July 6, 1965 F. J. DEWEZ, JR., ET AL 3,193,270

APPARATUS FOR HEAT-TREATING RAILS

Original Filed Oct. 12, 1962

4 Sheets-Sheet 1

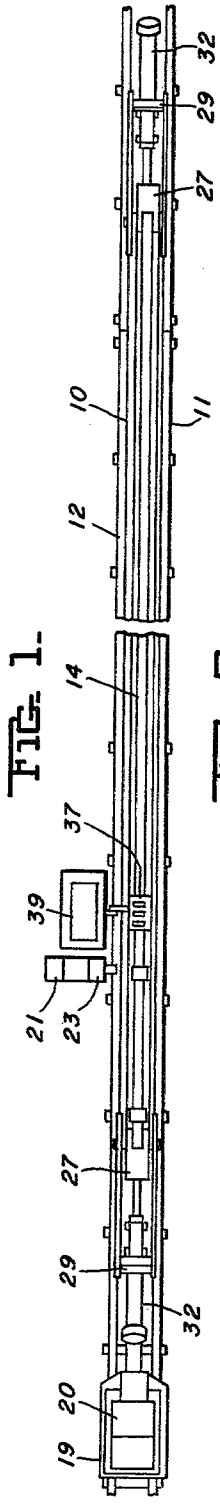


FIG. 1.

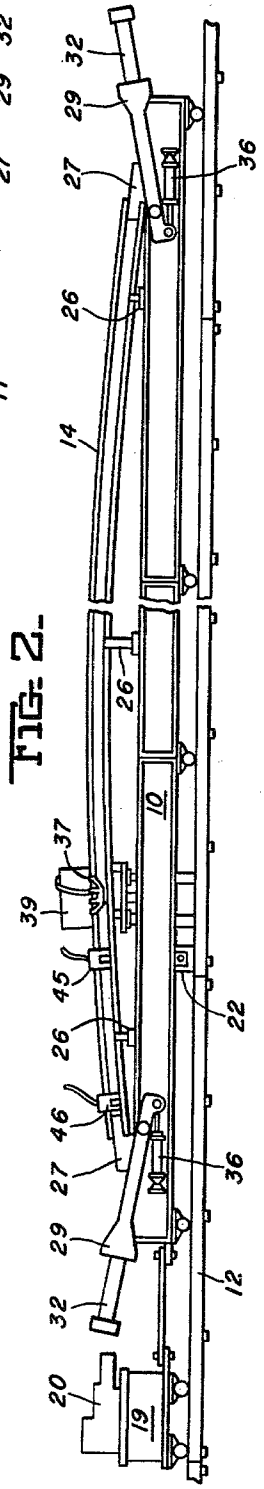


FIG. 2.

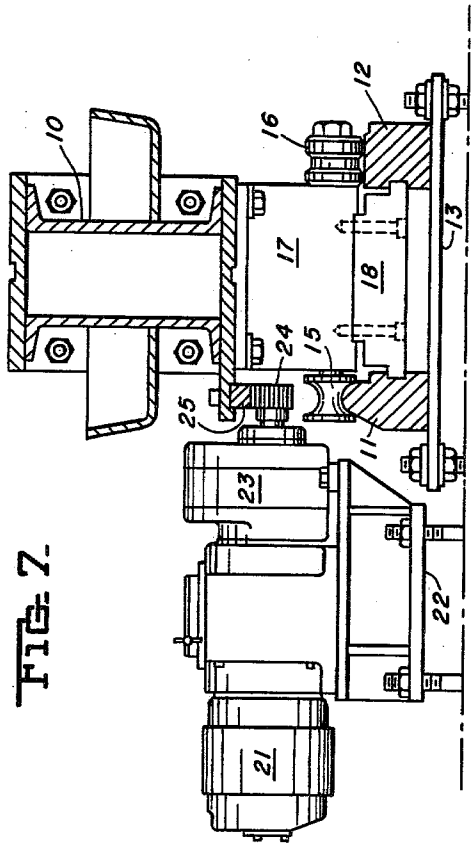


FIG. 7.

