

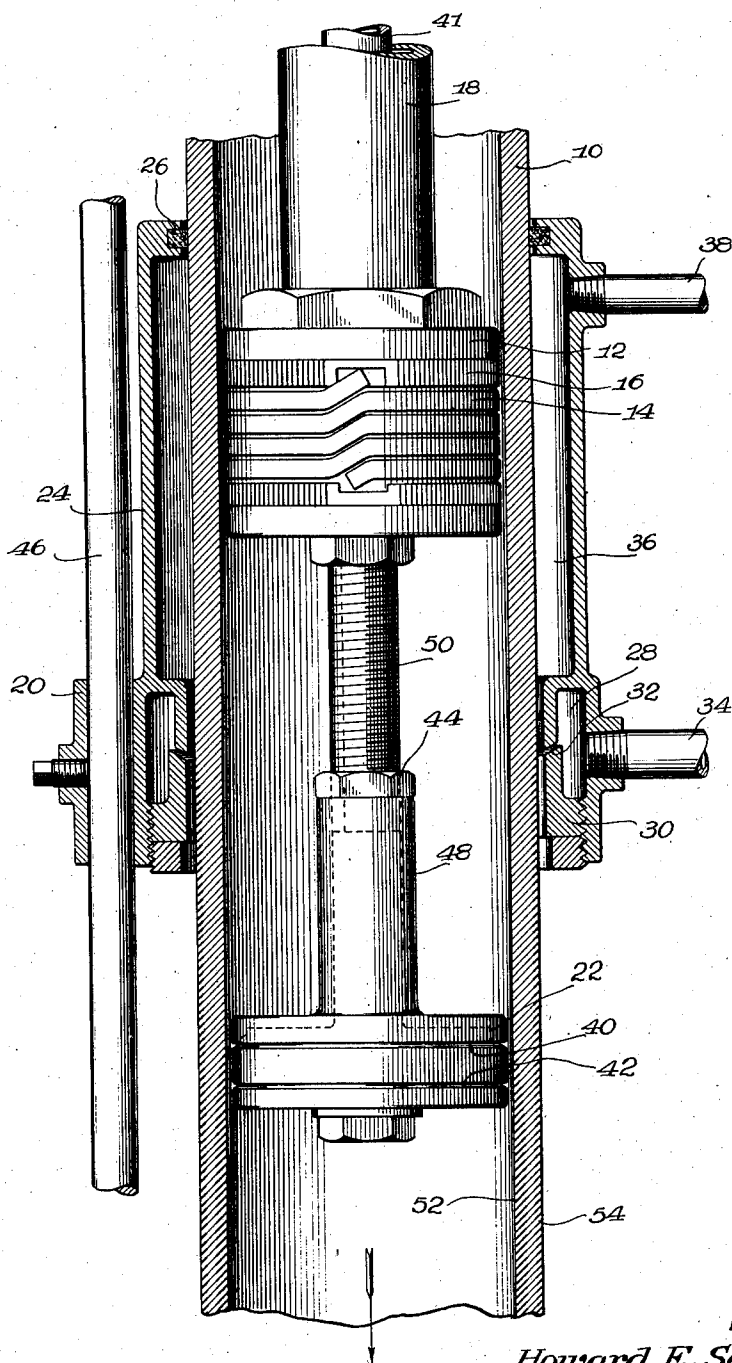
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HEAT TREATING

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HEAT TREATING

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This invention relates to heat treating and more particularly to internal and external heat treatment of elongated tubular metallic objects in order to improve the metallurgical characteristics thereof.

In the heat treatment of hollow or tubular objects through heating and quenching severe residual stresses are usually set up within the piece producing weakness, quenching cracks, spalling and other undesirable conditions and in order to avoid the setting up of such internal stresses, it has often been found necessary to control the quenching in such a way as to minimize the stresses and at the same time accept a degree of hardness lower than that desired. The present invention is directed to a process and apparatus wherein heating and quenching of the tubular object may be effected in proper sequence and in proper timed relation such that an improved hardened tubular structure avoiding many of the undesirable characteristics heretofore present can be produced.

It is, accordingly, an object of the present invention to provide a novel procedure for the heating and quenching of tubular objects such that desired hardness characteristics may be produced in the object without setting up detrimental stresses.

Another object of the invention is to provide a procedure of progressively heating and subsequently quenching either internally or externally or both in such a manner as to produce an object of improved characteristics.

