

Dec. 20, 1960

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2,965,368

WIRE TREATING APPARATUS

Filed Aug. 14, 1953

6 Sheets-Sheet 1

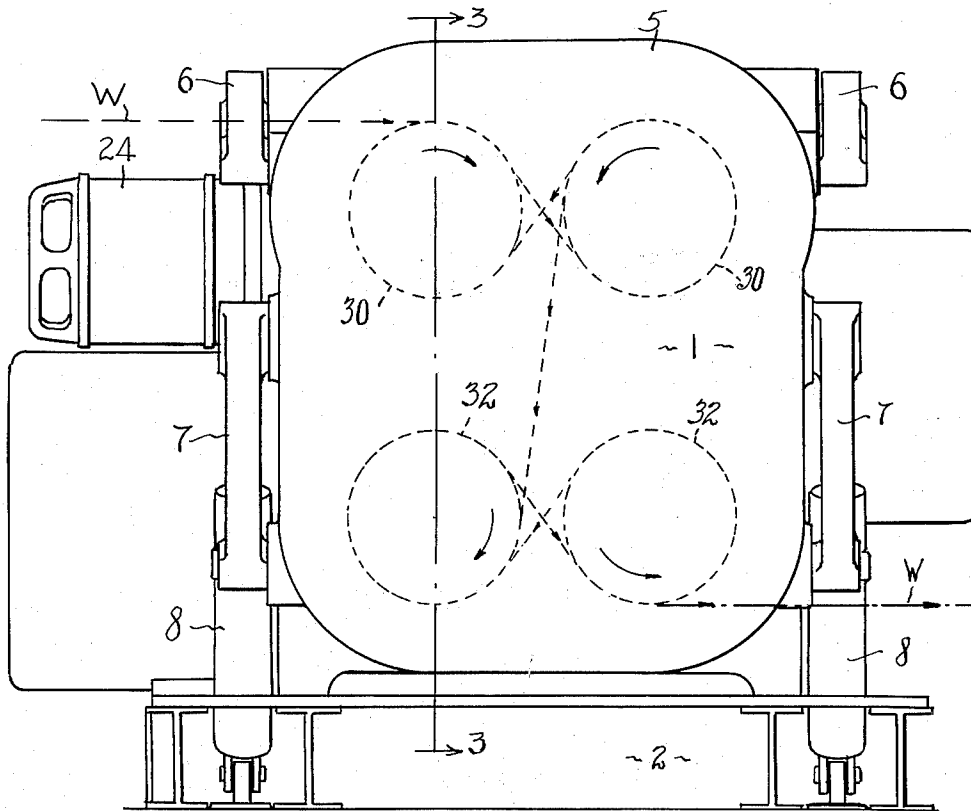


Fig. 1

