40 mounted against the underside of stand 11. Bottom plate 38 may be provided with a series of generally radial, curved walls 41 which extend up to and support the underside of intermediate plate 35, the respective plates in base 17 being suitably affixed to one another. Deflecting plates 24 may be provided with an upward and outward slope from plate 38 between the outer ends of ribs 41, as an aid in directing circulation of atmosphere from the outer periphery of the lower chamber of base 17 upwardly around the outside of coils 15 and the inside of cover 18.

Bottom 38 and hearth 11 are pierced for the passage therethrough of an outflow duct 42 and a return duct 43, which are respectively gas-tight around the outsides thereof where they pass through the hearth 11. Outflow duct 42, at least during the cooling phase, receives atmosphere from the lower base chamber between plates 38 and 35. Return duct 43, on the other hand, by means of an extension 44, delivers such atmosphere after it is cooled to the upper base chamber between plates 35 and 33 through an opening 45. The returned atmosphere from the cooling circuit fills the interior of the upper base chamber within rim 36 and passes out through opening 37. Base 17 may be made with only one chamber, in which event the return duct 43 would discharge its cooled atmosphere during a cooling phase to the space between such inner cover 18 and the outer wrap of the lowermost coil 15 above the seal.

The cooling circuit in the embodiment being described comprises outflow duct 42, a substantial portion of the length of which is covered by a cooling jacket 46, a jacketed duct bend 47 at the bottom of the outflow duct, an indirect heat transfer device 48 providing very extensive direct cooling for atmosphere gas passing through the cooling circuit, a return duct bend 49 and the return duct 43. Return duct 43 includes a motorized butterfly valve assembly 50 with a butterfly valve 50*a* therein and an enlarged section 51 provided therein with an independent axial flow fan 52 driven by a motor 53, which may be a single speed variable mass flow motor for economy's sake, supported in section 51 by brackets 54.

As shown more fully in FIGURES 1 and 4, cooling water from a water main 55 passes through an automatically controlled valve 56 around which a bypass 57 is provided in the inlet pipe line 58, in which there also may be a trap and a filter, if desired. Such cooling water passes into heat exchanger 48 through an inlet fitting 59 and exists therefrom through an outlet fitting 60 to pass by a pipe 61 into the jacket around the walls of duct bend 47 and from thence by pipe connection 62 into the jacket space 63 surrounding a substantial portion of duct 42 before the water exits from an outlet fitting 64. The outlet water is discharged through a pipe 65 into a drain 66 connected to a drain manifold 67 which takes the discharged cooling water and returns it to a cooling tower, or a cooling pond, or into some waterway or other suitable place. As the cooling water is discharged into pipe 65, its temperature is sensed and the impulse passed by a tube 68 to a response device 69 which regulates the opening of valve 56 correspondingly to maintain the water temperature leaving through outlet fitting 64 at a predetermined temperature. And if, as in a summer, the temperature of entering cooling water is warmer, the regulation affected by the response device 69 will increase the flow of cooling water through the control valve 56 and continue to obtain the desired amount of cooling for the portion of the atmosphere passing through the cooling circuit. Heretofore, it has been considered impracticable because of the poor heat transfer characteristics of gas-to-liquid through a separating metal wall, to drastically reduce the temperature of a hot furnace gas such as the atmosphere in an annealing furnace. However, in a cooling system of this invention, it has been discovered that such extensive surface area can be provided in a relatively short path with a relatively lower pressure drop therethrough so as to achieve markedly increased cooling efficiency suitable for industrial furnaces with which this invention is concerned. Butterfly valve 50*a* is opened in the cooling circuit at the start of such cooling, which usually immediately follows heating and any soaking of the work in the furnace to which such a cooling circuit is applied. And the fan 52 cooperates therein and, preferably, with fan 32 in obtaining the desired very fast cooling.

