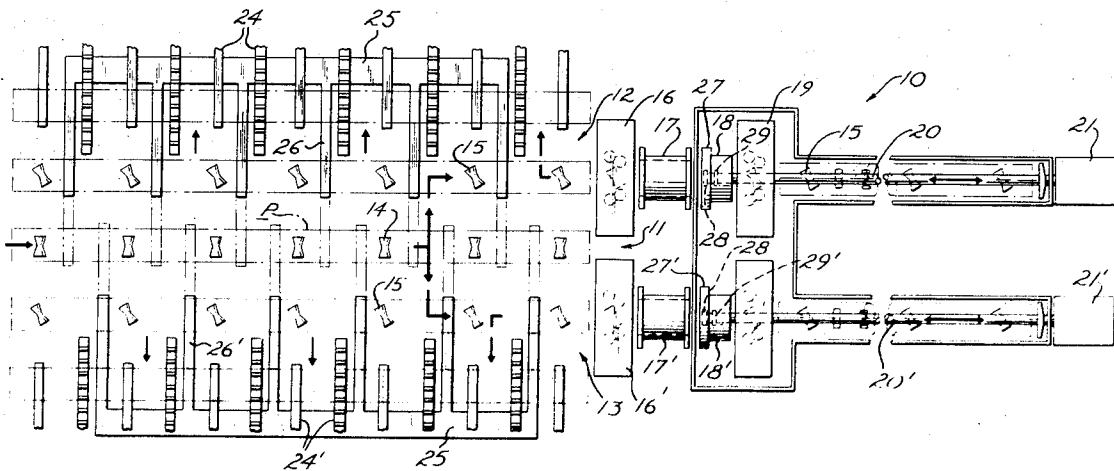


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9 Claims, 10 Drawing Figures



