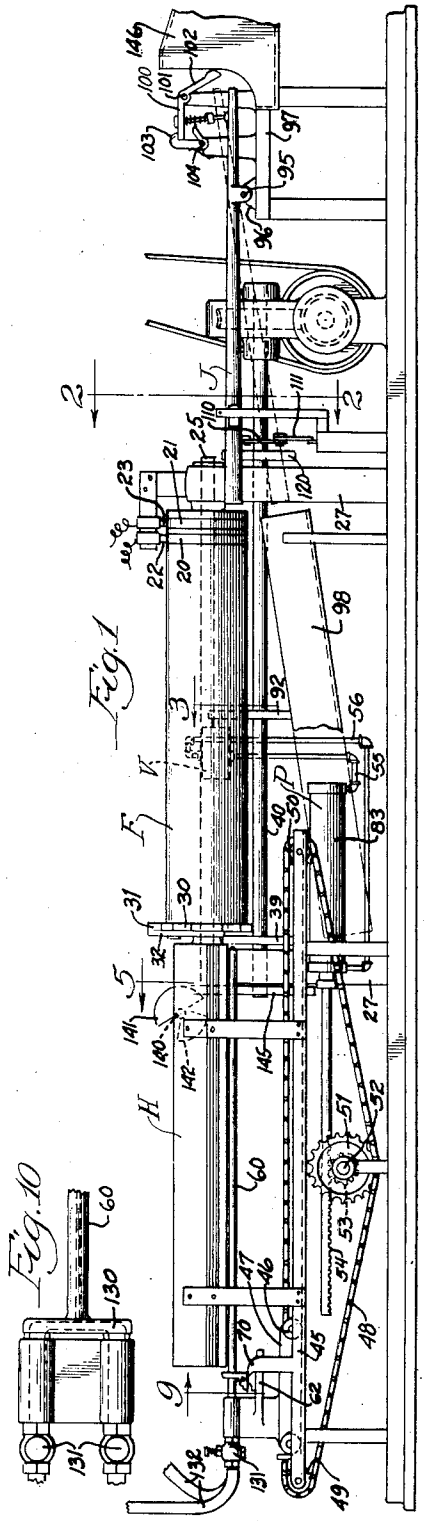
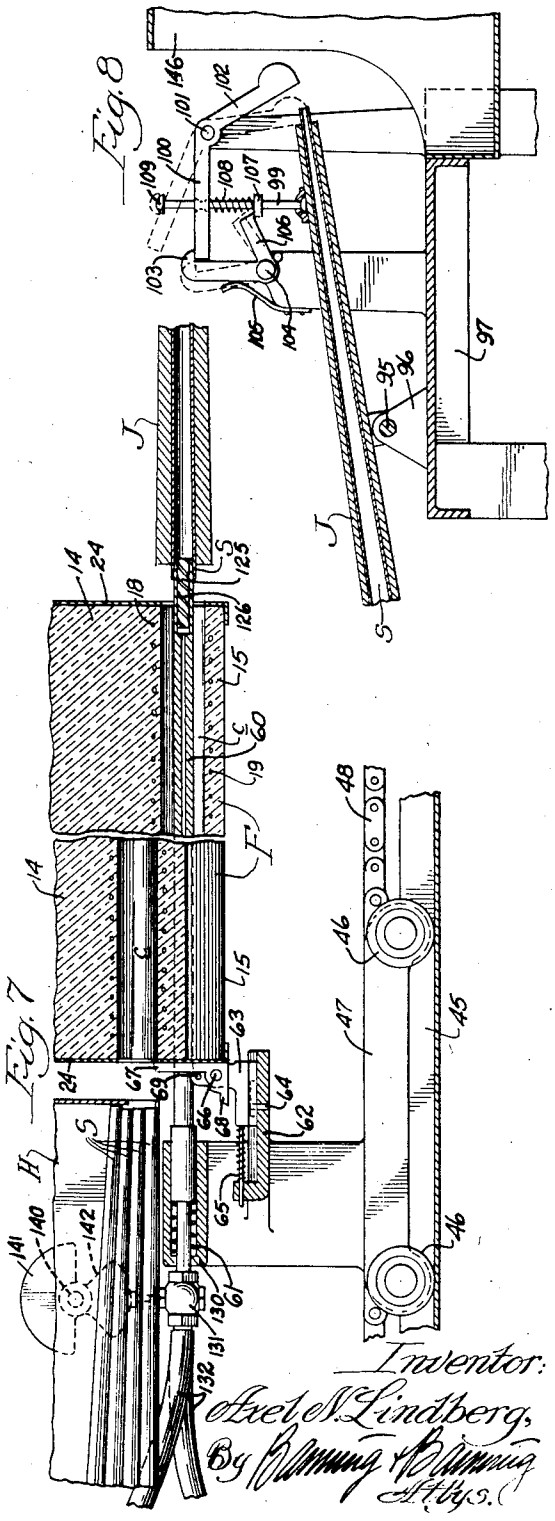
Dec. 11, 1934. A. N. LINDBERG 1,983,551