Jacket 46, as shown, is a concentric annular chamber around and along a selected length of outflow duct 42, the cooling water entering an inlet fitting 70 at the bottom of the jacket through pipe 62 and flowing in counterflow relation to atmosphere gas flowing through outflow duct 42 in the direction of arrow 71. Such countercurrent flow of cooling water to the flow of atmosphere gas being cooled, is preferred. The upper and lower ends of jacket 46 are closed tight by annular plates 72. Bend 47 is also jacketed on the upper side, its front and back sides and on its bend side, to provide a common chamber jacket, rods 73 being used to space the outer wall from the inner shell 74 at the bend. The inside of inner shell 74 communicates with the lower end of duct 42 and the atmosphere gas entry end of exchanger 48, the outer end of the exchanger gas passage being connected to the interior of return bend 49 which in turn communicates with the interior of the entry end of section 51 and return duct 43 for return of the cooled atmosphere gas, at the selected time or times, to the interior space, usually pressurized, within inner cover 18. Thereby, the pressure-tight and the gas-tight integrity of the respective gas and coolant portions of the cooling circuit are preserved to the atmosphere space within cover 18.

The bend portion of the jacket in bend 47 is bounded near the bottom by a cross wall 82 to form a transverse sump 83 at the lowest point in shell 74 and the cooling circuit. A drain outlet 84, which is normally closed by a petcock, is provided in the bottom of sump 83. In the heat treating of metal work, such as coils 15 when they are sheet coils, they may be coated with enough oil that there is a tendency for some of such oil to find its way down into the cooling circuit. When that happens, the sump 83 and drain 84 provide a collection place for such oil and a means for removing the same from the system.

Extraordinary cooling is obtainable in the use of exchanger 48 by virtue of the very extensive heat transfer area made available therein with the relatively low pressure drop desirable in the gas passage therethrough for the atmosphere. Exchanger 48 comprises partitioned upper panel cover 75 and a partitioned lower panel cover 76, the partitions in cover 76 being displaced one cross row of tubes 77 toward the entry end of the exchanger 48. The outsides of the upper and lower ends of tubes 77 are sealed tightly in tube sheets 78 and 79 to connect them with the respective transverse compartments formed by the respective partitions 80 and 81 which extend across the entire interior of those respective covers. As shown in FIGURES 5 and 6, a tortuous path for the liquid coolant is provided in that beginning at the cross row nearest the gas exit from exchanger 48, the cooling water passes downwardly through all of the tubes in such cross row, upwardly through all of the tubes in the next cross row, downwardly in the next, and so on, until the cooling water exits from exchanger 48 through outlet fitting 60. Moreover, the tubes in any cross row are laterally staggered relative to the tubes in the next cross row with the result that atmosphere gas passing through the atmosphere passages in exchanger 48 is in markedly extensive contact with a plurality of heat transfer area surfaces to give up heat to the cooling water on the inside of those heat transfer tubes 77.

In addition, the provision of independent atmosphere flow promotion means in the outflow duct 43, as shown,

where the enlarged section 51 permits fan 52 to be mounted in the flow stream of current atmosphere gas without restricting the atmosphere gas passage cross section, which otherwise would increase the pressure drop through the cooling circuit, is a further regulation element. Thus, separate fan means 52 may be used in cooperation with the centrifugal fan 32 to select the proportion of atmosphere gas which is to circulate in the atmosphere space of furnace 10 relative to the proportion of atmosphere which is to flow through the cooling circuit. Hence, a desired portion of the entire quantity of atmosphere in the whole furnace space including the space in the cooling circuit may be caused to pass through such cooling circuit for cooling to a desired temperature within the capacity range of the apparatus. At least during the cooling portion of the entire heating (including any soaking) and cooling cycle for a given stack of coils 15, at the inception of such cooling, valve 50*a* will be opened and centrifugal fan 32 will remain on to circulate and cool a portion of atmosphere gas which then will pass through the cooling circuit before it is returned. Motor 53 and fan 52 may not be turned on at the start of the cooling phase until there has been some drop in the temperature of the metal coils 15 depending upon whatever metallurgical effect is being considered. At a predetermined time in the cooling phase, fan 52 is turned on and a greater portion of atmosphere gas will pass through the cooling circuit to provide the selected quantity of atmosphere to be cooled and returned to the inside of cover 18. Greater flexibility may be obtained in some cases by the use of valve 56 as a modulating valve instead of using it as an on-off valve. Moreover, since prior to the inception of such a cooling phase the outer cover 23 is lifted off of stand 11 and taken away, additional cooling effect is obtained by radiation from the outside of inner cover 18 which, moreover, may have cooling air directed against the outside thereof, if desired. The remainder of the atmosphere gas at a given interval in the cooling phase which does not pass into outflow duct 42 admixes with discharged cooled atmosphere gas from outlet opening 45 and is circulated by fan 32 in the usual fashion to pass out, save for the quantity that enters duct 42, through the periphery of the lower chamber of base 17 into the space surrounding coils 15 inside cover 18.