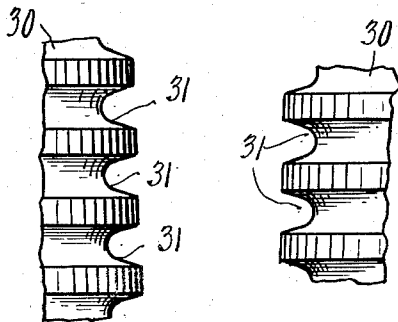


Fig. 6

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6 Sheets-Sheet 2

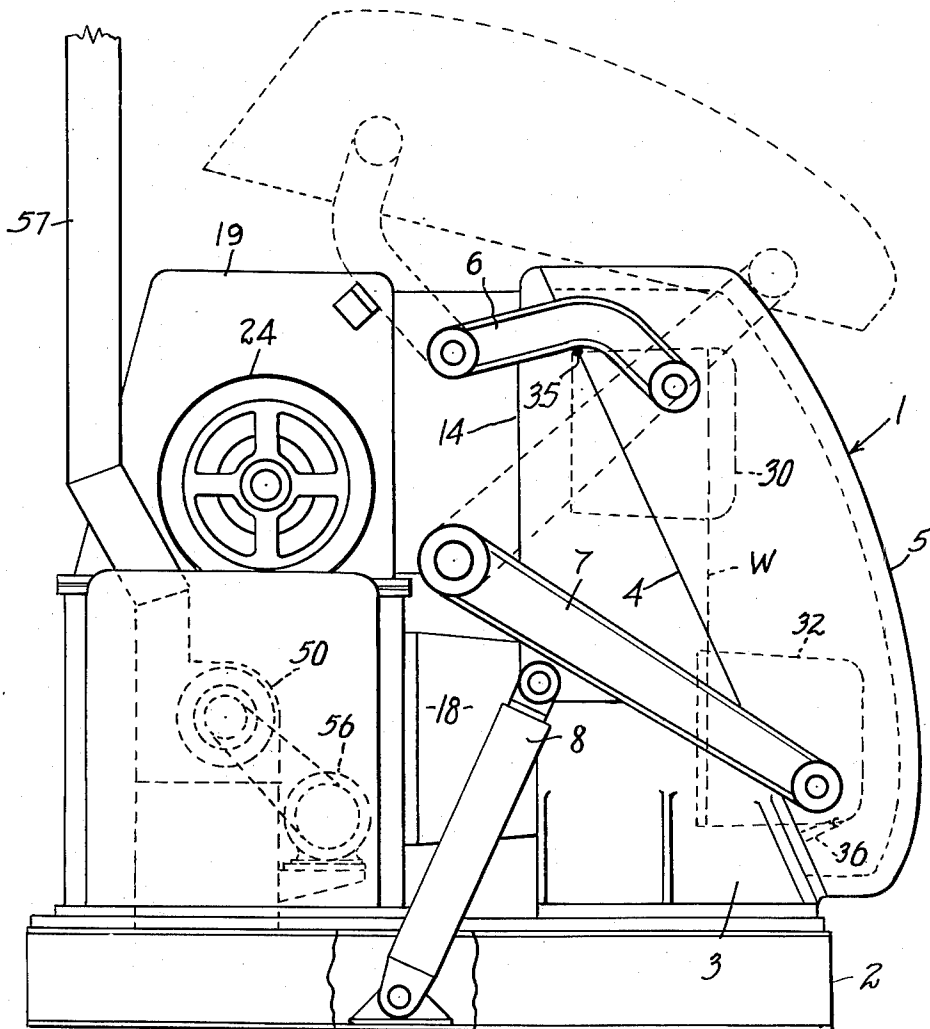


Fig. 2