HEAT TREATING APPARATUS

Original Filed Dec. 19, 1932 3 Sheets-Sheet 1





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HEAT TREATING APPARATUS

Original Filed Dec. 19, 1932 3 Sheets-Sheet 2

Fig. 2

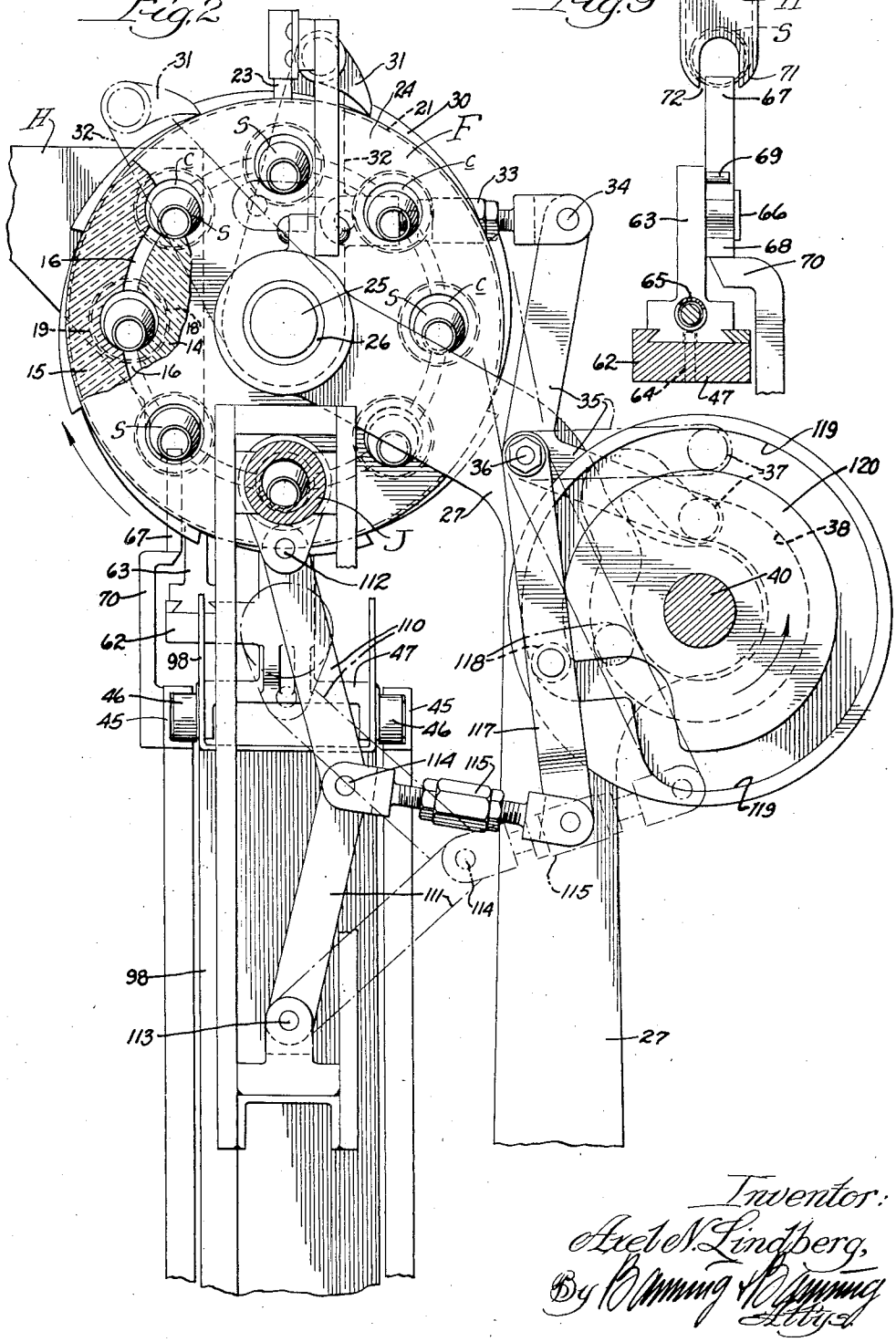


Fig. 9

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HEAT TREATING APPARATUS

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Fig. 3

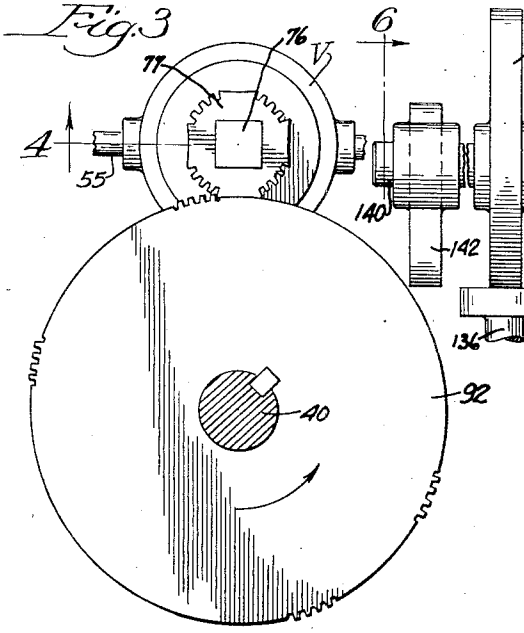


Fig. 5

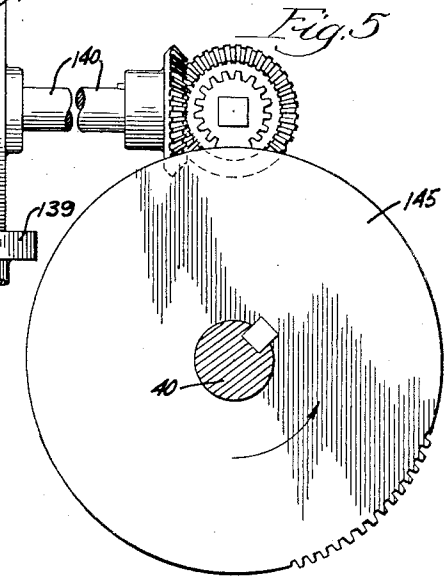


Fig. 4

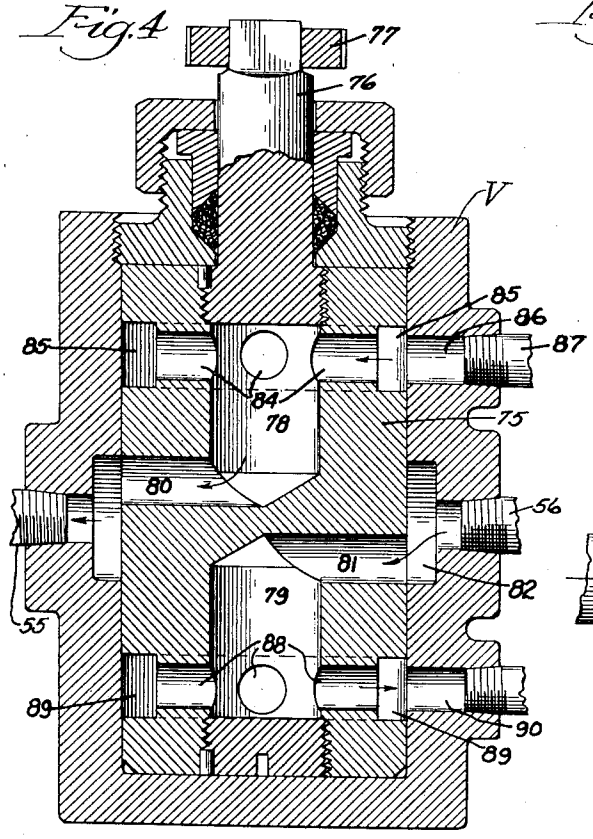
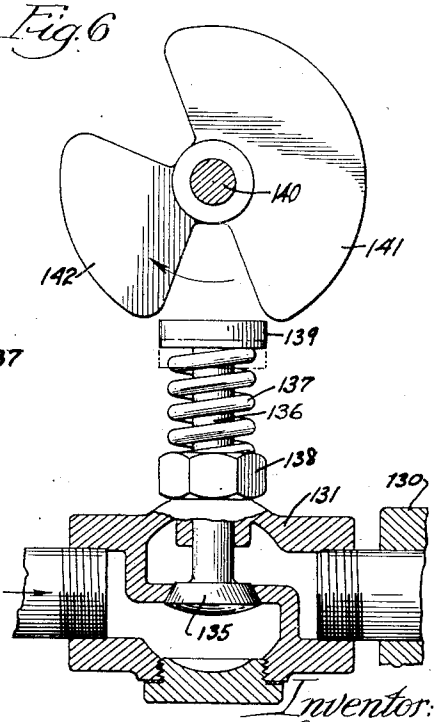


Fig. 6



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UNITED STATES PATENT OFFICE

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HEAT-TREATING APPARATUS

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Application December 19, 1932, Serial No. 647,938
Renewed February 28, 1934

22 Claims. (Cl. 266—4)

This invention relates to an apparatus which is designed particularly for the heat-treatment of tubular shafts and rods, such as are used for aeroplane struts, golf club shafts, fishing rods, and for various other purposes. More particularly, the present improvements have to do with certain co-related mechanisms by which a plurality of shafts are successively fed into a furnace for heat-treatment, are removed from the furnace and quenched immediately, and are then discharged into a chute or other receptacle, all these operations following one upon another automatically in timed relation without requiring special control or attention on the part of a human operator.

A heat-treating mechanism having the improved mechanisms as hereinafter disclosed is simple and susceptible of being operated with speed and certainty, and, in addition, assures a uniform heat-treatment and immediate succeeding quench at every point over the treated shaft.

A suggestive embodiment of this invention is illustrated in the accompanying drawings in the manner following:

Figure 1 is a side elevation of the combined charging and ejecting mechanism, the furnace, and the receiving jig, together with the kicker mechanism by which each shaft in turn is removed to a chute or other receptacle after being quenched;

Fig. 2 is an enlarged transverse section on line 2—2 of Fig. 1;

Fig. 3 is a detail in section on line 3 of Fig. 1;

Fig. 4 is a central longitudinal section through the valve control for the cylinder mechanism;

Fig. 5 is a section on line 5 of Fig. 1;

Fig. 6 is a detail in section on line 6 of Fig. 5;

Fig. 7 is a broken longitudinal section through the furnace and associated mechanism at opposite ends thereof;

Fig. 8 is a detail in longitudinal section through the shaft receiving jig and kicker mechanism associated therewith;

Fig. 9 is a detail in section on line 9 of Fig. 1; and

Fig. 10 is a detail in plan of the carriage body forming part of the ejector mechanism.