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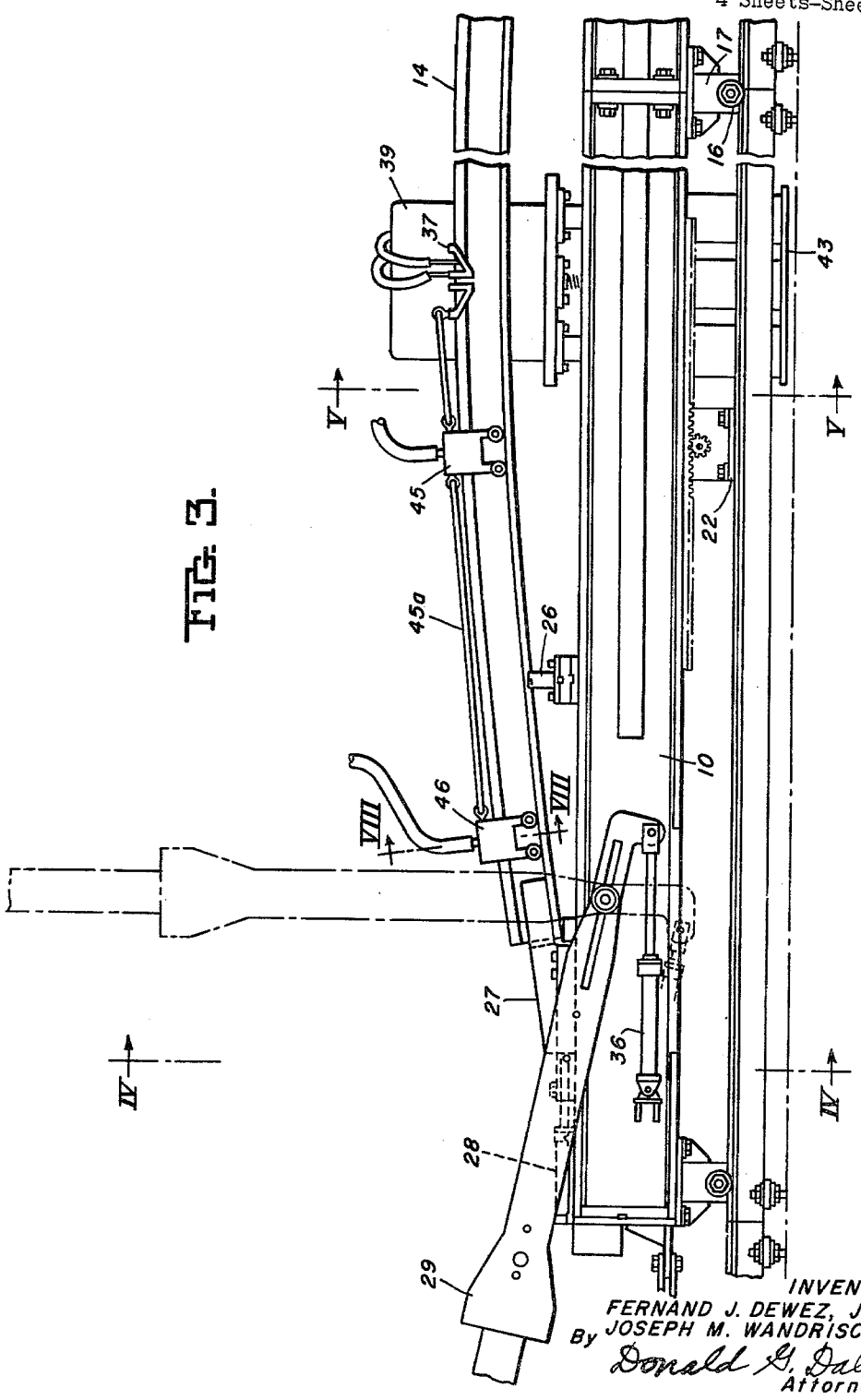
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FIG. 3.



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FIG. 4.

