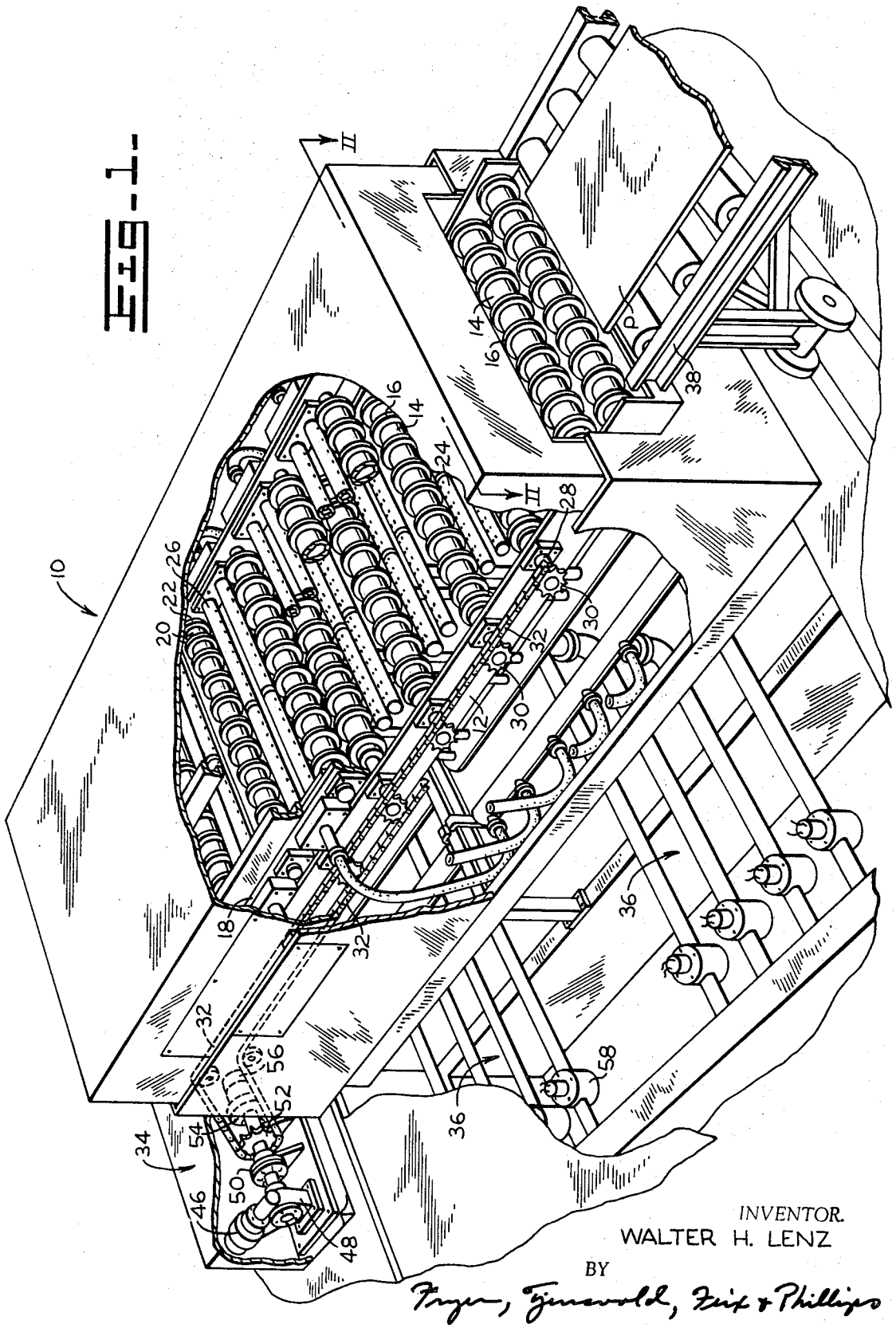
Dec. 15, 1970 W. H. LENZ 3,546,911

APPARATUS FOR QUENCHING STEEL PLATE

Filed March 29, 1965 4 Sheets-Sheet 1

Fig. 1.