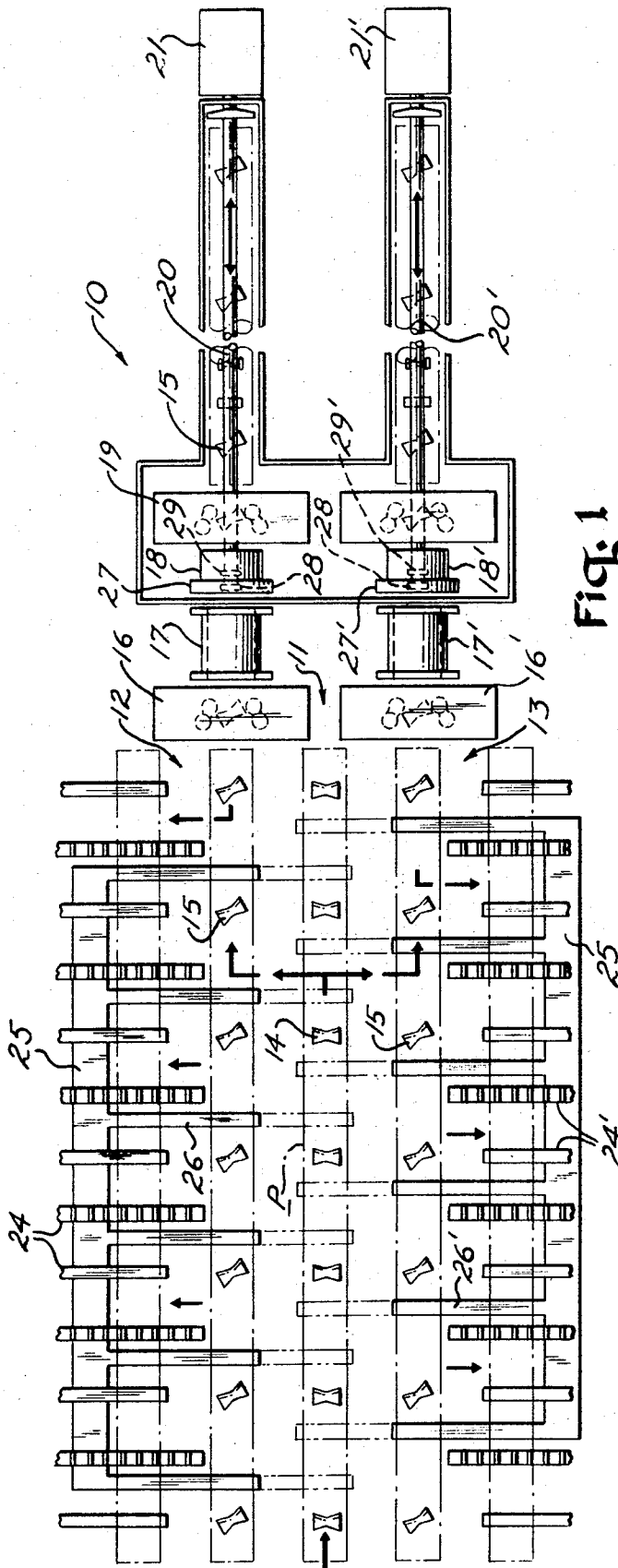


Fig. 1

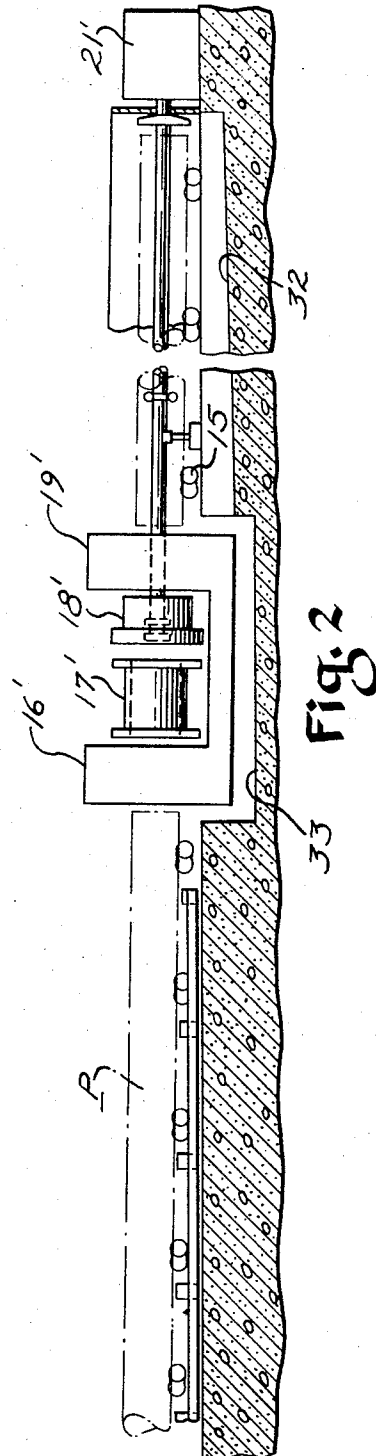
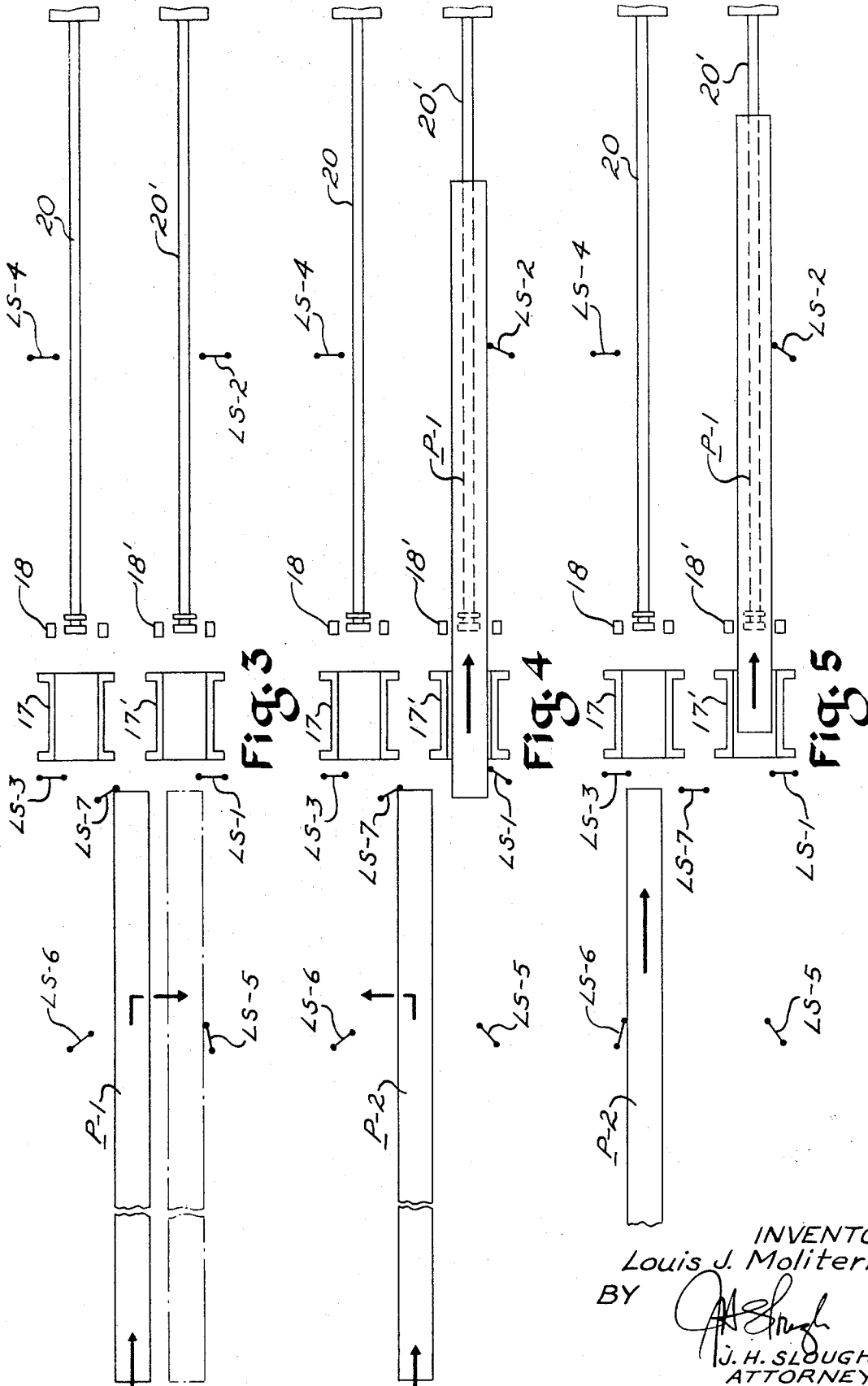