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6 Sheets-Sheet 3

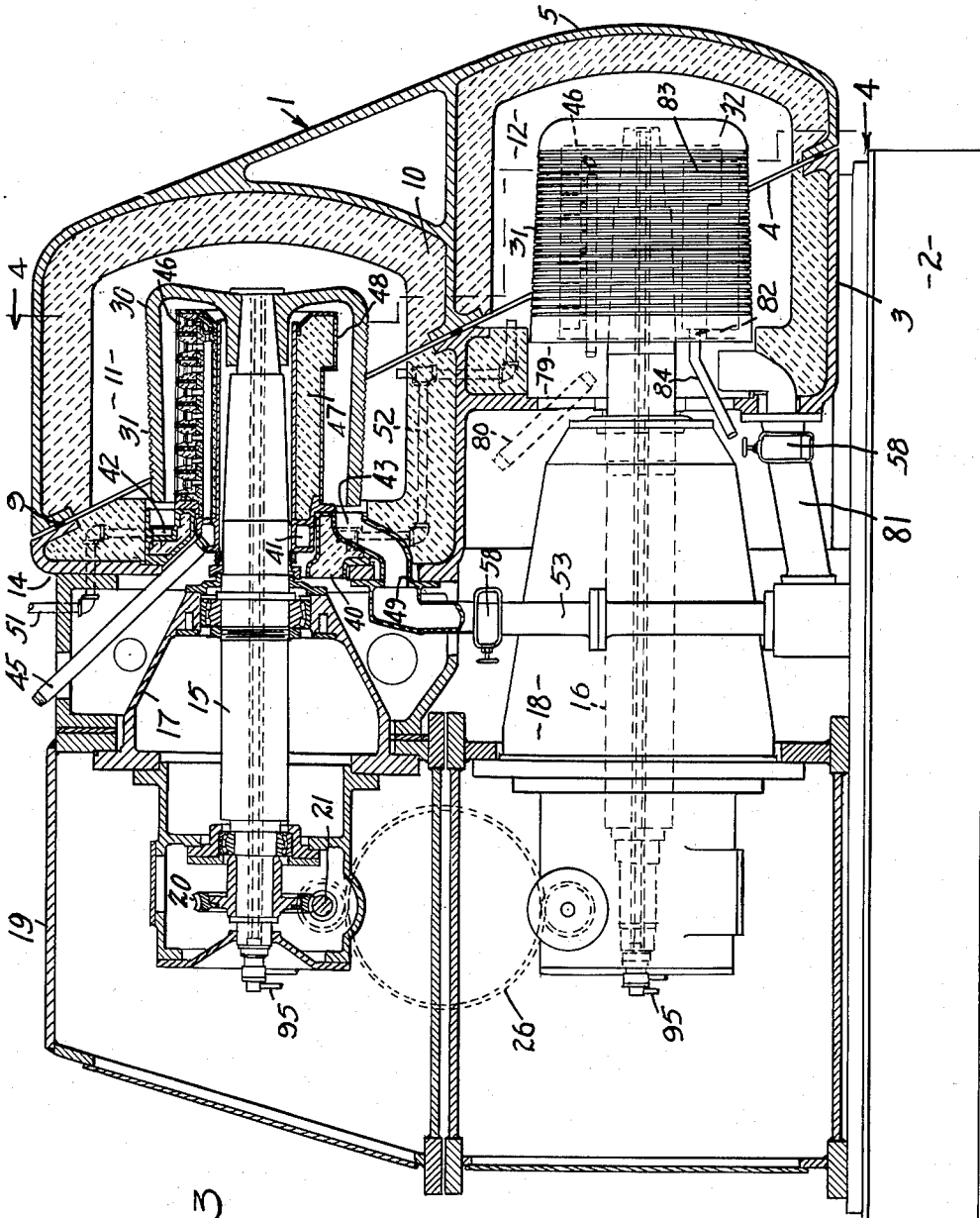


Fig. 3

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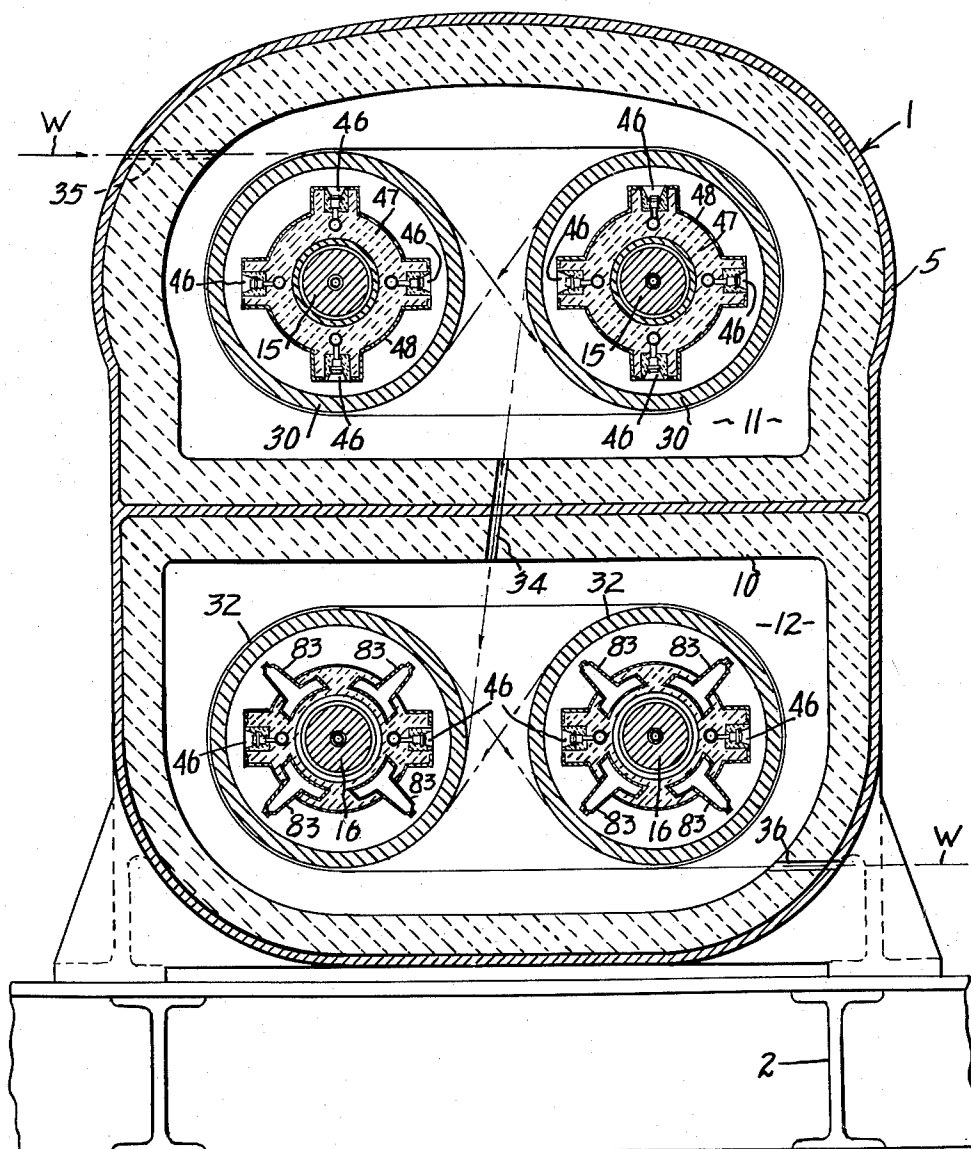