INVENTOR.
WALTER H. LENZ
BY
Fryer, Tjensvold, Feix & Phillips
ATTORNEYS

Dec. 15, 1970 W. H. LENZ 3,546,911

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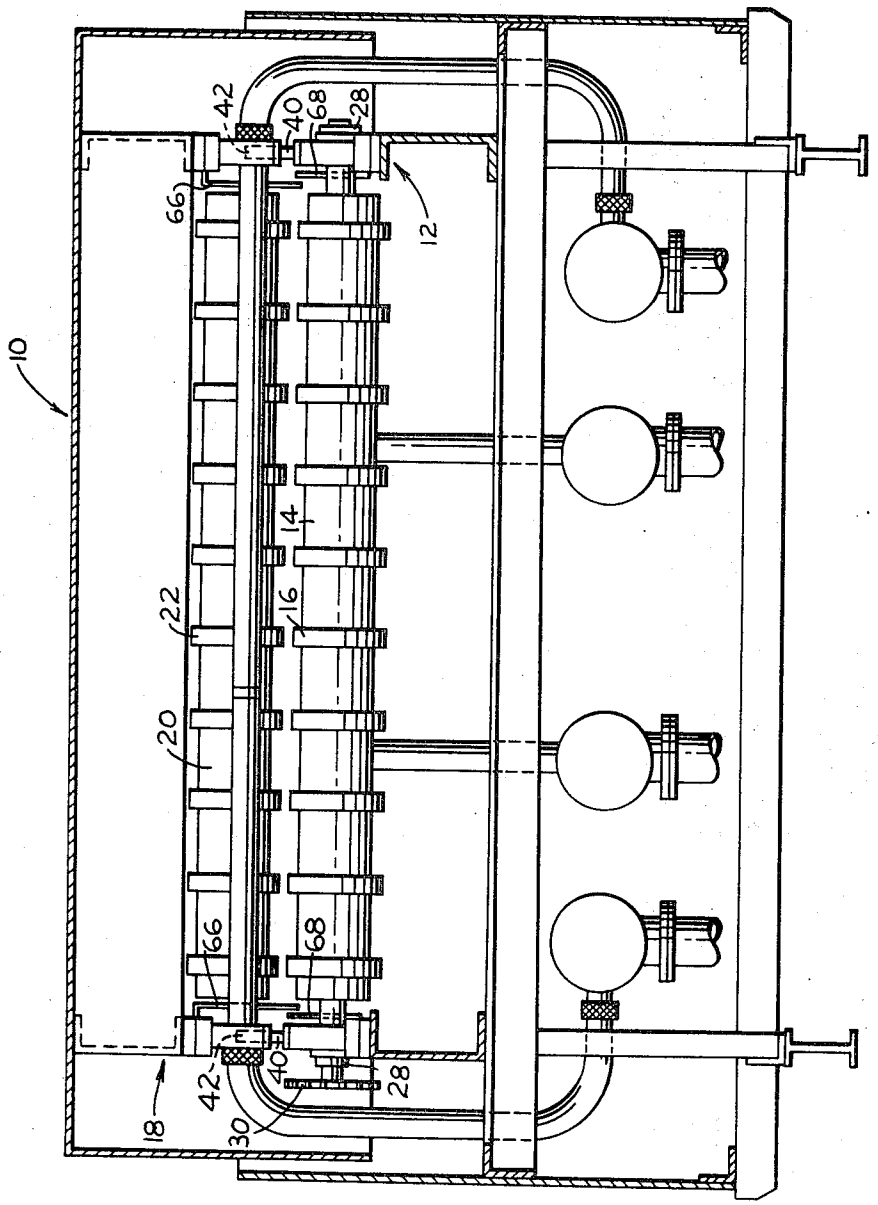
Fig-2-