Fig. 2

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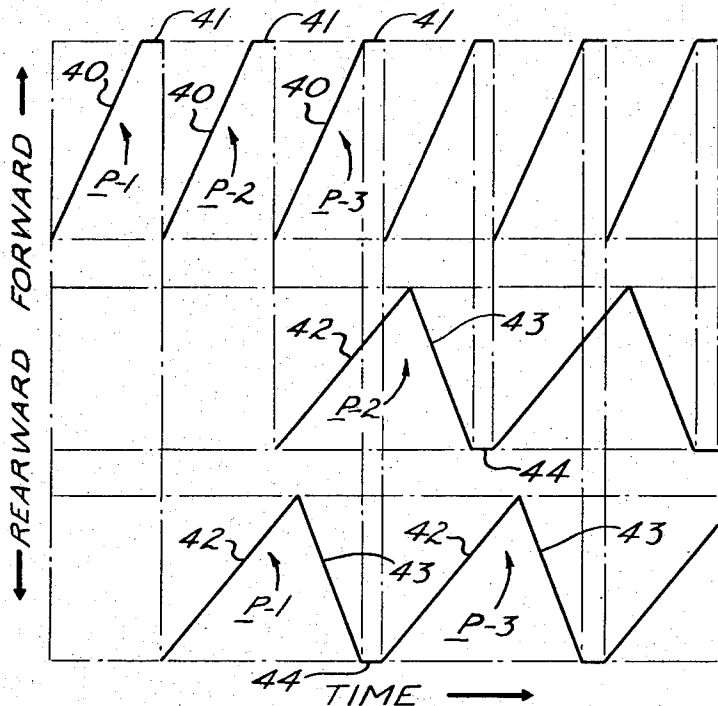


Fig. 9

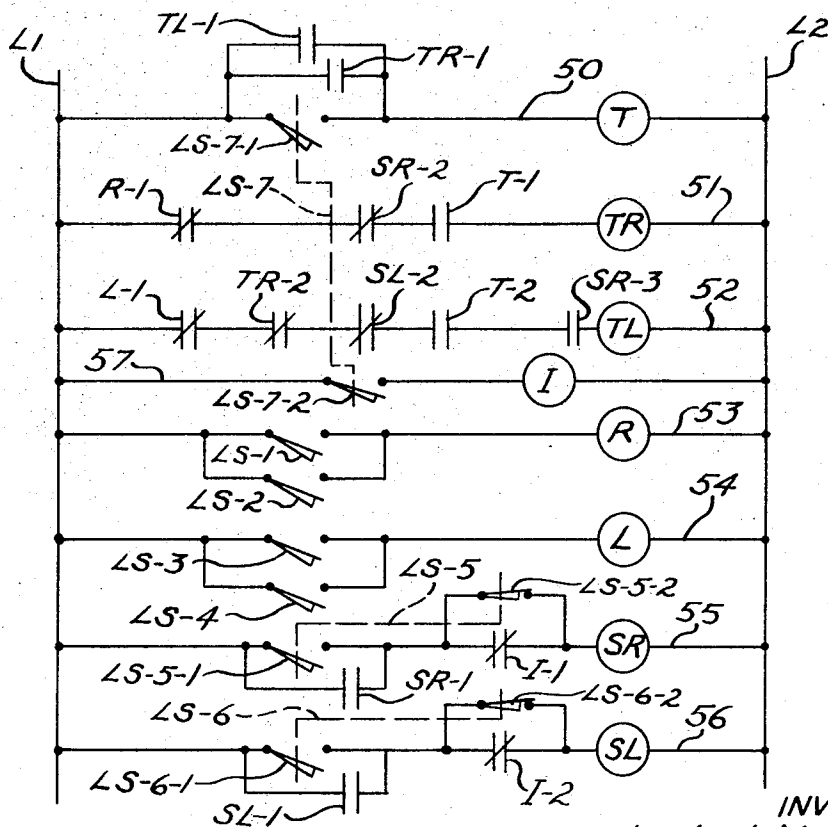


Fig. 10

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TANDEM SCAN HARDENING OF PIPE

This invention relates to the scan hardening and tempering of large diameter steel pipe by means of a solenoid type induction coil through which the pipe is conveyed in the axial direction.