The several operating units of my improved apparatus will now be described in detail.

The furnace

The furnace F herein shown is in the form of a revolvable barrel formed with a series of chambers *c* open at both ends of the barrel. These chambers, of which eight may be a convenient number, are spaced equidistantly from the axis of the barrel and from each other, as, for example, 45°. The furnace may be constructed of inner and outer refractory units 14 and 15, respectively, (see Fig. 2) surrounded by a protecting jacket. These refractory units are desirably in spaced relation to provide passages 16 which interconnect the several chambers whereby to promote a uniform interchange of heat. Suitable heating coils 18 and 19 are provided within the inner and outer refractory units whereby to heat the chambers between them. Electrical connections extend from the heating coils to collector rings 20 and 21 arranged circumferentially of the barrel to receive contact from brushes 22 and 23, respectively, which are in connection with a source of electric current. From the ends of the barrel which are desirably reinforced by heads 24 are extended trunnion shafts 25 journaled in bearings 26 carried upon a framework 27 which may be rested upon a floor or other base.

Means are provided for imparting to the rotatable furnace an intermittent index movement. As suggestive of a mechanism for this purpose, the furnace barrel may be equipped with ratchet teeth 30 arranged circumferentially at one end thereof. In operative relation with the ratchet teeth is a pawl 31 carried at one end of an arm 32 which is pivoted to the proximate barrel trunnion. Extending from the arm is an adjustable link 33 pivotally joined at 34 to a bell crank lever 35 which is fulcrumed at 36. The power end of this lever is shown as equipped with a roller 37 which tracks in a cam groove 38 formed in a disk 39 mounted fast on a control shaft 40 to which power is transmitted from any suitable source. The shape of the cam groove is such that at a predetermined point a quick oscillating movement is imparted to the bell crank. The extent of the bell crank movement is sufficient to rotate the barrel through the distance separating adjacent chambers, i. e. 45° in the construction illustrated. Any suitable detent device (not shown) may be employed to arrest movement of the barrel when its rotation has continued through the intended distance.

The charging and ejecting mechanism

In parallelism with the axis of the furnace at the receiving end thereof is a track or guide 45 for wheels 46 supporting a carriage 47 which is movable toward and from the furnace. As shown, the operating means for the carriage consists of an endless chain 48 which is trained over idler

pulleys 49 and 50 at opposite ends of the track or guide, and over a driving pinion 51 which is made fast to a shaft 52 whereon is also carried a smaller pinion 53 in mesh with a rack bar 54 one end of which constitutes a piston rod forming part of a piston mechanism P. As by pipes 55 and 56 extending from opposite ends of the cylinder to a valve V, the operations of the piston mechanism are controlled in timed relation with the heating apparatus in its entirety in a manner to be later explained.

The carriage body supports one end of a hollow rod 60 which is aligned with one of the chambers in the furnace barrel—the lowermost chamber in the arrangement shown. This rod acts as an ejector to push out from the delivery end of the furnace the shaft S which is in the lowermost chamber, this operation taking place as the carriage is advanced toward the furnace. The ejector rod is rigidly mounted upon the carriage body so that its acting end is maintained in line with the furnace chamber through which it is to be advanced. If desired, the rod may be yieldingly supported to slide on the carriage through the use of a coil spring 61 which normally projects the rod to a forward position (see Fig. 7).

Slidably carried by a shelf 62 which extends forwardly from the carriage body is a bracket 63 normally advanced against a stop 64 as by means of a spring 65. This bracket pivotally supports at 66 a lever in the form of a bell crank having an upstanding finger 67 and a base 68. In the position shown, the finger is rested against a stop 69 which sustains the finger against swinging rearwardly beyond the vertical. When the carriage is in its retracted position, as shown in Fig. 1, a stationary cam 70 engages with the base of the bell crank lever to restore the finger to upright position following its forward swinging movement which takes place during each return of the carriage to starting position.

The finger is located at one side of the ejector rod in line with the next chamber to the left, as indicated in Fig. 2, so as to be engageable with the end of a shaft S that is to be introduced into that chamber. A supply of such shafts may be contained in a hopper H whose bottom terminates in a well 71 forming a support for a single shaft, or a pluarlity of shafts in vertical alignment. The bottom wall of the well is slotted centrally at 72 for the length of the hopper, but the width of this slot is insufficient to release therethrough any of the shafts that are contained in the hopper. The finger, when moved to vertical position at a point rearwardly of the hopper, (see Fig. 1) is aligned with the well so as to move through the slot when the carriage is advanced (see Fig. 9), thereby engaging the proximate end of the lowermost shaft contained in the well to advance the same into the aligned chamber c of the furnace. Having advanced to its limit, as shown in Fig. 7, the moved shaft is deposited within the furnace so as to be wholly contained therein for heat treatment over a predetermined time interval. At the moment that the carriage reaches its extreme forward position, as shown in Fig. 7, it is possible for the bracket whereon the finger is supported to slide back slightly, as required, in order that the parts may be mutually accommodated in this relationship. On the return movement of the carriage, the finger will swing forwardly upon engaging with the forward end of the next succeeding shaft which drops into lowermost position within the well, and the finger is accordingly free to slide along under the hopper without interference. Upon reaching its opposite extreme position shown in Fig. 1, the finger is again restored to vertical position by the cam 70 so as to be positioned for engagement with the shaft next to be charged into the furnace. It is to be noted that the operation of charging the furnace with a fresh shaft proceeds simultaneously with ejection of a heated shaft, both being accomplished by movements of one and the same carriage whereon are mounted the respective devices for these purposes.