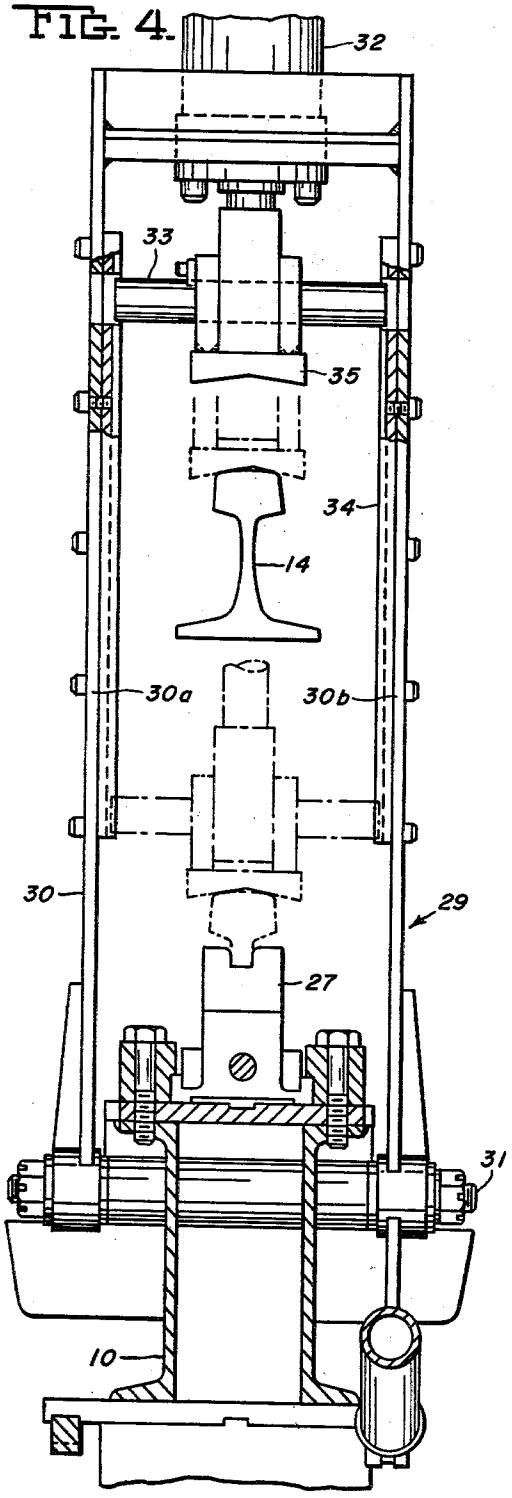
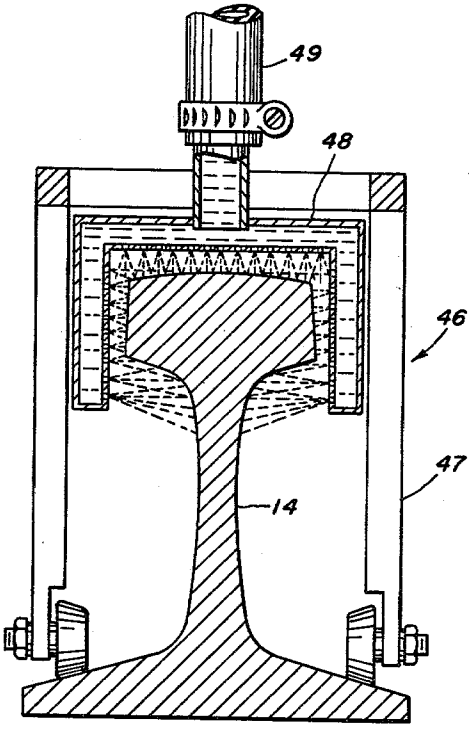


FIG. 8.



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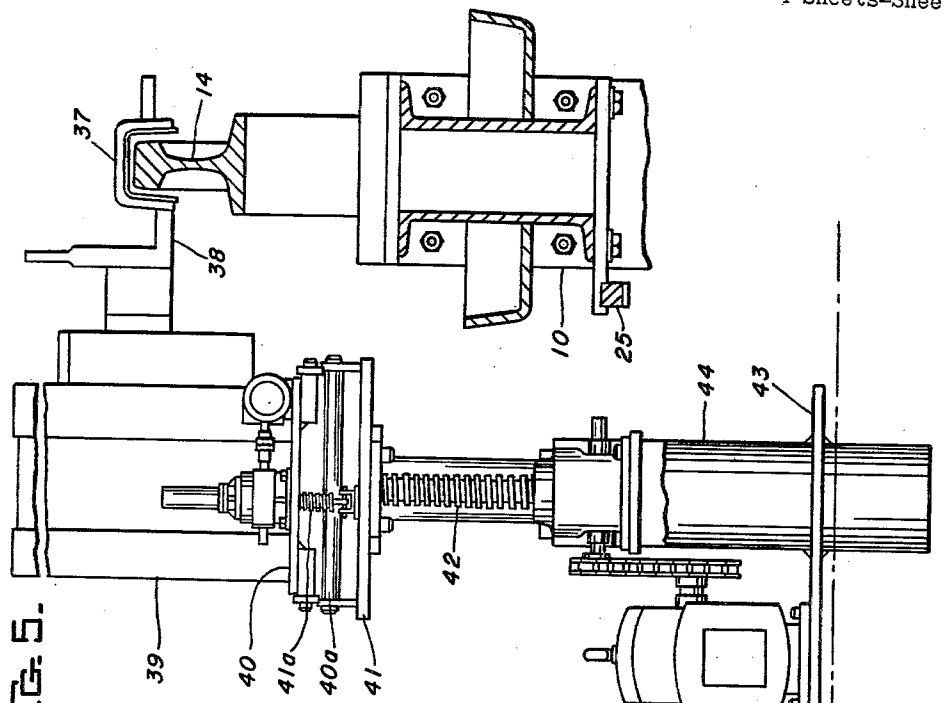