Fig. 4

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6 Sheets-Sheet 5

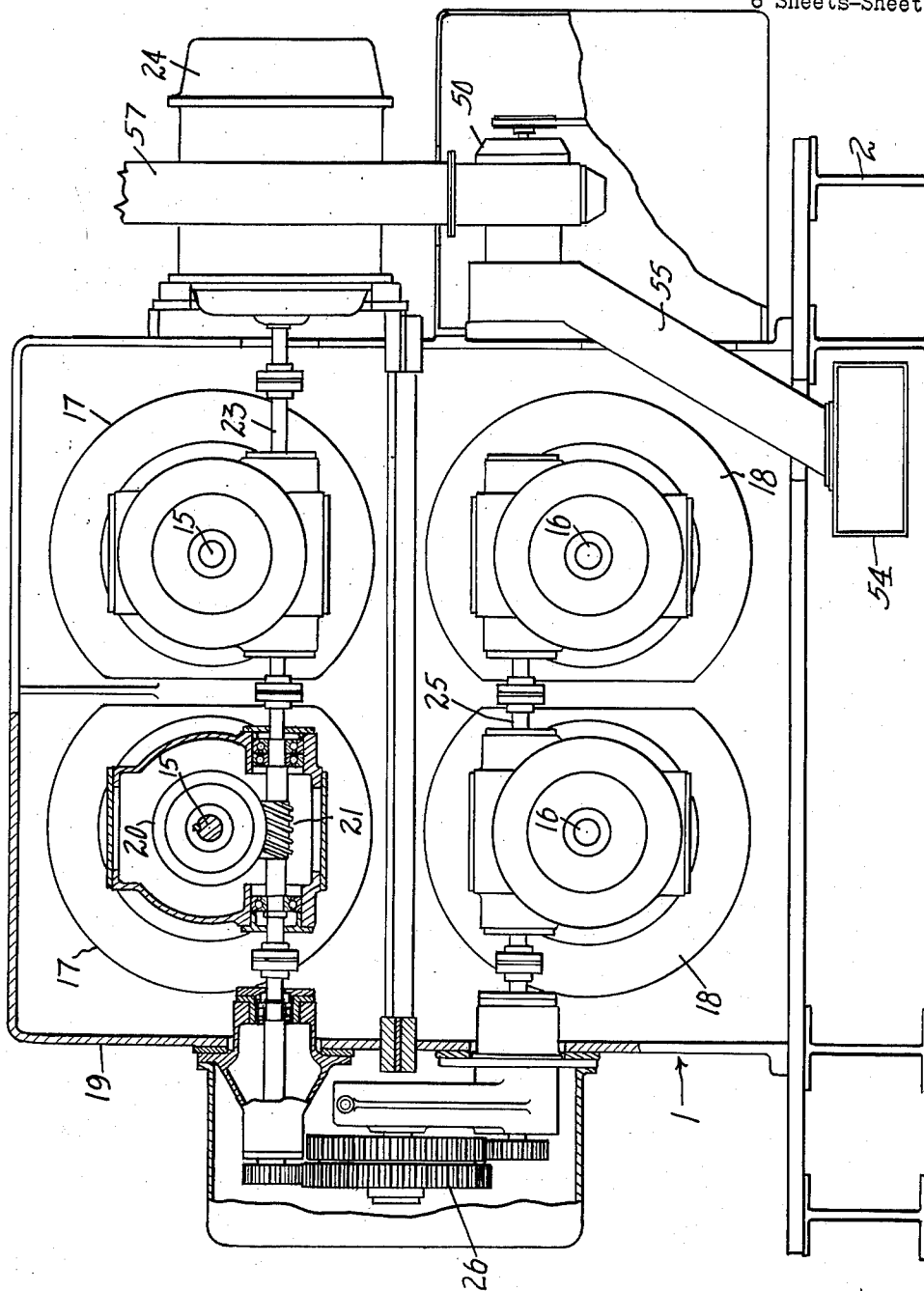


Fig. 5

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6 Sheets-Sheet 6

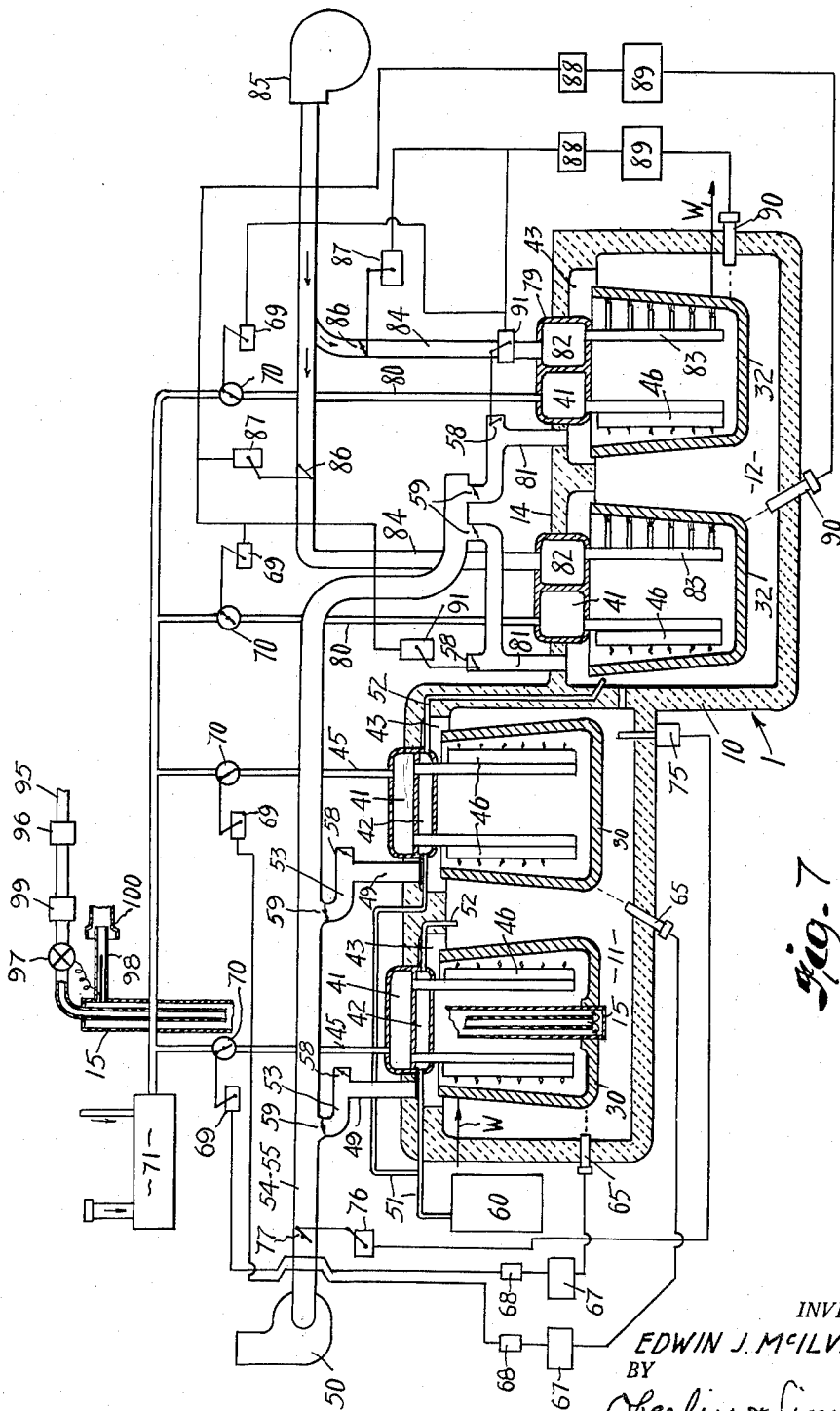


Fig. 7

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2,965,368

WIRE TREATING APPARATUS

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1 Claim. (Cl. 266—3)

The present invention relates generally as indicated to wire treating apparatus, and more particularly to an apparatus for continuously and uniformly heat-treating wire or like elongated material during the course of its longitudinal travel, the expression "heat treating" including annealing, patenting, hardening, tempering, etc., wherein the temperature of the material is modified, that is increased or decreased, to the temperature of an element over which said material passes in direct, heat exchange contact.