INVENTOR.
WALTER H. LENZ

BY

Fryer, Tjensvold, Feix & Phillips

ATTORNEYS

Dec. 15, 1970 W. H. LENZ 3,546,911

APPARATUS FOR QUENCHING STEEL PLATE

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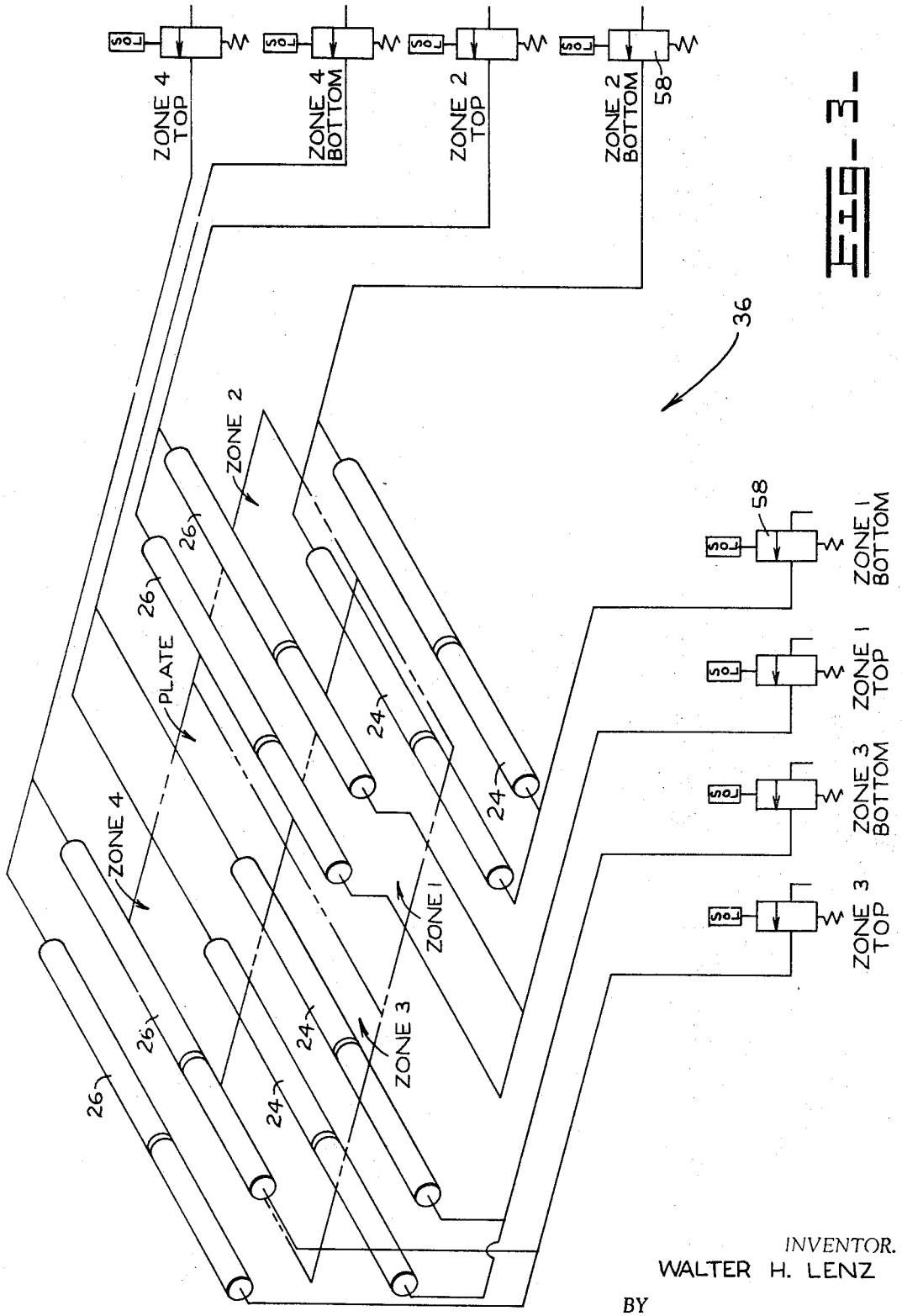

FIG. 3

INVENTOR.
WALTER H. LENZ

BY

Fraser, Trimmer, Feit & Phillips

ATTORNEYS

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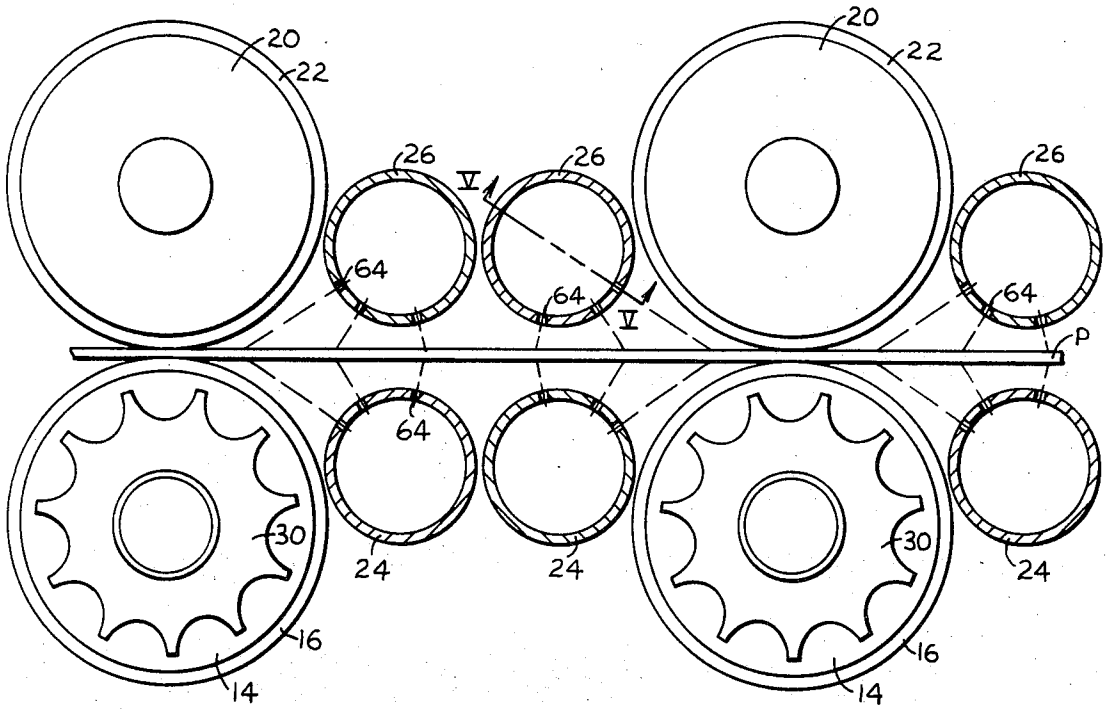
Fig. 4.