Normally, during the heat and any soaking portion of the cycle on a given batch of coils 15, valve 50*a* is closed. In that situation, all of the atmosphere gas in the furnace portion of device 10 passes down through the central opening through the stack in the direction of the wavy arrows and through the central openings in base 17 for engagement by fan 32 and return laterally and outwardly through the lower base chamber, then upwardly in the annular space between the outside of the coils 15 and inner cover 18, and thence into the stack central opening completing the atmosphere circuit inside cover 18. In some cases, however, even during the heating and any soaking portion of an operation cycle, some tempering of the high temperature of the atmosphere gas may be desired. In that event, valve 50*a* may be partially opened and fan 52 turned on together with an appropriate flow of coolant through the cooling circuit, to draw some atmosphere into the cooling circuit and discharge it through opening 45 to mix with and effect the desired reduction in the temperature of the atmosphere gas inside cover 18. Further, if desired, an injection of materials which may be gas-borne may be provided in the cooling circuit for treatment of the metal work in the furnace in the course of the passage of gas through such cooling circuit. When the cooling circuit is opened up at the start of a cooling portion of a single operation cycle, normally closed valve 50*a* usually is opened to its full extent and a predetermined portion of the atmosphere gas in the furnace and cooling system will thereupon circulate through the cooling circuit. At a predetermined point in the cooling phase, which may be measured, for example, by the temperature of the metal work being cooled, fan 52 will be turned on and a substantial and selected increased portion of atmosphere will circulate through the cooling system for discharge as cooled atmosphere through opening 45 to yield extraordinary cooling results of this invention. Moreover, the efficiency of heat transfer is advantageously held high both at the beginning of a cooling phase with valve 50*a* open and fan 52 off, when the thermal head of the atmosphere gas is higher, and, during the later operation of fan 52 in the cooling phase when, while the temperature head of the atmosphere gas from inside cover 18 has dropped, the mass flow of atmosphere gas through exchanger 48 will increase and maintain the exchanger's high level of efficient heat transfer. Consequently, greater efficiency and flexibility are obtained in this invention.

In the modified "surface installation" embodiment of this invention illustrated in FIGURES 7 and 8, parts corresponding generally in construction and functioning are provided with the same reference numerals with the addition of a prime accent thereto, respectively. Such modification utilizes a centrifugal fan 52′ in lieu of an axial flow fan and is of interest in those places where a furnace installation may have insufficient or no room below the furnace stand, due to any of a variety of reasons such as the case of a furnace erected on the low bank of a river in which the water table is close to the ground surface supporting the furnace. Base 17′, moreover, is conventional and has but a single chamber between upper annular support plate 33′ and lower plate 35′, the atmosphere being propelled laterally outwardly through the open outer periphery of base 17′ between the ribs 41′. In such an installation, the return duct 43′ also discharges its cooled atmosphere gas laterally outwardly substantially directly into the space between the inner cover 18′ and the lowermost coil 15′ adjacent the outer edge of base 17′.

The further modification of FIGURES 9 and 10 illustrates another arrangement of a cooling circuit embodiment of this invention to be located in a space beneath the furnace proper. Those parts in the further modification of FIGURES 9 and 10 which correspond generally in construction and functioning to the parts of the above first-described embodiment are provided with the same reference numerals, respectively, with the addition of a double prime accent thereto. In such further modification, the second fan 52″ again is a centrifugal fan, taking its suction directly off the delivery end of heat exchanger 48″. Although the return duct 43″ in such further modification has no cooling jacket thereon, such may also be provided if additional cooling regulation is desired, as such may also on the earlier described embodiments.