Heat treating processes which are now in use for the heat treatment of wire or the like include muffle annealing, continuous lead annealing, tube annealing, old process patenting, metallic hardening process, and double lead process. The practice of these processes requires employment of large size, elaborate, and expensive equipment; and because certain heating units, such as muffle furnaces and tube furnaces, have wire contacting flames and heating chambers at much higher temperatures than those to which the wire is desired to be heated, it is necessary, not only to closely regulate the furnace temperatures throughout their lengths, but, in addition, to closely regulate the lineal speed of the wire in order that the time of exposure of the wire in the furnace be constant for accurate heating. A critical factor is lineal speed, since there is, on the one hand, danger of overheating of the material due to decreased speed, and on the other hand, danger of underheating of the material due to increased speed.

Likewise, when a molten lead bath is employed for heating or quenching wire, it becomes necessary to employ elaborate heat control means in order to maintain a proper lead temperature throughout the length of the bath.

It is one principal object of this invention to provide a heat treating apparatus in which wire or like material is passed in contact with heating or quenching surfaces for a length which, at the desired lineal speed of the material, assures heating or cooling of the material to the temperature of such surfaces, this length of material being substantially in excess of that actually required so that if the lineal speed increases even a substantial amount above the desired value, the wire or like material will not be underheated or insufficiently cooled. Because the material temperature is changed to that of the surface, any reduction in speed of travel of the material, and consequent longer period of contact thereof with the heating or quenching surfaces, will not result in overheating or under-cooling.

Another object is to provide a unitary compartmentalized heating and quenching unit for wire or like material.

Another object is to provide a treating apparatus which has a novel form of burner unit and also combination burner and cooling unit for achieving uniform heating of the surfaces over which the wire is adapted to pass in contact for heating or quenching as the case may be.

Another object is to provide a heat treating apparatus which has a novel exhaust system to eliminate exposure

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of the material being heat treated to the products of combustion of the burner units.

Another object is to provide a heat treating apparatus having provision for circulation therethrough of a neutral, non-oxidizing, or other desired atmosphere to which the material being heat treated is exposed.

Another object is to provide a heat treating apparatus in which the peripheral surfaces of internally heated rotary drums constitute the heating or quenching surfaces which are contacted by the wire or other material being heat treated, said material being looped a plurality of times around said drums to provide a relatively long length of contact of the material therewith, while yet the apparatus occupies a small floor space as compared with the usual form of muffle furnace, tube annealing furnace, molten lead bath, and like apparatuses which are presently used for this purpose.

Another object is to provide a heat treating apparatus wherein the drums aforesaid, when employed for raising the temperature of the material looped therearound, are tapered so as to compensate for lineal expansion of the material during heating thereof. Similarly, when the drums are used for quenching purposes, they are tapered so as to compensate for lineal contraction of the material during quenching thereof.

Another object is to provide heat treating rotary drums which are formed with peripheral annular grooves thereabout in which the material is looped a plurality of times from one drum to an adjacent drum, the grooves of said adjacent drums being staggered relative to one another and so dimensioned that the material may be so looped with a minimum of rubbing contact between the material and the sides of such grooves.

Another object is to provide a heat treating apparatus in which heating and quenching drums are parallel and axially off-set relative to each other, the material being heat treated being wrapped a plurality of times around the heating drum or drums from one end toward the other and thence around the quenching drum or drums from one end to the other of the latter, the material passing substantially straight across from the other end of a heating drum to such one end of a quenching drum.

Another object is to provide a heat treating apparatus in which the ends of the rotary drum or drums have one end thereof unobstructed so that wire may be looped therearound a plurality of times while the drums are in heated condition.

Another object is to provide a heat treating apparatus in which the heating (or quenching) surfaces are enclosed within a controlled temperature atmosphere and which, in the case of a combination heating and quenching apparatus, is provided with a partition through which the wire passes from one chamber to the other.

Other objects and advantages of the present invention will become apparent as the following description proceeds.

To the accomplishment of the foregoing and related ends, the invention, then, comprises the features hereinafter fully described and particularly pointed out in the claim, the following description and the annexed drawings setting forth in detail certain illustrative embodiments of the invention, these being indicative, however, of but a few of the various ways in which the principle of the invention may be employed.