A further object of the invention is to provide apparatus adapted for the purpose of carrying on the heating and quenching in proper sequence so that tubular objects of improved characteristics may be effected.

The above and other novel features of the invention will appear more fully hereinafter from the following detailed description when taken in conjunction with the accompanying drawing. It is expressly understood, however, that the drawing is for purposes of illustration only and is not designed as a definition of the invention, reference being had for this purpose to the appended claims.

In the drawing, the single figure illustrates partially in section suitable heating and quenching apparatus for obtaining the results herein described.

Referring to the drawing, there is shown a tubular object 10 such as a pipe of structural hollow column, in which it is desired to vary either the internal or external surface hardness

and improve the physical characteristics of the tube. For the purpose of heating the tube, a high frequency high power induction heater 12 is illustrated, the same preferably having a plurality of turns 14 with a flux concentrating laminated iron core 16. Any suitable source of high frequency current may be connected to the coil through leads extending through the central tubular supporting arbor 18. While in the present disclosure induction heating is employed for purposes of illustration, it will be appreciated that other types of heaters such as flame and the like may be employed in situations where the high rate of heat input or the cleanliness or other features of induction heating are not essential or extremely desirable in connection with the heating of the tube. It should also be understood, however, that through induction heating, heat is generated within the tubular object rather than upon the surface thereof and as a result greater concentrations of heat can be generated within the tubular object at a rate greater than other forms of heating. By applying the heat internally, losses from radiation are minimized since the tube in effect forms a confining chamber acting against such radiation losses.

By moving the tube downwardly with respect to the heat treating coil the internally heated annulus of metal is brought adjacent to the external quenching fixture 20 and the internal quenching fixture 22. The external quenching fixture is preferably provided with a shield 24 having close engagement with the tubular object through a slidable packing 26 adapted to engage the exterior of the tubular object. The quenching nozzle consists of an annular chamber 28 formed partly by an adjustable annular nozzle lip 30 screw-threaded in the quenching fixture 20. The nozzle 32 is directed rearwardly and, through the admission of quenching fluid through the pipe 34 into the chamber 28 under pressure, is adapted to provide a conical quenching stream directed downwardly and away from the heat treat coil upon the exterior surface of the object. While the angle of the quenching nozzle 32 is sufficient in general to force all the liquid downwardly and thus prevent quenching fluid from striking the tubular object above the annular orifice, it may be preferable to maintain a gaseous medium under pressure above the orifice and this may readily be accomplished by introducing air or inert gas under pressure into the chamber 36 formed by the shield 24 through a suitable inlet pipe 38.

The internal quenching fixture 22 may simi-

larly be provided with annular conical jets 40 and 42 fed from a source of quenching fluid passing down through the center of the heating head, for instance through tube 41, and through the adjustable central support 44, through which the quenching fixture is supported from the heating head 12. The quenching nozzles 40 and 42 are rearwardly or downwardly directed away from the heat treat head so that quenching fluid will effect a smooth annular contact or engagement with the internal wall, such fluid as might tend to escape above the nozzle orifice being drawn down by suction created by the velocity of the quenching fluid downward emerging from the orifice. If desired, additional assurance that the quenching fluid will flow downwardly away from the head may be had by introducing air or gas into the top of the tube and forcing the same past the heat treat head into the space between the head 12 and the quenching fixture 22.

The quenching fixture 20 may be adjustably supported upon a support rod 46 so as to vary the axial spacing between the quenching nozzle 32 and the heat treat head 12, such adjustment being necessary to accommodate progressive treatment upon tubes of various composition or to produce different desired treatment. Similarly the quenching fixture 22 is adjustable in its spacing between the head 12 through the telescopic threaded members 48 and 50. While the limit of adjustment of the quenching fixture 22 would prevent the same from approaching exceptionally close to the heat treat head, it will appear obvious that, should conditions make it necessary, the adjustable members 50 and 48 may be varied in length so that the quenching fixture 22 may in practice be adjusted to any desired axial distance from the heat treat head. Thus the heat treat head and the external quenching fixture 20 and the internal quenching fixture 22 may be adjusted with relation to one another so as to bear a fixed relation to one another for the treatment of any particular tubular member desired. In practice, the heat treat head and quenching fixtures would preferably be maintained stationary while the tube is progressively moved downward with reference thereto and if desired, simultaneously rotated. In some instance, however, rotation of the quenching fixtures and the heat treat head may be resorted to in place of the rotation of the tubular object, or sufficient uniformity may be obtained without the relative rotation of either. If desired, the heat treat head and quench fixtures may be moved.