More particularly the invention is directed to a tandem method and apparatus for induction scan heating, quenching, and tempering of large diameter pipe in one of two side-by-side, parallel combinations of induction coil and quench means fed alternately by a common conveyor. Each pipe is conveyed through one coil and quench means in one direction at a given speed calculated to heat the pipe to quenching temperature and cool the same at a rapid rate. The pipe is then moved in the reverse direction back through the coil at an increased speed whereby the pipe is tempered. By large diameter pipe is meant pipe having a diameter substantially in the range of 24 inches to 100 inches and a wall thickness substantially in the range of three-eighths inch to 1 inch.

The general object of this invention is to provide pipe hardening and tempering means of the above type wherein maximum production rate is achieved when the same induction coils are used to both harden and temper the pipe.

Another object of the invention is to provide pipe hardening and tempering means wherein space requirements are minimized.

A further object of the invention is to provide pipe hardening and tempering means comprising means concurrently treating a succession of pipes in two overlapping cycles fed by a common supply conveyor line.

Still another object of the invention is to provide a method for hardening and tempering large diameter steel pipe with the maximum efficiency and economy.

Other objects of the invention and the invention itself will be apparent from the following description of the invention as shown in the accompanying drawings, in which said drawings:

FIG. 1 is a simplified top plan view of the pipe hardening and tempering apparatus of this invention having two parallel induction coils supplied by a common conveyor;

FIG. 2 is a side elevation of the apparatus of FIG. 1;

FIGS. 3-8 are semidiagrammatic top plan views showing in sequential steps the overlapping hardening and tempering cycles of the two parallel heating lines;

FIG. 9 is a diagrammatic view showing the time relationship between the supply cycle and the hardening and tempering cycles of the two heating lines; and

FIG. 10 is a wiring diagram of a simplified automatic control means for cycling pipe through said apparatus.

Referring now to the drawings in all of which like parts are designated by like reference numerals, the pipe hardening apparatus of this invention is generally indicated by the numeral 10 and comprises a central supply conveyor line 11, flanked on either side by pipe hardening lines 12 and 13. The supply conveyor line 11 comprises suitable power driven conveyor rolls 14 for conveying a pipe P in the right-hand or forward direction to the position shown in broken lines at the supply conveyor line in FIG. 1. The pipe hardening lines 12 and 13 also comprise suitable reversible, power driven conveyor rolls 15 which, as illustrated in FIG. 1, may be skewed or angled to cause rotation of the pipe if desired.

The pipe hardening line 12 extends to the right or forwardly of the supply conveyor line 11 and comprises, in sequence, a pipe restraining roll stand 16, an induction coil 17, a spray quench 18, a second pipe restraining roll stand 19, a quench liquid supply conduit 20, and quench pumps 21. The pipe hardening line 13 is identical to the line 12 comprising, in sequence, a pipe restraining roll stand 16', an induction coil 17', a spray quench 18', a second pipe restraining roll stand 19', a quench liquid supply conduit 20', and quench pumps 21'.

At the left end portion of the pipe hardening line 12 opposite the supply conveyor line 11, there is provided a discharge ramp 24 and a transfer unit 25 having inwardly projecting arms 26. The transfer unit 25 is movable laterally with respect to the supply conveyor line 11 and pipe hardening lines 12 and 13 whereby it is adapted to simultaneously move a pipe P from said supply line to the pipe hardening line 12 and another pipe from said pipe hardening line 12 to the discharge ramp 24. In a similar manner, the pipe hardening line 13 is provided with a discharge ramp 24' and a transfer unit 25' having inwardly projecting arms 26'. Thus, means are provided for transferring a pipe P laterally outwardly in either direction from the supply conveyor line 11 to a pipe hardening line 12 or 13 or from one of said pipe hardening lines to a discharge ramp 24 or 24', respectively.