FIG. 5.

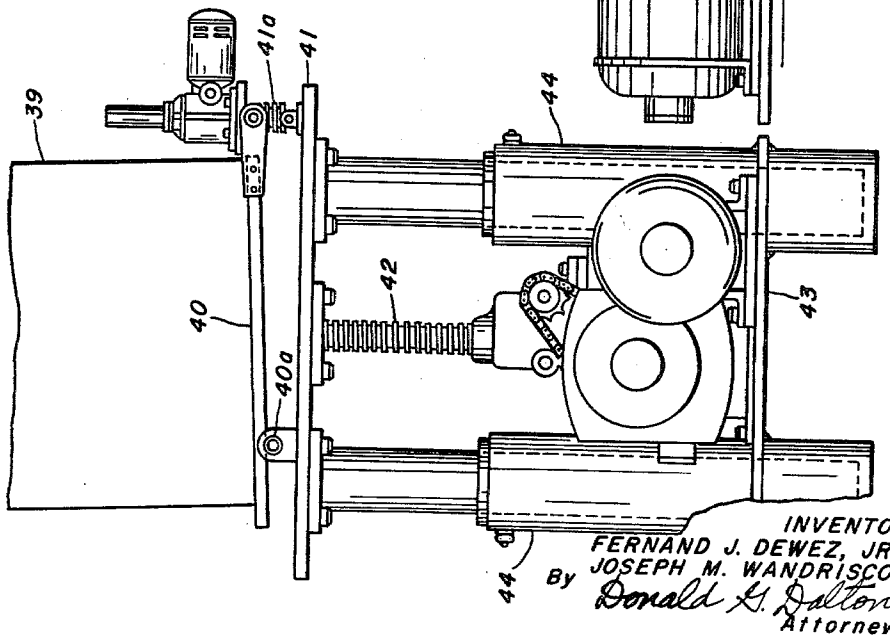


FIG. 6.

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APPARATUS FOR HEAT-TREATING RAILS

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Original application Oct. 12, 1962, Ser. No. 230,119, now Patent No. 3,124,492, dated Mar. 10, 1964. Divided and this application Sept. 5, 1963, Ser. No. 306,807

6 Claims. (Cl. 266—5)

This invention relates to apparatus for hardening the heads of steel railroad rails, thereby increasing their resistance to wear and plastic deformation under normally applied stress.

This is a division from our application Serial No. 230,119, filed October 12, 1962, now Patent No. 3,124,492.

The entire cross section or only the head section of rails may be heated-treated. Distortion of the rails resulting from the heat treatment usually necessitates subsequent mechanical straightening. Heat treatment of the head portion only causes the rail to distort so that the head has an upward concave curvature. The excessive mechanical straightening necessarily performed on such a rail may result in undesirable residual stresses which increase the danger of rapid fatigue failure in service.