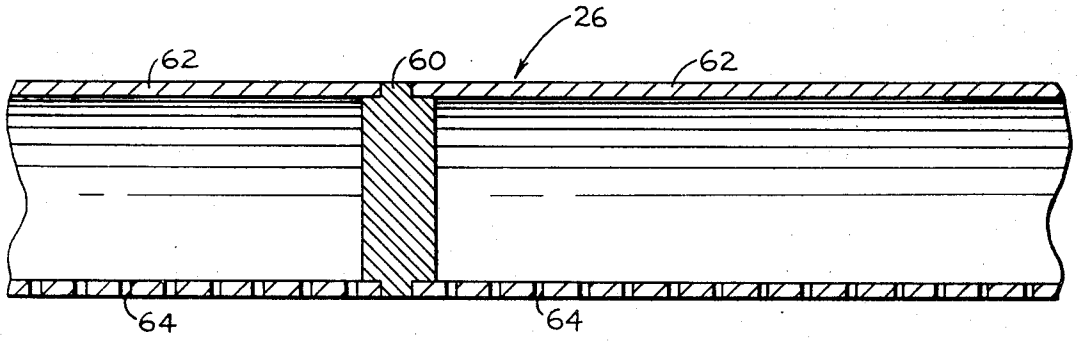


Fig. 5.

INVENTOR.
WALTER H. LENZ

BY

Fryer, Tjensvold, Feix & Phillips

ATTORNEYS

United States Patent Office 3,546,911
Patented Dec. 15, 1970

3,546,911

APPARATUS FOR QUENCHING STEEL PLATE

Walter H. Lenz, Washington, Ill., assignor to Caterpillar Tractor Co., Peoria, Ill., a corporation of California

Filed Mar. 29, 1965, Ser. No. 443,558
Int. Cl. B21b 27/10; C21d 1/62
U.S. Cl. 72—201 2 Claims

ABSTRACT OF THE DISCLOSURE

Apparatus for quenching steel plate by holding it between sets of rollers which retain it in flat condition and also driving the rollers to reciprocate the plate while applying quench in such large quantities as to maintain the plate entirely immersed in quench.

Success in increasing the horsepower and performance of engines used in all types of automotive equipment has dictated corresponding increases in strength and durability of its mechanisms and structural members. Where it is economically justifiable, it is the practice to employ steel having various alloying ingredients which provide such increases in strength and durability. Attempts in conditioning low-carbon steel plate having the desired properties have met with limited success due to non-uniform hardness characteristics and plate warpage.

Treatment of low-carbon steel plate to produce desired physical properties of toughness and resistance to deflection is presently accomplished by use of a platen press employing hold down fingers which engage the plate while it is being quenched. The plate produced by this method of treatment fails to give the desired physical properties mainly because of non-uniform and rather slow quenching and because the hold down fingers conduct heat from the plate before and at a different rate than the quenching fluid. These fingers also tend to baffle the water during the quench.

Experiments conducted with low-carbon steel plate have shown that the rate and uniformity of quench are of paramount importance to achieve desired qualities of toughness and flatness. In achieving this result, the method of the present invention locates the plate desired to be processed between sets of ribbed rolls, functioning to straighten the hot-plate prior to its being quenched, and then sprays water or other suitable quenching fluid to the opposite sides of the plate so held by the ribbed rolls. By providing ribbed rolls the area of plate contact is minimal thus substantially reducing the quantity of heat transferred from the plate, and the quenching fluid is supplied in sufficient quantities to actually flood the plate.

It was found that 70 to 150 gallons per minute per square foot of surface on each side of the plate resulted in a rate of quenching which prevented the plate from buckling or warping.