The movements of the pipe P at each pipe hardening line 12 and 13 are identical in speed and duration. The rolls 15 are power driven whereby the pipe at a pipe hardening line can be moved to the right or forwardly into the pipe restraining roll stand 16 or 16'. The pipe restraining roll stands 16, 16' and 19, 19' are identical, all being provided with a plurality of rolls 15 arranged circumferentially around the pipe and exerting inward pressure thereagainst to hold the roundness thereof. A pipe P leaving the restraining roll stand 16 or 16' enters the induction coil 17 or 17' which scans the pipe raising the same to quenching temperature. Quickly thereafter, the heated pipe enters the spray quench 18 or 18' where it is rapidly cooled just prior to entering the second restraining roll stand 19 or 19'. The pipe P is moved all the way to the right-hand position, shown in broken lines in FIG. 1, at a predetermined speed calculated to bring the pipe to quenching temperature in the induction coil. The rolls 15 are then rotated in the opposite direction whereby the pipe P is moved back or rearwardly through the restraining roll stand 19 or 19' through the quench 18 or 18' (which at this time is not operating), through the induction coil 17 or 17' and rearwardly just beyond the restraining roll stand 16 or 16'. The speed with which the pipe is moved in the rearward direction from right to left is substantially greater than the forward movement from left to right whereby the pipe is not again heated to quenching temperature but merely to a tempering temperature.

For very thick walled pipe, the spray quench 18 or 18' includes both an external quenching ring 27 and an internal quenching head 28, the latter being fed by the quench liquid supply conduit 20 or 20'. Rearwardly of the quenching head 28 or 28' there is preferably provided an air blast ring 29 or 29' which subjects the internal diameter of the pipe to a high velocity blast of air during the rearward tempering phase of the cycle to eliminate any remaining moisture. As shown in FIG. 2, the entire pipe hardening apparatus 10 preferably tilts

or slants downwardly a small amount in the forward or right-hand direction whereby the quenched pipe P will be in such position that the water will naturally drain therefrom. Water draining from the pipe flows into a channel 32 the bottom of which slants downwardly in the rearward direction for delivering the fluid back to a quench water pit 33.

Referring now to the semidiagrammatic FIGS. 3-8, a typical example of sequential steps in overlapping hardening and tempering cycles of the pipe hardening lines 12 and 13 are disclosed by way of example. It will be readily understood that the exact times involved in each step and phase of the operation would vary depending upon the length of the pipes involved, the size and wall thickness of the pipe, the power level at which the coil is energized, etc.

Referring now particularly to FIG. 3, each unit of pipe being hardened is assumed to be substantially 80 feet in length and the pipe hardening lines including the transfer stations shown at the left in FIG. 1 are approximately 200 feet in total length. A first pipe P-1 is shown in the supply conveyor line 11 just rearwardly of the induction coils 17 and 17'. In the example given, the load time is presumed to be 132.5 seconds. Thus, from a point beyond the left-hand end of the drawing to the load position as shown, the pipe P-1 took 132.5 seconds to reach the full line position shown. As indicated by the arrows, the pipe P-1 is transferred laterally into alignment with pipe hardening line 13 in an interval of the succeeding 15 seconds.

The pipe P-1 is moved forwardly through the coil 17' while simultaneously a second pipe P2 is moved into the load position in the supply conveyor 11. FIG. 4 shows the position attained by the pipe P-1 in the 132.5 seconds it takes for the pipe P-2 to reach the load position. During the movement of the pipe P-1, said pipe is being raised to quenching temperature and then rapidly quenched at the quench 18' as it passes forwardly.

FIG. 5 illustrates the pipe P-2 after it has been transferred laterally into alignment with pipe hardening line 12. During the 15 seconds of lateral transfer of the pipe P-2, pipe P-1 continues to be scanned and is in substantially the position shown in FIG. 5. At this point, pipe P-1 has been scanned for a period of 147.5 seconds.

FIG. 6 shows the pipe P-1 in its extreme right-hand position which it attains after 150 seconds of scan. Pipe P-1 is maintained in the extreme right-hand position for an additional 30 seconds to allow the quench water to drain off into the channel 32 and quench water pit 33, during which time the pipe P-2 has moved forwardly and received 32.5 seconds of scan heating and hardening whereas a third pipe P-3 has progressed through 32.5 seconds of load to the position shown.

FIG. 7 shows the positions of the pipes P-1, P-2, and P-3 substantially 100 seconds after their positions shown in FIG. 6. The first pipe P-1 has returned in 100 seconds all the way from the extreme right-hand position back to its initial or first position rearwardly of and coaxial with the induction coil 17'. The pipe P-2 is disposed at the same position with respect to the induction coil 17 as pipe P-1 was in FIG. 4 having received 132.5 seconds of scan. The third pipe P-3 is now in the load position.

FIG. 8 shows how the transfer unit 25' then simultaneously moves the pipe P-3 from the load position at the supply conveyor line 11 into alignment with the pipe hardening line 13 and move the now fully hard-

ened and tempered pipe P-1 onto the discharge ramp 24'. The pipe P-2 is now at the position of 147.5 seconds of scan or the same point attained by the pipe P-1 in FIG. 5. It will be readily appreciated that in the subsequent 32.5 seconds, the pipe P-2 will have attained the position of the pipe P-1 in FIG. 6, the pipe P-3 will have attained the position of pipe P-2 in FIG. 6, and a new pipe will be at the position shown by pipe P-3 in FIG. 6.