In employing the apparatus disclosed for the purpose of providing a hardened external surface or layer such as 52 as well as an internal surface and adjacent layer such as 54 upon a tubular object such as that disclosed, sufficient heat is induced in the tube 10 so that by the time the heated annulus has moved to the point adjacent the external quenching nozzle 32, such internally heated layer will have soaked through to the outer layer to raise the temperature thereof sufficient to that required for hardening to the degree desired upon quenching. It will appear that throughout the operation just described the internal layer or surface will remain hotter than the external surface so that it is not desirable to quench the internal surface, if it be desired to harden the internal surface, until after the external surface has been quenched. For this reason, the internal quenching nozzle is preferably arranged to effect quenching of

the internal surface of the tube at a time subsequent to the quenching of the external surface. The higher temperature of the internal surface during quenching of the external surface would be sufficient to maintain the internal surface plastic so that it will be enabled to readily conform to the reduction in external diameter resulting from the cooling by the external quench without overstressing the external surface layers. Thus a hardened external layer may be provided which will be free from a tendency to crack due to enormous internal residual stresses which result in most heating and quenching operations.

If it be desired to also provide a hardened internal layer, the internal quenching fixture 22 may be adjusted to a proper relative position with respect to the external quenching fixture and the heat treat head so that quenching of the internal wall may be accomplished before the temperature of the internal wall has dropped below the critical temperature.

It will readily appear that varying hardnesses of internal and external wall and surface may be obtained by relative adjustment of the time between heating and quenching; the quenching rates may be adjustable by providing the quenching nozzles with quenching fluids at different pressures or by adjusting the size of the quenching orifice. Various degrees of hardness may be obtained by employing other quenching fluids such as oil or gases. A wide range of physical characteristics may thus be effected in a tubular structure of the type disclosed and through the uniform progressive movement of the tubular structure past the heat treat head and the quenching fixtures, one or both being employed as the case may be, long lengths of tubes having extremely uniform characteristics throughout the length thereof will result. If desired, the external surface can be controllably hardened to the limit of machinability so that the structure can be employed for well casings and the like, it being possible under such circumstances to cut threads in the external diameter. At the same time, if the internal wall is hardened, such internal wall, if hardened to a sufficient depth, will increase the structural strength of the tube against collapse and tension since through hardening the yield strength of the hardened portion increases in proportion to the increase in hardness.

Through such a procedure, assuming the apparatus to be adjusted correctly, the tensile and compressive strength of the tube may be increased and hardened without the consequent danger of checking and spalling which have ordinarily attended the hardening of tubes heated throughout and quenched from one side, such as the external surface alone. Through the apparatus described accurate control to produce desirable characteristics free of such excessive stresses as those heretofore known in tubular objects is readily accomplished. Such treatment may be effected at the rate of an inch or more per second, particularly if the heat treat head is of the electromagnetic induction type and adapted to generate heavy heating currents within the tube. It will also appear that the rate of speed of treatment will vary in accordance with the critical temperature sought in connection with the external or internal hardening and by varying the axial length of the tube axially exposed to pressure quenching, the quenching effect may be in effect interrupted so as to retain

the structure in the quench section in a particular phase such as austenitic, whereby the structure would be less apt to develop quenching or hardening stresses, it, of course, being the object of the invention to prevent the development of such stresses unless they are beneficial to the over-all strength and improvement of the physical characteristic of the tube. For details of apparatus suitable for effecting such controlled length of quench or for generating heat at a high rate within the tubular object, reference may be made to a copending application Serial No. 277,996, filed June 8, 1939.

There is thus described an efficient apparatus for rapidly processing tubular members to improve the characteristics thereof by hardening the same internally or externally or both or completely through as may be desired while at the same time effecting such changes without the danger of setting up exceptional hardening stresses often accompanying such operations by other methods.

Though a single embodiment of the invention has been diagrammatically illustrated and described together with the uses thereof, it is to be understood that the invention is not limited thereto but may be embodied in various modified forms and utilized in various ways without departing from the spirit of the invention, as will be apparent to those skilled in the art. Accordingly, reference will be had to the appended claims for a definition of the limits of the invention.