Various changes in details of the illustrated embodiments may be made and other embodiments provided, without departing from the spirit of this invention, or the scope of the appended claims.

What is claimed is:

1. In a cooling system for an industrial furnace for the annealing of a stack of metal coils, having a hearth, an inner cover covering said stack and a centrifugal fan at the foot of said stack to circulate a protective atmosphere around said coils within said inner cover, apparatus comprising, in combination, an annular base having a central opening in vertical concentric alignment with the central opening through said stack, an outflow duct for an atmosphere cooling circuit connected to the interior of said base, means for cooling said outflow duct, an indirect relatively low-pressure-drop heat exchanger connected to said outflow duct, said heat exchanger having an extensive surface area for heat transfer from said atmosphere, a return duct connected to said heat exchanger to return the portion of the atmosphere being cooled to the space within said inner cover, independent fan means in said cooling circuit following said heat exchanger to

regulate the flow of atmosphere through said cooling circuit and within said inner cover respectively in cooperation with said centrifugal fan, valve means in said cooling circuit following said heat exchanger to regulate the flow of atmosphere through said cooling circuit, means for circulating a liquid coolant in a countercurrent direction through said heat exchanger and first-named means, and means for regulating the flow of said liquid coolant in accordance with the temperature rise thereof in said cooling circuit.

2. In a cooling system for atmosphere in an industrial furnace for the heat-treating of work, having a hearth, a cover covering said work and a fan at the foot of said work to circulate atmosphere around said work within said cover, apparatus comprising, in combination, a base to support said work, an outflow duct for an atmosphere cooling circuit connected to the space within said cover, cooling means for surrounding said outflow duct, an indirect coolant tube heat exchanger connected to said outflow duct, said heat exchanger providing extensive surface area for heat transfer from said atmosphere, a return duct having an enlarged section therein and connected to said heat exchanger to return cooled atmosphere to the space within said cover, separate fan means for said cooling circuit mounted in said enlarged section, external conduit means for coupling said heat exchanger to said cooling means so as to provide a series flow path through said heat exchanger and said cooling means, and means for circulating a liquid coolant through said flow path.

3. In a system for cooling atmosphere in an industrial furnace for the heat treating of work, said furnace having a hearth, a cover covering said work and a fan at the foot of said work to circulate atmosphere around said work within said cover, the combination comprising a base to support said work, an outflow duct for an atmosphere cooling circuit connected to the space within said cover, an indirect coolant tube heat exchanger connected to said outflow duct, an annular cooling jacket surrounding said outflow duct for circulation of a liquid coolant therethrough, a return duct connected to said heat exchanger to return cooled atmosphere to the space within said cover, separate fan means in said cooling circuit to regulate the flow of atmosphere through said cooling circuit and within said cover in cooperation with said fan, and conduit means coupled to said heat exchanger and to said cooling jacket for circulating a liquid coolant in series through said heat exchanger and said jacket.

4. In a cooling system for atmosphere in a furnace for the heat-treating of work, having a hearth, a cover covering said work and a fan at the foot of said work to circulate atmosphere around said work within said cover, apparatus comprising, in combination a base to support said work, an outflow duct for an atmosphere cooling circuit connected to the space within said cover, an indirect coolant tube heat exchanger connected to said outflow duct, said heat exchanger providing extensive surface area for heat transfer from said atmosphere, a return duct connected to said exchanger to return cooled atmosphere to the space within said cover, separate fan means in said cooling circuit following said heat exchanger, external conduit means having inlet and outlet portions coupled to said heat exchanger for circulating a liquid coolant therethrough to cool said atmosphere when circulated through said cooling circuit, valve means coupled in said inlet portion, temperature-sensitive valve operating mechanism coupled to said valve means, and temperature-sensing means coupled in said outlet portion and to said valve operating mechanism for controlling the operation of said valve operating mechanism.