The diagrammatic view of FIG. 9 shows the relationship of the overlapping cycles of the two pipe hardening sequences just described. Also, diagrams indicating additional pipes have been added to illustrate the manner in which the present apparatus and method are adapted for continuous pipe hardening. Generally speaking, the horizontal axis of the diagram represents time, advancing from left to right, and the vertical axis represents direction, the forward direction being upwardly and the rearward direction being downwardly. Thus, in the top row of the diagram, the angled lines 40 represent the forward moving loading time of the respective pipes P-1, P-2, and P-3. The small horizontal lines 41 at the top of the angled lines represent the 15 second transfer time at which point an incoming pipe is transferred into alignment with a pipe hardening line. At the next two levels of the diagram, the upwardly and forwardly tilted lines 42 represent the forward movement and the scanning time plus drainage time of each pipe. The downwardly and forwardly slanted lines 43 represent the reverse movement and tempering of each pipe. The short horizontal lines 44 represent the final transfer of each pipe out of the system and away from the apparatus as illustrated in FIG. 8. Thus, by drawing a vertical line through any point in the diagram, the relative locations of pipes being treated can be determined.

FIG. 10 shows a simplified electrical diagram disclosing one example of automatic control means for operating the scan hardening and tempering apparatus of this invention. In the diagram, many complicated holding circuits, safety interlocks, overload protectors, and the like, all well known in the art, have been eliminated in the interest of clarity. The control elements are shown disposed across a pair of supply leads L1 and L2, and all switches and contacts are shown in their normal, unactuated position when the controlling relay or timer is not energized, or in the case of limit switches, when the pipe is not contacting the switch.

A first control line 50 across the leads L1 and L2 has a master transfer relay T and normally open contacts LS-7-1 of a limit switch LS-7 interposed therein. The next two lines 51 and 52 have a transfer right relay TR and a transfer left relay TL, respectively, interposed therein. A pair of control lines 53 and 54 have a pair of pipe sensing relays R and L, respectively, connected in series therewith. A pair of timers SR and LS are interposed in two lines 55 and 56, respectively. The timer SR is adapted for timing and controlling the scan hardening and tempering operation in the right-hand pipe hardening line 13, and the timer SL is similarly adapted to control the scan hardening and tempering operation in the left-hand pipe hardening line 12.

The limit switch LS-7 is located adjacent to the forward end of the supply conveyor line 11 whereby it will be struck and actuated by a fully loaded pipe. A pair of limit switches LS-1 and LS-2 are located in the right-hand pipe hardening line 13, one or both of which will

be contacted and closed by a pipe P during the scan hardening and tempering thereof. Limit switches LS-1 and LS-2 are disposed in parallel in line 53 whereby when either one of them is closed the pipe sensing relay R will be energized. In a similar manner, limit switches LS-3 and LS-4 are connected in parallel in line 54 to sense a pipe being scanned in the left-hand pipe hardening line 12 to energize the pipe sensing relay L. The timers SR and SL in lines 55 and 56, respectively, which represent means for initiating and carrying out the complete forward and rearward movement of the pipe for scan hardening and tempering, are energized by a pair of limit switches LS-5 and LS-6, respectively, adapted to be closed when a pipe is moved from the load position laterally into alignment with one of the pipe hardening lines. The limit switch LS-7 has additional normally open contacts LS-7-2 in line 57 for controlling an isolating relay I which controls normally closed contacts I-1 and I-2 in lines 55 and 56, respectively. Thus neither time SR or SL can be actuated to initiate a scanning and tempering cycle while a load is at the load position causing energization of the isolating relay I. Only upon transfer of a load right or left will one of the timers SR or SL be actuated.

In operation of the control means, assuming the entire apparatus to be initially empty, a pipe P-1 arriving at the load position in the supply conveyor line actuates the limit switch LS-7 to close contacts LS-7-1 thereby energizing the master transfer relay T in line 50. This in turn causes a pair of contacts T-1 in line 51 to close to energize the transfer right relay TR. A second pair of contacts T-2 in line 52 are closed by the relay T but the transfer left relay TL is isolated by a pair of normally open contacts SR-3 of the right-hand timer SR and is further immediately isolated by a pair of contacts TR-2 which are opened by the relay TR. This insures that when the apparatus is empty, the first lateral transfer will be made to the right or toward the pipe hardening line 13 (FIG. 3). The relay TR also closes normally open holding contacts TR-1 disposed in parallel with the limit switch contacts LS-7-1 whereby the master transfer relay T remains energized even when the pipe is transferred from the load position to the pipe hardening line 13.