The carriage is operated by mechanism P which is controlled by a valve V, such, for example, as is indicated in Fig. 4. Here I have shown a housing containing a plug 75 having an operating stem 76 upon which is carried a mutilated pinion 77. The plug is provided with two separated axial chambers 78 and 79. From the chamber 78 leads a radial port 80 and from the chamber 79 is extended a radial port 81, each port being opposite an opening 82 when the plug is rotated to the position shown in Fig. 4. Connected to one of these openings is the pipe 55 leading to one end of the cylinder 83 and to the other opening is connected the pipe 56 leading to the opposite end of the cylinder (see Fig. 1). From the chamber 78 other ports 84 communicate with an annular passage 85 extending around the plug opposite an opening 86 to which is connected a pipe 87 leading to a source of fluid under pressure. Likewise a series of ports 88 extends radially from the chamber 79 to communicate with an annular passageway 89 which is opposite a second opening 90 with which connects a pipe 91 through which fluid is exhausted from the valve. The arrangement of the ports is such that successive intermittent movements of the valve plug will open communication for fluid under pressure to pass into the cylinder 83 first at one end and then at the other to reciprocate the rack bar 54 and with it the carriage 47.

Operation of the valve is controlled by a mutilated gear 92 carried upon the control shaft 40. This gear is in mesh with the mutilated pinion 77, and the interrupted arrangement of the teeth on these meshing elements is such that the valve will be rotated through 90 degrees with intermissions correctly timed for (1) advance of the carriage, (2) pause at the end of its forward movement, (3) return movement of the carriage, and (4) pause before repetition of this cycle.

The jig mechanism

At the delivery end of the furnace, and in line with the lowermost chamber from which a heated shaft is ejected by the rod 60, a jig J is positioned. This jig is constructed to provide a seat for the shaft; and, for a tapered shaft, such as is illustrated in the drawings, the seat is desirably similarly tapered. The final position of the shaft within the jig may accordingly be determined by the fit of the shaft within its seat. The jig may also be slightly shorter than the shaft, so that the smaller end of the latter will project slightly beyond the proximate end of the jig in a position to receive thrust from a kicker mechanism which will presently be described. The opposite shaft end may, if desired, remain protruded slightly beyond the proximate end of the jig, as shown in Fig. 7. When so related, it is possible to treat a shaft having a flare or bell at its larger end, this being a formation which commonly results from the drawing operations resorted to in producing the shaft.

In the construction shown, the jig is pivotally mounted at 95 upon a bracket 96 upstanding from a table or support 97. This pivotal support for the jig is located somewhere between its two ends, so that swinging movement of the jig from the horizontal will cause the receiving end of the jig to drop below the proximate end of the furnace barrel while its opposite end is raised sufficiently to position the proximate protruding end of the shaft in operative relation to the kicker mechanism. When so tilted, as indicated in Figs. 1 and 8, the larger end of the jig lies opposite a chute 98 into which the several shafts, as discharged successively from the jig, are received. With each tilting movement of the jig, an upward thrust is exerted upon a stem 99 which is extended loosely through the horizontal arm 100 of a bell crank lever having a pivotal mounting at 101, the lever being formed with a depending arm 102 the free end of which is utilized as a kicker for striking the proximate protruding end of the shaft within the jig. So that the bell crank lever may function properly for this purpose, I provide a catch 103 engageable with the free end of the lever arm 100. The catch which is pivoted at 104 is normally held in engaging position by a spring 105. Extending from the catch is an arm 106 adapted to be engaged by a collar 107, which is fixed on the stem 99. A spring 108 encircling the stem is compressed between the collar and the horizontal arm of the lever beyond which is a stop-head 109 at the stem end. In the inactive position shown in Fig. 1 the spring is expanded to hold the lever arm against the catch, the striking end of the lever being thereby maintained away from the jig. With tilting movement of the jig, however, its rearward end is elevated to compress the spring as the collar 107 is raised. With completion of this movement, the collar engages the arm 106 to trip the trigger, thereby releasing the kicker lever which, in response to tension force of the spring, is operated to kick the proximate end of the shaft and so remove it from the jig into the chute. In this manner, the jig is cleared for the reception of the next succeeding shaft which is advanced thereinto from the furnace.