We have invented apparatus for progressively heat-treating the head portion only of a rail section according to the method claimed in our patent aforesaid, from one end of the rail to the other, without leaving curvature in the treated rail such as to require excessive mechanical straightening. In a preferred practice of that method, we first bend within its elastic limit a rail at atmospheric temperature standing in normal position, longitudinally in a vertical plane so that the head portion has an upward convex curvature and the flange is concave downwardly. We then heat the head portion progressively along its length to a temperature such as to austenitize it. Thereafter we apply a mild quench to cause the transformation of the austenite on the surface to pearlite. Self tempering by absorption of internal heat is then permitted for a predetermined period after which the head portion is finally quenched substantially to atmospheric temperature. As a result, the fully treated rail is left substantially straight and requires little or no mechanical straightening. The apparatus claimed herein for carrying out the method outlined above is shown in detail in the accompanying drawings. In the drawings:

FIGURE 1 is a plan view on a small scale showing the general arrangement;

FIGURE 2 is an elevation thereof;

FIGURE 3 is a portion of FIGURE 1 to enlarged scale;

FIGURES 4 and 5 are cross sections taken along the planes of lines IV—IV and V—V of FIGURE 3, respectively, with parts in elevation;

FIGURE 6 is an elevation of the apparatus shown in FIGURE 5, looking from the left thereof; and

FIGURES 7 and 8 are views similar to FIGURES 4 and 5 taken, respectively, along the lines VII—VII and VIII—VIII of FIGURE 3.

Referring now in detail to the drawings and, for the present, particularly to FIGURES 1–3 and 7, our apparatus comprises principally a rigid elongated box-section transport frame or carriage **10** adapted to travel along

ways **11** and **12** secured to fixed cross beams **13**. Carriage **10** is also adapted to support and hold a rail **14**, having a head, web and flange, bent longitudinally as shown, with the head portion convex upwardly and the flange concave downwardly, in a vertical plane, during progressive heat treatment as will be described in greater detail later. For travel along ways **11** and **12**, carriage **10** is fitted at intervals with wheels **15** and **16** (FIGURE 7) journaled on shafts fixed in trucks **17**. A hold-down plate **18** is secured to each truck and has its ends dove-tailed into longitudinal grooves on the inner faces of the ways. A car **19** similarly constructed is coupled to one end of carriage **10** for travel along the ways and carries a motor-driven pump **20** for supplying liquid under pressure to hydraulic auxiliaries to be described shortly. Carriage **10** is driven by a motor **21** mounted on a base **22**. The motor drives a reduction gear **23** and a pinion **24** which meshes with a rack bar **25**. The bar is mounted on the bottom of the frame **10** at one side thereof.

Rail-supporting blocks or abutments **26** of varying heights are mounted on carriage **10** and spaced therealong. A hold-down jaw **27** is gibbed to each end of the frame so as to be slidable into and out of engagement with an end of rail **14**. A hydraulic power unit **28** including a cylinder and piston is provided for actuating each jaw **27**. Each end of the frame also has a rail bending jack **29** pivoted thereon for movement into and out of operating position. The jack structure is more clearly shown in FIGURES 3 and 4.

Each jack **29** comprises a rectangular frame **30** pivoted to carriage **10** on a through shaft **31**. The frame is surmounted by a fluid-pressure cylinder and piston **32**. The piston rod thereof actuates a cross-head **33** reciprocable in slotted guides **34** carried by spaced side rails **30***a* and **30***b* of the frame. The cross-head has a pad **35** thereon adapted to engage the end of a rail placed on blocks **26** and bend it to a curved condition as shown in FIGURE 1, within the elastic limit. Each jack **29** has a fluid-pressure cylinder and piston **36** pivoted thereto and to carriage **10**, whereby it may be raised to vertical operative position or tilted down to an out-of-the-way position as shown in FIGURE 1.

For effecting the desired heat treatment of a rail which has been prebent as explained above, we provide an inductor **37** adapted to travel along the head of the rail as the latter is carried by carriage **10** along ways **11** and **12**. As shown in FIGURE 5, the inductor is mounted on an arm **38** extending laterally over carriage **10** from a transformer **39**. The inductor and its current supply are of the well known high-frequency electromagnetic induction type of industrial heating equipment commercially available. The transformer is mounted on a tilting table **40** pivoted at **40***a* to a sub-platform **41**. A motor-driven screw jack **41***a* on the platform operates to tilt table **40** as necessary to keep the inductor in close proximity to the head of the rail as it travels thereunder. Platform **41** may be raised and lowered by a motor-driven screw jack **42** standing on a base plate **43**. Piston-cylinder guides **44** also standing on plate **43** are actuated to hold platform **41** horizontal as it is raised or lowered.