In said annexed drawings:

Fig. 1 is a front elevation view showing in dotted lines a top pair of heating drums and a bottom pair of quenching drums, over which drums wire or like material is adapted to pass in figure 8 form as shown;

Fig. 2 is a side elevation view of the apparatus as viewed from the lefthand side of Fig. 1;

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Fig. 3 is a cross-section view, on somewhat enlarged scale, taken substantially along the line 3—3, Fig. 1;

Fig. 4 is a cross-section view taken substantially along the line 4—4, Fig. 3;

Fig. 5 is a rear elevation view of the apparatus, partly in cross-section to show the mechanism for driving the drums;

Fig. 6 is a fragmentary enlarged view of adjacent drums to show the staggered relation of the peripheral annular grooves around the drums, and to show the preferred shape of the grooves; and

Fig. 7 is a schematic wiring and piping diagram for achieving uniform control of drum temperatures, for exhausting the products of combustion of the drum burner units, for circulating coolant within the quenching drums, and for circulating a desired atmosphere in the heating and quenching chambers.

Referring now more specifically to the drawings, the heat treating apparatus therein illustrated comprises a combination heating and quenching unit 1 mounted on a base 2, said unit 1 including a rear or main part 3 which has an inclined front wall 4 and a cover part 5 which, as best shown in Fig. 2, is swingably mounted on said main part 3 by means of links 6 and 7 pivoted to said cover part 5 at opposite sides and to said main part 3. An actuating cylinder 8 is pivotally connected at its ends to said cover part 5 and said base 2 so that when said cylinder 8 is extended, said cover part 5 will be swung to the dotted line position as shown in Fig. 2, and when said cylinder 8 is contracted, said cover part 5 will be drawn tightly against the gasket 9 which is disposed between said front wall 4 of said main part and the rear wall of said cover part.

Said main and cover parts 3 and 5 are preferably in the form of cast metal shells lined with refractory material and define therebetween, on opposite sides of partition 10, two separate chambers, viz. a heating chamber 11 and a quenching chamber 12.

The parting line between said main and cover parts 3 and 5 is preferably inclined as shown so as to provide heating and quenching chambers 11 and 12 which are axially offset with respect to each other as best shown in Fig. 3, and to provide for convenient access to the rotary drums in the respective chambers as will hereinafter be described in greater detail.

The rear wall 14 of said main part 3 has openings there-through, through which internally cooled drive shafts 15 and 16 project into the respective chambers 11 and 12, said drive shafts being journaled in the bearing housings 17 and 18 which are mounted on a main drive base 19.

Each drive shaft 15 and 16 has secured adjacent its rear end portion a worm wheel 20 driven by a worm 21 in mesh therewith. The worm shaft 23 for driving the upper pair of drive shafts 15 is driven directly by the electric drive motor 24 and the worm shaft 25 for driving the lower pair of drive shafts 16 is driven through gearing 26.

Mounted on the front end of each of the upper drive shafts 15 is a hollow drum 30 which is closed at its front end and open at its rear end, and which has, for example, 72 annular grooves 31 therearound, which grooves, for handling up to .150" diameter wire for example, are .150" or more in depth, and have .075" radius bottoms and slightly tapered sides as best shown in Fig. 6. As shown in Fig. 6, the grooves 31 of adjacent drums 30 are staggered to minimize and equalize the angle of the wire W as it passes back and forth from a groove of one drum over to a groove of the other drum. In the heating of steel wire for patenting thereof, that is, heating to approximately 1750° F., it has been found desirable to taper said drums 30 not only to compensate for lineal expansion but to additionally stretch the wire W after it reaches drum temperature. The figure 8 loops of wire W are thus maintained tight about said drums 30 during the heating operation and after.

In this particular structure, the drums 30 are of 32"

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diameter, and usually it will not be necessary to wrap the wire around the entire 72 grooves in each drum, but instead to skip several grooves between each loop, that is, to provide only some 20 to 30 wraps instead of 72, the cross-section shapes of the grooves 31 being such as to permit such skipping without undue rubbing of the wire W against the sides of the grooves. At the present time, there is no need for pulling the wire W through the heating and quenching unit at the rate of several thousand feet/min. as could be done if the wire were wrapped around all or most of the 72 grooves.

Mounted on the free end of each of the lower pair of drive shafts 16 is a quenching drum 32 which, except for opposite taper, is generally the same as the drums 30 just described, and therefore repetition of the structure thereof is not deemed necessary.

As shown in Fig. 4, the cover part 5 is formed with an angularly disposed slot 34 (open at the main part-cover part parting line) through which the wire W passes from the righthand heating drum 30 to the lefthand quenching drum 32. Also, as shown in said Fig. 4, the wire W enters the heating chamber 11 from the left through a slot 35 in cover part 5 and passes a part-turn clockwise around the lefthand heating drum 30, counter-clockwise around a groove of the righthand heating drum 30, counter-clockwise around a groove of the lefthand drum, and similarly back and forth a desired number of times between the two drums in figure 8 fashion. The wire W similarly passes around the two quenching drums 32 in figure 8 form, and is drawn off the righthand drum through the slot 36 at the lower righthand portion of the cover part 5.

The quenching drums 32, in the case of the patenting of steel wire W, are maintained at a temperature of 1000° F. In other words the wire W, heated to approximately 1750° F. in passing around the drums 30 in the heating chamber 11, is quenched to 1000° F. when passing around the drums 32 in the quenching chamber 12. As in the case of the heating drums 30, the taper of said quenching drums continues even though the wire W has been cooled to 1000° F. (or to whatever temperature the quenching drums are maintained at) prior to reaching the ends of said drums 32, but because the wrapping or looping of the wire W is done while the quenching drums are in heated condition, the wire W will, nevertheless, remain tight about said drums 32. Stated in another way, the wire W while being wrapped around the drums 32 heated to approximately 1000° F. when originally preparing the apparatus for operation, is heated from room temperature to approximately drum temperature, and therefore no looseness will develop nor will the wire jump from the grooves when the apparatus is set in actual operation with wire at 1700° F. coming into contact with the drums maintained at 1000° F. Furthermore, the relative speeds of drive shafts 15 and 16 are such that stretching of the wire W occurs when passing around drums 32.