According to the construction disclosed, the kicker mechanism is actuated and operated through movements of the jig alone. From the control shaft are extended connections timed to operate with each index movement of the furnace barrel, by which to tilt the jig in the manner explained. As a convenient mechanism for this purpose, I have shown in Fig. 2 a pair of links 110, 111, one pivoted to the jig at 112 near its receiving end, and the other pivoted at 113 to a fixed support, the two links being interconnected at 114 to provide a toggle joint. As by an adjustable link connection 115, the toggle is joined at 116 with a link 117 having a pivotal mounting at 36. Intermediately of its ends, the link 117 may be provided with a roller 118 which tracks in a cam groove 119 in a disk 120 carried fast on the control shaft 40. The form and arrangement of this cam is such that at a given point in the rotation of the control shaft, timed to follow after delivery into the jig of a shaft from the furnace, the jig will be swung down, whereby its receiving end is disposed below the furnace; at this juncture the kicker is actuated to eject the shaft from the jig into the chute as already explained.

The quenching mechanism

The mechanisms thus far described provide for the successive charging of shafts into the furnace and simultaneously for the removal of other shafts from the furnace; for the delivery into the jig of each shaft so discharged from the furnace; for the repositioning of the jig shortly after the shaft is received therein; for the ejection from the jig of the received shaft promptly upon repositioning of the jig; for the return movement of the carriage together with its shaft charging and ejecting mechanism, and also of the jig; and for an index movement of the furnace about its own axis following this cycle of operations. These several movements are timed to follow closely one upon another. It remains now to describe the quenching mechanism by which the heat-treated shafts are quickly cooled in a uniform manner with a minimum of delay following their discharge from the furnace.

The ejector rod 60 is provided at its acting end with a nozzle having a plug 125 about which are formed spiral grooves 126 through which a stream of quenching fluid is forced as and when discharged from the nozzle. The shape of the nozzle is such as to interfit with the proximate end of the shaft which, as shown in Fig. 7, remains desirably protruded for a slight distance from the jig. The nozzle remains fitted to the shaft up to the point that movement of the latter is arrested by its seating firmly within the jig, and thereupon this interfit becomes even more close, due to the forward projection of the rod by the spring 61 when the carriage is advanced to its limit. At the rearward end of the rod is a T-head 130 providing two passages in communication with the main passage through the rod. Each branch passage is valve-controlled at 131, and is connected as by flexible tubing 132, one with a source of quenching fluid under pressure, and the other with a source of air under pressure.

Referring now to Fig. 6, I have here shown one of the valves 131 which may be of conventional type, in that it comprises a plug 135 carried at one end of a stem 136 around which is a coiled spring 137 exerting opposite thrusts against a packing gland 138 and a head 139 which is carried at the end of the stem. In the extreme forward position of the carriage these two valves are brought into adjacent relation with a shaft 140 having two cams 141 and 142. One of these cams is in operative relation to the head 139 of the stem of one valve, and the other cam is similarly related to the other companion valve. The cam shaft is suitably connected in driven relation to a mutilated gear 145 mounted on the control shaft 40. The interruptions in the teeth of the mutilated gear are so arranged that the cam shaft is rotated through 360° for a brief period at a proper point in the cycle of operations, viz., when the carriage is advanced to the limit of its forward movement. The timing of the cam shaft operation may be otherwise arranged, however, depending upon the exact point in the cycle when it is desired that the two valves 131 should be operated. In the construction shown, the cam 141 opens the valve controlling the discharge of quenching fluid immediately upon the completion of the forward movement of the carriage, and this coincides with the final seating in the jig of the heated shaft which is to be quenched. The valve remains open as rotation of the cam continues for a brief interval of time which is determined by the length of the cam surface in relation to its speed of rotation. Thereafter, immediately, or with such pause as is desired, the remaining cam 142 operates the com-

panion valve to release air under pressure. This discharge of air through the same rod which delivers the quenching fluid to the shaft effectively blows out from the rod and shaft any quenching fluid remaining therein. The fluid so forced out from the shaft is caught in a hood 146 for return to the supply source.

At this point it is to be noted that the quench is applied to the shaft immediately upon its removal from the furnace. The movement of the carriage is preferably timed for speedy operation, so that the time interval required for shaft movement into the jig is very short. The application of the quench may start even while the shaft is being moved into the jig, but preferably is timed to take place immediately upon the shaft coming to rest therewithin. Accordingly, there is no delay, and only a minimum of drop in temperature, from the moment that the shaft starts from the furnace until the quench is applied. The form of the quench is also such that the entire shaft surface, both circumferentially and from end to end, is subjected to the cooling influence at practically one and the same moment. This is accomplished by discharging the quench in the form of a whirling stream which is projected from the nozzle with sufficient force to strike the inner surface of the shaft at every point from end to end at one and the same moment, or substantially so. As the walls of the shaft are relatively thin, it is unnecessary that the quench be continued for more than a very brief period, and the air which follows immediately upon termination of the quench cleans out the shaft so as to prepare the shaft for prompt removal from the jig in the manner already explained. This operation by which the shaft is kicked out from the jig, follows immediately upon the quench, and proceeds during return movement of the carriage, so that there is no loss of time. The restoration of the jig to receiving position follows immediately upon ejection of the treated shaft, and during index movement of the furnace to its next position.