5. In a cooling system for an industrial furnace for the heat-treating of metal work, having a hearth, a cover covering said work and a fan below said work to circulate a protective atmosphere around said work within said cover, apparatus comprising, in combination, an annular base having a central opening in vertical concentric alignment with a central opening within said work, an outflow duct for an atmosphere cooling circuit, said outflow duct being connected at one end to the space within said cover and at the other end to an indirect heat exchanger, said heat exchanger having a plurality of liquid-cooled tubes for heat transfer from said atmosphere, a return duct connected to said heat exchanger to return the atmosphere being cooled to the space within said cover, separate fan means in said cooling circuit to regulate the flow of atmosphere through said cooling circuit in cooperation with said fan, valve means in said cooling circuit to circulate the flow of atmosphere through said cooling circuit, an annular jacket surrounding said outflow duct for circulation of a liquid coolant therethrough, a bend at the bottom of said outflow duct to connect it to said heat exchanger, said bend having a cooling jacket for circulation of a liquid coolant therethrough, conduit means coupling said heat exchanger to said annular jacket and said cooling jacket for providing a flow path for liquid coolant in countercurrent series through said heat exchanger and said cooling jacket and said annular jacket, and circulating means for circulating said liquid coolant through said flow path.

6. In a cooling system for an industrial furnace for the heat-treating of metal work, having a hearth, a cover covering said work and a fan below said work to circulate a protective atmosphere around said work within said cover, apparatus comprising, in combination, an annular base having a central opening in vertical concentric alignment with a central opening within said work, an outflow duct for an atmosphere cooling circuit, said outflow duct being connected at one end to the space within said cover and at the other end to an indirect heat exchanger, said heat exchanger having a plurality of liquid-cooled tubes for heat transfer from said atmosphere, a return duct connected to said heat exchanger to return the atmosphere being cooled to the space within said cover, separate fan means in said cooling circuit to regulate the flow of atmosphere through said cooling circuit in cooperation of said fan, valve means in said cooling circuit to circulate the flow of atmosphere through said cooling circuit, an annular jacket surrounding said outflow duct for circulation of a liquid coolant therethrough, conduit means coupling said heat exchanger to said annular jacket for providing a flow path for liquid coolant in series through said heat exchanger and said annular jacket, second valve means coupled in the inlet portion of said conduit means, temperature-sensitive valve operating mechanism coupled to said second valve means, temperature-sensing means coupled in the outlet portion of said conduit means and to said valve operating mechanism for controlling the operation of said valve operating mechanism, and circulating means for circulating said liquid coolant through said flow path.

7. In a cooling system for an industrial furnace for the heat-treating of metal work, having a hearth, a cover covering said work and a fan below said work to circulate a protective atmosphere around said work within said cover, apparatus comprising, in combination, an annular base having a central opening in vertical concentric alignment with a central opening within said work, an outflow duct having an atmosphere cooling circuit connected to the space within said inner cover, an indirect heat exchanger connected to said outflow duct, said heat exchanger having a plurality of liquid-cooled tubes for heat transfer from said atmosphere, a return duct connected to said heat exchanger to return the atmosphere being cooled to the space within said cover, separate fan means in said cooling circuit to regulate the flow of atmosphere through said cooling circuit in cooperation with said fan, valve means in said cooling circuit to circulate the flow of atmosphere through said cooling circuit, an annular jacket surrounding said outflow duct for circulation of a liquid coolant therethrough, a bend at the bottom

of said outflow duct to connect it to said heat exchanger, said bend having hollow top, side and bend walls for the circulation of a liquid coolant through said walls, and said return duct having an enlarged section for the mounting of said separate fan means therein in the flow path of said atmosphere being cooled, and means for circulating a liquid coolant through said heat exchanger and said annular jacket and said hollow walls.

References Cited by the Examiner

UNITED STATES PATENTS

1,727,192	9/1929	Bailey.	
1,938,306	12/1933	Webb.	
2,018,780	10/1935	Folsom	165—65
2,028,457	1/1936	Karmazin	165—150
2,063,988	12/1936	Dick	165—150
2,477,796	8/1949	Germany	266—5
2,902,265	9/1959	Dubovick.	
3,011,926	12/1961	Rowe	148—13
3,071,500	1/1963	Corbett et al.	148—13

FOREIGN PATENTS

635,369	1/1962	Canada.
930,063	7/1963	Great Britain.

JOHN F. CAMPBELL, *Primary Examiner.*

WHITMORE A. WILTZ, *Examiner.*

M. L. FAIGUS, *Assistant Examiner.*