An initial quenching head **45** is adapted to a ride along the rail flange a predetermined distance behind inductor **37** and a final quenching head **46** (see FIGURE 8) a predetermined distance behind head **45**. Heads **45** and **46**

are generally similar each comprising a wheeled frame **47** mounting a nozzle manifold **48** to which a flexible hose **49** supplies quenching fluid. In the case of head **45**, the fluid is air to effect a mild quench. In the case of head **46** the fluid is water. Both heads are manually portable and are applied to the rail head by hand as the inductor **37** reaches its proper position in advance along the length of the rail. Head **45** is connected to inductor **37** and head **46** to head **45** by spacer rods **45***a* (see FIGURE 3) to keep them in properly spaced relation.

While the operation of the apparatus will probably be clear from the foregoing, it will be briefly summarized at this point. With the carriage **10** at its extreme right-hand position along ways **11, 12** as viewed in FIGURE 1, jaws **27** retracted and jacks **29** in the downtilted position there shown, a rail **14** is placed on blocks **26** and the jacks erected by operation of cylinders **36**. The jacks are then operated to bend the rail to the position shown, within the elastic limit, as previously explained, and jaws **27** are advanced to hold the rail in its bent condition. Jacks **29** are then retracted and tilted down.

Movement of carriage **10** along the ways is then initiated by operating motor **21** and inductor **37** is positioned close to the rail head by adjustment of platform **41** and table **40** as necessary. The inductor quickly heats the rail head from atmospheric temperature to austenitization temperature (about 2000° F. on the surface) to a depth of as much as 1½" but preferably from ¼ to 1". When the inductor has attained its proper lead as a result of continued travel of frame **10**, quenching head **45** is manually placed on the rail and rides therealong as the rail continues to move. The airjets discharged by head **45** effect a mild quench which transforms the austenitized portion of the rail head to pearlite.

Following the initial air quench, self tempering of the surface of the rail head is permitted by outward flow of heat from the interior thereof, causing the surface temperature to rise again to about 1250° F. After further travel of the rail to afford suitable spacing behind head **45**, final quenching head **46** is similarly applied to the rail head. The water jets therefrom cool the rail to atmospheric temperature, abstracting substantially all sensible heat.

After the trailing (right-hand) end of the rail has passed the inductor **37**, the quenching heads **45** and **46** are taken off in their turn and disposed ready to hand for the next rail. Jacks **29** are again erected and their piston rods extended to hold the rail ends down for withdrawal of jaws **27**, thereafter, the piston rods of cylinders **32** are backed off to ease the rail into normal condition. The rail may then be removed for further processing and carriage **10** returned to starting position.

As a specific example of the practice of our invention, standard 39' railroad rails (Section 13225) were treated in the following manner. Each rail was prebent to a curvature producing a rise of about 10½" at the midordinate, by the use of apparatus shown in the drawings. Two 3" high supports **26** were located 39" from each end of the rail and two 10" high supports were located at points 4' from the center of the rail length. The inductor **37** was energized with 960-cycle current with a power input of 230 kw. The rail **14** was passed beneath the inductor at a speed of 12½" per minute and the rail head was heated thereby above the transformation temperature to a depth of about 1". The maximum surface temperature attained was about 2000° F. The rail-head surface cooled in the ambient air to about 1350° F. prior to reaching the air-quench head **45** which was spaced 1¼' from the trailing end of the inductor. The high-pressure air from the head **45**, by an initial mild quench, transformed the austenitized portion of the rail head to a microstructure of pearlite.

After the air-quench, sufficient residual heat remained within the rail head to reheat the quenched surface thereof to a temperature of about 1250° F. for tempering. The final water-quench head **46**, which was positioned 4' from the trailing end of the air-quench head **45** delivered water sprays to the rail head at a rate of 3 gallons per minute. This quickly cooled the rail head from the tempering temperature to ambient temperature. When a treated rail was released from the clamps, it exhibited only a ½" curvature along the entire length. In addition, the head hardness ranged from 320 to 350 Brinell to a depth of ¾" along the length of the rail. The tensile properties at the hardened portion are presented in Table I.

Table I

TYPICAL TENSILE PROPERTIES OF SPECIMENS FROM NEAR THE GAGE CORNER OF THE HEADS OF SECTION 13225 RAILROAD RAILS

Treatment	Yield Strength (0.2% Offset), p.s.i.	Tensile Strength, p.s.i.	Elongation in 1 Inch, percent	Reduction of Area, percent
Induction-heat-treated	120,400	177,900	13.0	37.0
Untreated controlled-cooled	72,500	135,800	12.5	24.5

The rail also developed desirable residual compressive stresses adjacent to the head surface and at the edges of the flanges. The magnitudes of these stresses (about 35,000 p.s.i. at the head and 15,000 p.s.i. at the edges of the flanges) are such that the rails will resist failure at these locations resulting from the dynamic tensile stresses developed in service. These compressive stresses were balanced by internal residual tensile stresses up to about 25,000 p.s.i., which because of their location do not prove harmful to service performance.