Operation

The capacity of the present apparatus is necessarily governed somewhat by the time required for heat-treatment of the shafts. By the apparatus disclosed, it is possible to so time the operations that the several shafts per minute may be introduced into the furnace, be ejected therefrom and be quenched, and finally be removed from the receiving jig. As the control shaft is the medium by which the operations of the several mechanisms are governed, the connections therefrom need only be arranged and adjusted for proper timing in order that the mechanism in its entirety may function smoothly, continuously and efficiently. In the heat-treating of shafts these are important considerations because the quench should desirably follow immediately upon removal of the shaft from the furnace, otherwise an inferior product will result. The several units which have been incorporated into the apparatus hereinbefore described may accordingly be constructed to operate in conjunction with each other by suitable mechanisms of which a suggestive embodiment has been indicated, but obviously numerous changes in details of construction and arrangement of parts may be made as found desirable, without departing from the principles of this invention, as defined by the claims following.

I claim:

1. In a heat-treating apparatus, the combination of a furnace open at both ends adapted to receive therein a shaft, a jig for receiving the shaft disposed opposite the opening at one end of the furnace, and a combined ejector-nozzle movable through the opening at the opposite furnace end for pushing the shaft into the jig and there applying a quench to the shaft.

2. In a heat-treating apparatus, the combination of a furnace open at both ends adapted to receive a shaft, a jig opposite the opening at one end of the furnace for receiving the shaft which is advanced thereinto from the furnace, an ejector-nozzle fitted to the shaft end adjacent the opposite end of the furnace for removing the shaft therefrom into the jig, and valved connections from the ejector-nozzle to (1) a source of quenching fluid under pressure and (2) a source of air under pressure permitting selectively passage of quenching fluid and/or air through the ejector-nozzle to the shaft.

3. In a heat-treating apparatus, the combination of a furnace open at both ends for the reception of a shaft, a jig opposite the opening at one end of the furnace for receiving the shaft when moved thereinto, an ejector-nozzle at the opposite end of the furnace movable thereinto to displace the shaft therefrom, means for guiding the ejector-nozzle in a line coincident with its own axis, means for limiting the advance of the ejector-nozzle to a point at which the shaft is seated in the jig, and means for delivering a quenching fluid through the ejector-nozzle and over the surface of the shaft while seated within the jig.

4. In a heat-treating apparatus, the combination of a furnace open at both ends for the reception of a shaft, an ejector movable through the furnace from one end thereof to eject the shaft from the opposite furnace end, a jig opposite the delivery end of the furnace adapted to receive the shaft ejected therefrom, and means for discharging the shaft from the jig.

5. In a heat-treating apparatus, the combination of a furnace open at opposite ends for the reception of a shaft, an ejector movable through one end opening of the furnace for ejecting the shaft from the opposite end thereof, a jig at the delivery end of the furnace for receiving the shaft ejected therefrom, means for discharging the shaft from the jig, and coordinated operating mechanisms for the ejector and jig.

6. In a heat-treating apparatus, the combination of a furnace having opposite end openings through which a shaft is movable, a combined charger and ejector at one end of the furnace adapted simultaneously to introduce a new shaft thereinto and to remove a heated shaft therefrom, and a jig at the delivery end of the furnace positioned to receive the heated shaft ejected therefrom.

7. In a heat-treating apparatus, the combination of a furnace having opposite end openings through which a shaft may pass, a combined charger and ejector at one end of the furnace for simultaneously introducing a new shaft thereinto and for removing a heated shaft therefrom, a jig at the delivery end of the furnace for receiving therein the heated shaft removed from the furnace, and a kicker mechanism associated with the jig for removing therefrom the shaft after being cooled therein.

8. In a heat-treating apparatus, the combination of a furnace having opposite end openings through which a shaft may be passed, a combined charger and ejector-nozzle at one end of the

furnace adapted simultaneously to feed thereinto a new shaft and remove therefrom a heated shaft, a jig at the opposite end of the furnace for receiving therefrom the heated shaft, and means for applying to the shaft while in the jig a stream of quenching fluid delivered through the ejector-nozzle while still advanced through the furnace.

9. In a heat-treating apparatus, the combination of a furnace having opposite end openings through which a shaft may be passed, a combined charger and ejector nozzle at one end of the furnace for simultaneously feeding thereinto a new shaft and ejecting therefrom a heated shaft, a jig at the opposite end of the furnace for receiving therefrom the heated shaft, a connection from the ejector-nozzle to a source of quenching fluid under pressure, and means operable with advance of the ejector-nozzle to a pre-determined point for releasing the quenching fluid for discharge through the nozzle upon the surface of the shaft.

10. In a heat-treating apparatus, the combination of a furnace having opposite end openings through which a shaft may be passed, a combined charger and ejector-nozzle at one end of the furnace for simultaneously feeding thereinto a new shaft and ejecting therefrom a heated shaft, a jig at the opposite furnace end for receiving therefrom the heated shaft, connections from the ejector-nozzle to a source of quenching fluid under pressure and to a source of air under pressure, and means operable upon advance of the ejector-nozzle through a pre-determined distance for releasing, first, quenching fluid through the nozzle for delivery upon the walls of the shaft, and, second, air through the nozzle for cleansing the quenching fluid therefrom and from the shaft.