Lateral transfer of the pipe P-1 closes limit switch LS-5 thereby closing normally open contacts LS-5-1 and energizing the scanning timer SR to cause the pipe P-1 to be run through the hardening and tempering portion of the cycle. At the same time, normally closed contacts LS-5-2 of limit switch LS-5 in parallel with normally closed contacts I-1 open, the circuit being through contacts I-1 now closed because no load is at the load position. The timer SR closes holding timer contacts SR-1 around the limit switch contacts LS-5-1 and also opens normally closed contacts SR-2 in line 51 to isolate the transfer relay TR. As the pipe P-1 moves forward to be scanned, it sequentially closes limit switches LS-1 and LS-2 whereby the pipe sensing relay R in line 53 is energized. Relay R opens normally closed contacts R-1 in line 51 to further isolate the transfer relay TR. Throughout the scanning and tempering cycle wherein the pipe P-1 is moved from the broken line position of FIG. 3 to the full line position of FIG. 6, and then back to the initial position, at least one of the limit switches, LS-1 or LS-2 or the contacts LS-5-1 are closed so that no pipe can be transferred to

the right during the hardening and tempering phase of the cycle at line 13.

During the time that the pipe P-1 is being scanned, the pipe P-2 arrives at the load position and actuates the limit switch LS-7. This energizes the master transfer relay T which again closes the contacts T-1 in line 51 and T-2 in line 52. Since the Relay TR is already isolated by the now open contacts R-1 and SR-2, and whereas normally open contacts SR-3 are closed, the transfer left relay TL is now energized and closes the holding contacts TL-1 disposed in parallel with the limit switch contacts LS-7-1. The pipe P-2 is then transferred left (FIG. 5) and actuates the limit switch LS-6 which closes normally open contacts LS-6-1 to energize the left-hand scanning timer SL which in turn closes holding contacts SL-1 for the period of the scanning and tempering cycle. At the same time, normally closed contacts LS-6-2 of limit switch LS-6 in parallel with normally closed contacts I-2 open, the circuit being through contacts I-2 now closed because no load is at the load position. Timer contacts SL-2 in line 52 are at this time opened to isolate the transfer left relay TL to prevent any transfer in the left-hand direction or toward the pipe hardening line 12 while a pipe is already in the system. As the pipe P-2 is scanned, limit switches LS-3 and LS-4 will be sequentially closed to energize pipe sensing relay L which in turn opens normally closed contacts L-1 to further isolate the transfer left relay TL during the scan hardening and tempering cycle (FIG. 6).

As stated above, a new load, arrives at the load position while a previous load (P-1) is being scanned. This causes energization of the isolating relay I thus tending to interrupt the scanning circuits. However, the sequence is such that a load being scanned rides off of the timer initiating switch LS-5 or LS-6 before a new load trips limit LS-7 whereby contacts LS-5-2 or LS-6-2 close to maintain a scanning circuit.

During the scanning of the pipe P-2, pipe P-1 returns to its initial position and pipe P-3 reaches the load position at the supply conveyor line 11. The new pipe P-3 actuates limit switch LS-7 to close contacts LS-7-1 to again energize the master transfer relay T. At the same time, contacts LS-7-2 are closed to energize relay I in line 57. Relay I, in turn, opens normally closed contacts I-1 in line 55 to isolate relay SR and prevent operation of the scanning portion of the cycle due to pipe P-1 closing limit switch LS-5 and closing contacts LS-5-1 but also opening contacts LS-5-2. The tempered pipe P-1 is now clear of the limit switches LS-1 and LS-2 in line 53 and normally closed contacts R-1 remain closed. Upon closing of the contacts T-1, the apparatus is set to make a transfer right movement. Such movement places the new pipe P-3 in the original position of pipe P-1 in alignment with the pipe hardening line 13, while at the same time shifting the tempered pipe P-1 out of the system and onto the discharge ramp 24' (FIG. 8). Thus, the pipe P-3 is moved off of the limit switch LS-7 deenergizing the timer interrupter relay I and allowing contacts I-1 to close in line 55 for energization of the timer SR.

From the foregoing, it will be seen that the timers SR and SL are separately initially energized by the limit switches LS-5 and LS-6 and are thereafter maintained throughout the entire hardening and tempering phase of the cycle by the timer contacts SR-1 and SL-1, respectively, until the timers time out. It will be further

understood that these timers cannot be initiated when a load is at the load position due to energization of the isolating or interrupter relay I by closing of the limit switch contacts LS-7-2.

By the above described apparatus and method, it has been found that large diameter pipe can be rapidly and continuously hardened and tempered by induction heating with a great saving of time. This saving is due to the fact that the scan hardening and tempering portions of the cycle at each pipe hardening line continue to operate independently of the other line and in overlapping relation therewith whereby a fully tempered pipe is discharged from the system at shorter intervals than the total amount of time needed to load, transfer, harden, temper, and discharge a single pipe. Due to the particular timing described, the supply conveyor line 11, operating on the shorter time interval, can keep both lines fully occupied at maximum production. The system affords great saving of space due to the fact that each pipe reverses movement and returns to its initial location for transfer out of the system rather than being moved forwardly along an additional spaced consuming conveyor. The present system also affords the advantage that the same induction coil is used for both hardening and tempering the pipe. An additional advantage also resides in the fact that where an internal quench is used, said quench can be stationary, and consequently there is no need to provide complicated apparatus or means for moving the quench away from the pipe.