What is claimed is:

1. The method of progressively heat treating a tubular member which consists in applying heat to an annular internal zone of the member of less length than the length of the member while moving the member and shifting the zone simultaneously progressively along the length of the member, applying quenching fluid to said tubular member externally at a point spaced from the application point of said heat and in the direction of movement of the member after the heat applied to the internal zone has flowed to a desired amount to the external surface and while the internal surface layers remain at a temperature greater than the temperature of the external surface being quenched, whereby said internal layers may upset as a result of the contraction due to quenching of the external layers, and applying quenching fluid to the interior surface of the tubular object at a point spaced from the application point of said heat and in the direction of movement of the member.

2. The method of progressively heat treating a tubular member which consists in applying heat to an annular internal zone of the member of less length than the length of the member while moving the member and shifting the zone simultaneously progressively along the length of the member, applying quenching fluid to said tubular member externally at a point spaced from the application point of said heat and in the direction of movement of the member after the heat applied to the internal zone has flowed to a desired amount to the external surface and while the internal surface layers remain at a temperature greater than the temperature of the external surface being quenched, whereby said internal layers may upset as a result of the contraction due to quenching of the external layers, and applying quenching fluid to the interior surface of the tubular object at a point spaced from the application point of said external quenching

and in the direction of movement of the member.

3. The method of progressively heat treating a tubular member which consists in generating annular heating currents in an annular internal zone of limited axial length while moving the member relative to the zone in the direction of its axis, applying quenching fluid to said tubular member externally at a point spaced from the point of the heating currents and in the direction of movement of the member after the heat generated in the internal annulus or zone has flowed to a desired amount to the external surface and while the internal layers remain at a temperature greater than the temperature of the external surface being quenched, whereby said internal layers may upset as a result of the contraction due to quenching of the external layers, and applying quenching fluid to the interior surface of the tubular object at a point spaced from the external quenching point and in the direction of movement of the member.

4. The method of heat treating a tubular member which consists in applying heat to an annular internal zone of the member in an amount sufficient to heat the same to an upsetting temperature, applying quenching fluid to said tubular member externally opposite the zone heated and substantially uniformly around the periphery in a manner effective to contract said member and upset the metal of said inner zone by an amount resulting from the contraction due to the external quenching, and quenching the internally heated zone subsequent to external quenching to harden said internal zone.

5. The method of treating a hollow cylinder of hardenable ferrous metal which comprises heating the cylinder to bring both faces to at least a hardening temperature, quenching one face to harden and strengthen it whereby it is more resistant to cracking or spalling on hardening the opposite face, and then quenching the remaining face to harden it after the first face has been quenched and hardened.

6. The method of treating a hollow cylinder of hardenable ferrous metal which comprises rapidly putting energy into one face to bring the same to above the critical temperature for hardening before the opposite face has been so heated, allowing the heat to soak through from the energy input face to the opposite face, quenching said opposite face to harden and strengthen the same, and then quenching the energy input face to harden the same whereby the opposite face has been treated to reduce danger of cracking or spalling on hardening the energy input face.

7. The method of treating a hardenable ferrous metal hollow cylinder which comprises rapidly heating the inner face to bring the same above a hardening temperature before the outer face has been so heated, allowing the heat to soak through from the inner face to the outer face, quenching the outer face to harden and strengthen the same, and then quenching the inner face to harden the same whereby the outer face has been strengthened against cracking or spalling, on hardening the inner face.

8. The method of compacting and hardening an inner surface of a tubular ferrous member which comprises rapidly heating such inner surface to above the critical temperature, allowing the heat to soak through to an outer surface of the member, quenching the outer surface while the inner surface is in plastic condition whereby the outer surface shrinks thereby applying a

compressive stress to compact the plastic inner surface, and then quenching the compacted inner surface to harden the same.

9. The method of compacting and hardening an inner surface of a tubular ferrous member which comprises rapidly heating such inner surface to above the critical temperature, allowing the heat to soak through to an outer surface of the member, quenching the outer surface in a manner to harden the outer surface to below but near the limit of machinability and increase its strength while the inner surface is plastic and hotter than was the outer surface at the time it was quenched, and then quenching the inner surface after the outer surface.

10. In an apparatus for progressively heat

5 treating the surface of a workpiece by electromagnetic inductive heating and by quenching, having an inducing head, and a quenching head constructed to discharge a peripherally continuous sheet of quenching liquid toward the work, the heads and work surface being relatively movable for progressively heating and quenching such surface, the improvement for controlling the extent of heat conduction from the heated work surface before the same is quenched, which improvement comprises a connection between the heads capable of adjustment to control the longitudinal distance between the trailing edge of the inducing head and the quenching sheet.

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