11. In a heat-treating apparatus, the combination of a furnace having openings at opposite ends through which a shaft may be passed, a jig at one end of the furnace adapted to receive a shaft which is ejected therefrom, means movable through the opposite end of the furnace for moving the shaft therein into the jig, means for applying a quench to the heated shaft contained within the jig, and means for discharging the quenched shaft from the jig.

12. In a heat-treating mechanism, the combination of a furnace having openings at opposite ends through which a shaft may be passed, a jig mounted at one end of the furnace adapted to receive a shaft which is ejected therefrom, means movable through the opposite end of the furnace for moving the shaft therein, means for shifting the jig from shaft receiving position, means for quenching the shaft while retained within the jig, and means for discharging the shaft from the jig following its shifting movement from shaft receiving position.

13. In a heat-treating apparatus, the combination of a furnace having openings at opposite ends through which a shaft may be passed, means movable through the opening at one end of the furnace for ejecting therefrom a heated shaft, a jig at the opposite furnace end for receiving the shaft so displaced from the furnace, means for applying a quench to the shaft while retained within the jig, and means for discharging the quenched shaft from the jig.

14. In a heat-treating apparatus, the combination of a furnace having an opening through which a shaft may be passed, a jig opposite the opening adapted to receive therefrom a heated shaft, an ejector engageable with the shaft for moving the same from the furnace into the jig, a connection from the ejector to a source of quenching fluid under pressure, and valved means operable at a pre-determined point during advance of the ejector for releasing quenching fluid therethrough whereby to discharge the same upon the shaft.

15. In a heat-treating apparatus, the combination with a furnace and a juxtaposed jig of means for transferring a heated shaft from the furnace into the jig, and means for releasing a quench upon the shaft coincidentally with arrest of shaft movement within the jig.

16. In a heat-treating apparatus, the combination of a rotatable barrel furnace having a plurality of equally spaced chambers extending from end to end of the furnace, an ejector at one end of the furnace movable through one chamber thereof, a jig at the opposite furnace end in line with the ejector adapted to receive a heated shaft displaced from the furnace by the charger, and means for quenching the shaft while retained within the jig.

17. In a heat-treating apparatus, the combination of a rotatable barrel furnace having a plurality of chambers extending from end to end of the furnace, an ejector at one end of the furnace movable through one of the chambers thereof to displace a shaft therefrom, a jig at the opposite furnace end in line with the ejector for receiving the ejected shaft, and co-ordinated mechanism for operating the ejector for discharging the shaft from the jig, and for thereafter imparting to the furnace an index movement.

18. In a heat-treating apparatus, the combination of a rotatable barrel furnace having a plurality of chambers extending longitudinally therethrough, an ejector at one end of the furnace movable through a chamber thereof, a jig at the opposite furnace end, in line with the chamber through which the ejector is moved, adapted to receive a shaft displaced from the furnace by the ejector, means for applying a quench to the shaft while retained in the jig, and co-ordinated operating mechanism for advancing the ejector through the furnace, for releasing the quench upon the shaft, for discharging the shaft from the jig, for withdrawing the ejector, and for imparting to the furnace an index movement.

19. In a heat-treating apparatus, the combination of a rotatable barrel furnace having chambers extended therethrough from end to end, an ejector-nozzle at one end of the furnace having means by which it is moved through a chamber thereof to dislodge therefrom a heated shaft contained therein, a jig at the opposite furnace end, in line with the furnace chamber from which the shaft is removed, adapted to receive the shaft, means for releasing through the ejector-nozzle a stream of quenching fluid for delivery upon the shaft while retained within the jig, means for discharging the quenched shaft from the jig, and co-ordinated mechanisms for operating the several means aforementioned.

20. In a heat-treating apparatus, the combination of a rotatable barrel furnace having a plurality of chambers extended therethrough from end to end, a carriage at one end of the furnace mounting a charger and an ejector-nozzle adapted for movement through two of the chambers in the furnace, a jig at the opposite end of the furnace in line with the chamber

through which the ejector-nozzle is moved, and co-ordinated mechanisms for advancing the carriage whereby simultaneously to introduce a new shaft into one chamber of the furnace and to remove a heated shaft from another chamber thereof into the jig, for withdrawing the carriage together with the charger and ejector-nozzle, and for thereafter imparting to the furnace an index movement.

21. The method of heat-treating a tubular shaft which consists in first heating the shaft in a furnace, in then removing the shaft from the furnace by thrust from an ejector-nozzle fitted to one end of the shaft, and, finally, in releasing through the ejector-nozzle while still fitted to the shaft a stream of quenching fluid for delivery lengthwise along the shaft surface.

22. The method of heat-treating a tubular shaft which consists in first heating the shaft in a furnace, in then removing the shaft from the furnace by thrust from an ejector-nozzle fitted to one end of the shaft, in releasing through the ejector-nozzle while still fitted to the shaft a stream of quenching fluid for delivery lengthwise along the shaft surface interiorly thereof, and, finally, upon shutting off of the quenching fluid, releasing through the ejector-nozzle a blast of air to remove any remaining quenching fluid from the shaft.

AXEL N. LINDBERG.