Although we have described one specific example of the apparatus of our invention, all standard railroad rails and crane rails, with weights in the range of 85 lbs. per yd. to 175 lbs. per yd. may be heat-treated thereby to depths greater than 3/16" by our method at speeds ranging from 6" to 36" per minute The extent of prebending required is inversely proportional to the section modulus of the rail and the rate of heat treatment. It may vary in the range from a rise of 6" at the midordinate for the heavier sections to 18" at the midordinate for the lighter sections. At increased rates of heat treatment, the extent of prebending will be increased accordingly. The rails may be tempered within the range from 800° F. to temperatures less than the lower critical temperature of the steel. The time at temperature varies inversely with the tempering temperatures up to 12 minutes at lower tempering temperatures. Also the length of rail being subjected at any one time to austenitizing, quenching, and tempering may vary within the range of 2 to 9' depending upon the cross-sectional area of the rail and the rate of heating.

In the use of our apparatus, it is critical that an essentially pearlite microstructure be formed in the rail head. This microstructure forms at relatively high transformation temperatures; it is more ductile and, therefore, exhibits greater crack resistance than microstructures formed at lower transformation temperatures. In addition, since the desired pearlitic microstructure forms at high temperature, the necessary quench permits sufficient heat to remain in the rail head for adequate self tempering. Microstructures formed at lower transformation temperatures with a more severe quench require the application of external heat for tempering. A pearlitic microstructure is also desirable because the stresses resulting from the volumetric change during transformation from austenite aid in producing the desirable residual compressive stresses in the rail head. Furthermore, large volumetric changes, which might change the desirable stress pattern, do not occur during subsequent tempering. Microstructures, such as martensite, undergo a large volumetric change during tempering that result in undesirable residual tensile stresses in the rail head. Therefore, the micro-

structure obtained in the practice of the present invention must be esentially pearlite. It is to be understood, however, that amounts of proeutectoid ferrite up to 10% and bainite up to 25% may be present without harming the desired residual-stress pattern or the ductility.

The final water quench does not affect the mechanical properties of the rail but, when used in combination with the prebending step, produces a rail that is substantially straight. In the absence of the final water quench, the temperature variations along the length of the rail create corresponding variations in the thermal expansion of the rail. Consequently, the radius of the rail curvature varies along the heated part of the rail during heat treatment. By using a final water quench, the length of the heated portion of the rail is relatively short at all stages of the treatment; hence, the radius of curvature and the prestress in the portion of the rail length being austenitized, quenched and tempered are maintained uniform during the heat-treating operation.

Although we have disclosed herein the preferred embodiment of our invention, we intend to cover as well any change or modification therein which may be made without departing from the spirit and scope of the invention.

We claim:

1. Apparatus for heat-treating rails comprising an elongated carriage movable longitudinally, a jack pivoted to said carriage adjacent each end thereof, said jacks being adapted to force toward the carriage the ends of a rail disposed thereon in alinement therewith but spaced thereabove, thereby bending the rail, an electromagnetic inductor adapted to embrace the head of the rail progressively as the carriage moves and means adjacent the path of the carriage mounting said inductor for angular movement to conform to the angle of deflection of the rail from point to point therealong.

2. Apparatus as defined in claim 1, characterized by power means for tilting said jacks from inoperative to operative position.

3. Apparatus as defined in claim 1, characterized by means for adjusting said mounting means vertically

4. Apparatus as defined in claim 1, characterized by hold-down jaws on said carriage adapted to engage the ends of a rail.

5 Apparatus as defined in claim 4, characterized by power means for advancing and retracting said jaws.

6. Apparatus as defined in claim 1, characterized by spaced ways supporting said carriage and hold-down plates secured to the carriage and dove-tailed into said ways.

References Cited by the Examiner

UNITED STATES PATENTS

1,865,070	6/32	Amsler	153—38
2,223,970	12/40	Stansel	238—122
2,261,949	11/41	Bender	153—38
2,831,788	4/58	Bridge et al.	148—150 X

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