It is to be understood that the foregoing references to actual temperatures are merely illustrative for the patenting of steel wire, and obviously the temperatures will be varied for annealing or other heat treatments of steel, copper, or other wire materials.

Surrounding the openings through which the upper drive shafts 15 extend into the heating chamber 11 are a pair of combination units 40 which provide a header 41 for burner gas mixture, a recuperator chamber 42 in heat exchange relation with the products of combustion from said burner gas, and annular exhaust duct 43 which removes the burned gases from within the drums 30 and which maintains a circulation of the heated non-oxidizing, neutral, or other atmosphere in the heating chamber 11.

Gas-air mixture is supplied to the header 41 as through the pipe 45 and connected to said header are four series of eight burner jets 46 which direct flames against the interior wall of the surrounding drum 30. The carrier

47 for said series of burner jets 46 is of refractory material and has a stainless steel casing 48 therearound.

The annular exhaust 43 is, as shown, disposed in communication with the open end of each drum 30, and there is further a small annular gap between the open end of each drum 30 and the opening in the main part 3 whereby upon connection of the exhaust 43 to a duct 49 (which leads to an exhaust fan 50) the burned gases will be withdrawn from within the respective drums 30, and gas will be drawn out of chamber 11 so as to maintain a flow of the desired atmosphere from pipe 51, through recuperator 42, and through pipe 52 into chamber 11 and also into chamber 12.

As shown, the gases exhausted from within said drums 30 and from the chamber 11 flow through the conduits 53, 54, and 55 to the intake of the aforesaid exhaust fan 50 which is driven as by the electric motor 56 and thence are discharged into a flue 57. In the conduit 53 is a butterfly or damper 58 which is preferably manually operated or adjusted to regulate the amount of atmospheric air bled in with the gases thus exhausted from within the drums 30 and from the heating chamber 11, and of course another damper 59 is provided to regulate the rate of flow of gas into the main line 54—55 which leads to the fan intake. The second mentioned dampers 59 are best shown in the schematic diagram, Fig. 7.

The recuperator 42 is in the form of a header which is in heat exchange relation with the annular exhaust 43 so that the nonoxidizing, neutral, or other atmosphere from a suitable converter 60 (see Fig. 7) is heated before being introduced into the heating chamber 11 through the pipe 52. The heated gas thus introduced into the heating chamber 11 is a protective atmosphere which prevents oxidation or other harmful effects on the highly heated wire W and drums 30.

As best shown in the schematic diagram, Fig. 7, the heating chamber 11 is provided with radiation pyrometers 65 which are directed at the end portions of the respective drums and are operatively connected with temperature controllers 67 which in turn operate relays 68 for the control units 69 of the gas valves 70. Air and burner gas are introduced into mixer 71, and from said mixer, the gas-air mixture passes through the gas valve 70 at a rate of flow as determined by the temperatures of the respective drums 30, each heating drum 30 being separately controlled through its associated pyrometer 65, temperature controller 67, relay 68, gas valve operator 69, and gas valve 70.

Also disposed in the heating chamber 11 is a static pressure controller 75 which controls an operator 76 for damper 77 to control the rate of flow of the protective atmosphere through said heating chamber 11, the damper 77 being located in the conduit 54—55 which leads to the intake of fan 50.

With reference to the combination units 79 which surround the drive shafts 16 adjacent the rear ends of the quenching drums 32, these too have headers (like 41) for supplying, through pipe 80, burner gas mixture for supplying two series of burner jets 46, exhaust annuli 43 arranged similarly to those in the heating chamber 11, including dampers 58 and 59 and a duct 81 connected to the main exhaust conduit 54—55 which leads to the intake of the exhaust fan 50. In addition, these combination units each have a header 82 for cooling air, which header communicates with four series of air jets 83 for directing the cooling air against the interior wall of the quenching drums 32, such cooling air being supplied to said header through the duct 84 which leads from a cooling air blower 85 and a damper 86 is provided in each cooling air duct 84 controlled by the unit 87, relay 88, temperature controller 89, and radiation pyrometer 90. In this case, the relays 88 operated by the temperature controllers 89 serve not only to regulate the dampers 86 in the cooling air supply ducts 84, but as well, the gas valve operators 69 and gas valves 70. The dampers 75

58 are automatically operated by the units 91 which are responsive to relays 88, and in this way atmospheric air bled into ducts 81 is cut off when there is demand for cooling air to reduce the temperature of quenching drums 32.

Also, as shown in the schematic diagram, Fig. 7, is the coolant water supply 95 for circulation of water through the interior of the drive shafts 15 and 16, there being an automatic water valve 96 which opens when the gas-air mixture controller 71 is started; and as the water is discharged from the shafts 15 and 16, the valve 97 is opened or closed according to the temperature as indicated by the water temperature control 98 in the discharge. There is also included in the water supply line 95, a pressure control valve 99 which prevents operation of the burners 46 unless there is sufficient water pressure to open said pressure control valve 99. This mechanism therefore assures that the apparatus can not be operated unless proper water supply for cooling the drive shafts 15 and 16 is available. A visual water drain 100 is provided.