It will be understood that many changes in the details of the invention as herein described and illustrated may be made without, however, departing from the spirit thereof or the scope of the appended claims.

I claim:

1. The method of tandem scan hardening and tempering of pipe in two parallel, spaced pipe hardening lines, each including an induction coil and quench means; the step of providing a supply line between the hardening lines having a load position adjacent to the entrance ends of the coils; the step of sequentially conveying new pipes to the load position and alternately shifting the pipes laterally to the hardening lines; the step of conveying each pipe at each hardening line, in sequence, through the coil and progressively heating the pipe to quenching temperature, through the quench means and quenching the pipe to harden the pipe, back through the coil for tempering the pipe, and laterally of the hardening line for discharging the pipe; the step of maintaining the speed of new pipe conveyed to the load position and the speed of hardened pipe moving back through the coil for tempering substantially greater than the speed of the pipe through the coil and quench during hardening of the pipe whereby the hardening of a new pipe is begun before the completion of the hardening of the prior delivered pipe in overlapping cycles.

2. The method as set forth in claim 1: the step of sensing the presence of a pipe being treated at either hardening line and shifting a new pipe from the load position laterally, only to a hardening line prepared to receive the pipe.

3. The method as set forth in claim 1: the hardening of the pipe including the step of quenching both the interior and exterior of the pipe as it passes from the induction coil.

4. The method of tandem scan hardening and tempering of pipe in two parallel pipe hardening lines, each

line including an induction coil and quench means; the step of conveying a first pipe at a predetermined speed through a first of the two hardening lines in a forward direction to harden the pipe; the step of moving the first pipe rearwardly through the same hardening line to temper the pipe; the step of delivering a second pipe to the second hardening line before completion of the hardening of the first pipe at the first hardening line; the step of delivering a third pipe to the first hardening line and transferring the first pipe away from the first hardening line before completion of the hardening of the second pipe in said second hardening line, in a continuous cycle.

5. A method of treatment of successive pipes by scan hardening and tempering thereof in like manner in two pipe treating lines having the entrance ends thereof disposed adjacent to each other, each line including an induction coil and quench means, the method comprising: the steps of sequentially conveying pipes to a load position adjacent to the entrance ends of the pipe treating lines; the step of conveying a first pipe from the load position through a first of the pipe treating lines in a forward direction to harden the pipe; the step of moving the first pipe rearwardly through the same pipe treating line to temper the pipe; the step of delivering a second pipe to the second pipe treating line for like treatment before completion of treatment of the first pipe at the first pipe treating line; and the step of transferring the first pipe away from the first pipe treating line and delivering a third pipe to the first pipe treating line before completion of treatment of the second pipe in the second pipe treating line, in continuous overlapping cycles.

6. The method as set forth in claim 5 including the step of sensing the presence of a pipe being treated at either pipe treating line and causing a new pipe to be shifted from the load position into an empty pipe treating line only.

7. The method of treatment of large diameter steel pipe by tandem scan hardening and tempering in two pipe treating lines having the entrance ends thereof disposed adjacent to each other, each line including an induction coil and quench means; the step of sequentially moving pipes to a load position adjacent to the entrance ends of the pipe treating lines; the step of shifting alternate pipes from the load position to the respective pipe treating lines; the sequential steps at each pipe treating line of conveying each pipe forwardly through the coil and progressively heating the pipe to quenching temperature, conveying the pipe through the quench means and quenching the pipe to harden the pipe, conveying the pipe back through the coil for tempering the pipe, and conveying the pipe away from the pipe treating line, while maintaining the speed of new pipe conveyed to the load position, and the speed of hardened pipe moving back through the coil for tempering, substantially greater than the speed of the pipe through the coil and quench means during hardening of the pipe whereby the second pipe is delivered to the second pipe treating line before completion of treatment of the first pipe, and the first pipe is transferred away from the first pipe treating line and the third pipe is delivered to the first pipe treating line before completion of treatment of the second pipe in the second pipe treating line, in continuous overlapping cycles.

8. The method of treatment of large diameter steel pipe as set forth in claim 7 wherein the pipe is conveyed

axially through each pipe treating line with the pipe being tilted downwardly at its forward end and including the step of maintaining the pipe in the extreme forward position after quenching for a predetermined time to allow quench liquid to drain therefrom, the relative speeds of the pipes causing hardening of a new pipe to begin before completion of drainage of the prior delivered pipe.

9. The method of treatment of large diameter steel pipe as set forth in claim 7 wherein the relative speeds of the pipes causes hardening of a new pipe to begin before completion of the hardening of the prior delivered pipe.

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