Having thus described the structure of a preferred embodiment of the present invention, reference will now be made to the operation thereof. Following is an outline of the steps in the operation with special reference to the schematic diagram of Fig. 7.

(1) Before stringing up the apparatus with the wire W to be heat treated, it is usually brought up to operating temperature. The starting can be made responsive to a single control, but whether so started or by separate controls or switches is a matter of indifference. When separate controls are employed, these should be arranged so that the drum drive motor 24 is first energized before the air-gas mixture controller 71 is turned on to supply combustible mixture to the burner jets 46 through gas valves 70, said controller 71, as aforesaid, being coupled to the water pressure control valve 99 and the automatic water valve 96 so that water must flow through the drive shafts 15 and 16 before the burners 46 can be supplied with the air-gas mixture.

(2) The exhaust fan 50, cooling air blower 85, and protective atmosphere converter 60 are then energized, and appropriate adjustments are made in the manually operated dampers 58 and 59 and in the temperature controllers 67 and 89.

(3) During the warm-up period, the heating chamber control systems composed of elements 65, 67, 68, and 69 maintain the gas valves 70 in open position, and the quenching chamber control systems composed of elements 88, 89, and 90 maintain the gas valves 70 in open position through elements 69, maintain the dampers 58 in closed position through elements 91, and maintain the dampers 86 in the cooling air ducts 84 in open position through elements 87.

(4) After the apparatus has reached operating temperature, viz. 1750° F. in the heating chamber 11 and 1000° F. in the quenching chamber 12 for the patenting of steel wire, the actuating cylinder 8 is extended to raise the cover part 5 to the dotted line position of Fig. 2 whereupon wire W may now be looped (preferably in figure 8 form) a desired number of times around the heating drums 30 and thence similarly around the quenching drums 32 whereupon the cylinder 8 is contracted to swing the cover part 5 to closed position, the slots 34, 35, and 36 therein being open at the parting line between said cover part 5 and the main part 3.

(5) The wire W is then continuously pulled from the slot 36 of the quenching chamber 12 for coiling or subsequent drawing or other operations, and such travel of the wire W around the drums 30 and 32 in contact therewith effects continuous, uniform heat treatment of the wire, the wire being first heated to the temperature of drums 30 and then quenched to the temperature of drums 32.

As evident, two 32" diameter heating drums 30 and

two 32" diameter quenching drums 32, each provided with 72 grooves, can accommodate more than 1000 feet of wire W in contact with the drums in the heating and quenching chambers and therefore even at a lineal wire speed of 5000 ft./min., for example, which is greater than can be conveniently handled with existing reeling or drawing equipment, the wire W contacts the heating drums 30 and the quenching drums 32 for a period of 12 seconds, and of course the wire temperature is increased or decreased to drum temperature in a much shorter period of time, especially small size wire up to .150" diameter.

The stringing of the wire W around the tapered heating drums 30 and the oppositely tapered quenching drums 32 maintains, as aforesaid, the wire W in tight condition around the peripheral grooves of said drums to thus establish efficient heat exchange between the drums and the wire. The tapering of the drums also stretches the wire to some degree to improve its physical properties.

In tests conducted with 12" diameter drums heated to 1740° F. and 1000° F. respectively, for patenting steel wire of .043" diameter, the physical properties of the finished .0092" diameter wire were substantially identical at all lineal speeds of the wire between 100 and 720 ft./min. For example, with 25 wraps of the .043" diameter wire around the heating drums, there was approximately 174 feet of wire in the furnace and 118 feet of the wire in contact with the heating drums, and similarly for quenching there was 174 feet of wire in the quenching chamber and 118 feet of wire in contact around the quenching drums. Following is a chart of the tensile and torsion strengths of the .0092" diameter finished wire made from .043" diameter wire which was heat treated at the designated lineal speeds as appearing in the first column of the chart.

Feet/minute	Tensile Strength (p.s.i.)	Torsion (Revs. in 2")
103-----	381-382,000	95-98
174-----	379-381,000	100-101
270-----	378-381,000	90-96
260-----	381-382,000	95-100

Substantially identical results were obtained at lineal speeds several times greater than indicated in the chart above.

The present application is a continuation-in-part of my copending application Ser. No. 239,493 filed July 31, 1951, now abandoned.

Other modes of applying the principle of the invention may be employed, change being made as regards the details described, provided the features stated in the following claim, or the equivalent of such, be employed.

I therefore particularly point out and distinctly claim as my invention:

- 10 Apparatus for changing the temperature of a longitudinally travelling wire and the like, comprising a rotary drum with which the wire travels in heat exchange contact, and which is disposed so that when rotated successive longitudinal portions of the wire are thus
- 15 brought into contact with said drum, means inside said drum for maintaining the same at a prescribed temperature to which it is desired to change the temperature of the wire as it travels in contact with said drum, drive means effective to rotate said drum at a speed which
- 20 is not greater than that required to change the temperature of successive drum-contacting portions of the wire to such prescribed temperature, means forming a chamber about said drum, means for introducing a protective atmosphere for the wire and for the exterior of said
- 25 drum, such chamber having an opening through which said drum extends into the chamber and with which opening said drum defines an annular gap, and exhaust means in communication with such gap for maintaining circulation of such protective atmosphere through such
- 30 chamber and around the wire and drum therein.

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