Although the particular apparatus disclosed in this invention is merely representative of a preferred form of construction, the basic functions thereof were dictated by the salient method steps. The apparatus is so designed that a plate approximately 12 feet long and 48 inches wide may have a selected portion thereof quenched. This is accomplished by providing selectively operable spray bars, overlying the upper and lower surface of the plate, and suitable controls to admit water or other suitable quenching fluid to desired ones of such spray bars. In this manner, it is possible to quench a longitudinal strip of the plate or a portion extending the entire width and a portion of its length. For example, it is possible to quench a strip 18 inches wide and 12 feet long or a strip 48 inches wide and 6 feet long.

In contrast to present quenching practices, the plate

quenched by the present invention is "waltzed" or reciprocated between selected limits during the quenching operation. Such reciprocation insures uniform quenching and assists in maintaining the plate flat.

Accordingly, it is an object of this invention to quench steel plate by a method which maintains its flatness.

Another object of this invention is to prevent distortion of flat steel plates by uniformly and simultaneously distributing quenching fluid to the surfaces of such plate.

Another and more particular object of this invention is to quench steel plates in order to maintain their flatness by a method whereby the plate is reciprocated while it is being subjected to large quantities of sprayed quenching fluid.

A further object of this invention is to provide an apparatus for carrying out the method of this invention.

Another object of this invention is to reciprocate and restrain a flat plate against distortion during the quenching operation.

Still another object of this invention is to provide a new and improved plate quenching apparatus which is automatic in operation.

These and other objects and advantages of the invention will, however, hereinafter more fully appear in the course of the ensuing description.

Reference will now be made to the drawings for a more particularized disclosure of the invention, wherein:

FIG. 1 is a perspective, with parts broken away, showing a preferred form of the apparatus for carrying out the method;

FIG. 2 is an enlarged transverse section taken substantially along the line II—II of FIG. 1;

FIG. 3 is a diagrammatic perspective of a representative number of spray bars, the quenching fluid distribution system, and a suitable plate shown in phantom outline and which is divided into four quenching zones;

FIG. 4 is an enlarged side view of FIG. 1 showing a plate located between the roller frame and the spray pattern of the spray bars; and

FIG. 5 is a longitudinal section of a spray bar taken substantially along the line V—V of FIG. 4.

Now, referring to FIG. 1, it will be seen that the quenching apparatus constructed according to this invention includes a quenching unit **10** being in the form of an elongate, generally rectangular, housing and including a lower stationary roller frame **12** rotatably supporting a plurality of longitudinally spaced transversely extending rollers **14** which are provided with regularly axially spaced ribs **16**. A vertically reciprocable roller frame **18**, including similarly formed rollers **20** rotatably mounted thereon is positioned so that rollers **20** are in vertical alignment with the rollers **14**. Ribs **22** are also formed on the rollers **20** and are located to be co-planar with the ribs **16**.

The longitudinal spacing of the rollers **14** and the rollers **20** are sufficient to provide the inclusion of spray bars **24** and **26** being associated, respectively, with the frame **12** and the frame **18**. Each of the rollers **14** has reduced diameter portions extending through bearings **28** which are suitably mounted on the side rails of the frame **12**. These reduced diameter portions have sprockets **30** rigidly mounted thereon which are in meshing engagement with suitable chains **32** being driven by a drive mechanism **34**.

The drive mechanism **34** is associated with a control circuit which is responsive to the position of a plate located in the quenching unit to cause reversible rotation of the rollers **14**. A quenching fluid distribution system generally indicated by the numeral **36** is arranged to provide flow of quenching fluid to selected ones of the upper and lower spray bars so that if it is desired just a portion of the plate may be quenched. Of course,

this quenching fluid distribution system is also operable to supply quenching fluid to all of the upper and lower spray bars at the same time.

As shown in FIG. 1, a hot-plate, indicated by the letter "P" and supported on a suitable transport table **38**, is fed between the forward-most lower and upper sets of rolls whereupon the plate is transported inwardly into the quenching unit for processing.

Referring now to FIG. 2 which shows a vertical transverse section of the quenching unit **10**, it will be seen that the upper rollers **20** have their ribs **22** closely adjacent the ribs **16** of the lower rolls **14**. When a plate is inserted into the quenching unit, its thickness is sufficient to cause upward movement of the roller frame **18** and in this manner pressure is applied to the opposite surfaces of the plate while it is in the quenching unit. To allow such vertical movement of the upper frame **18**, there are provided vertical guide rods **40** which are secured to the stationary frame **12** and are received in suitable bores **42** formed in the upper frame **18**. Accordingly, when the plate is fed into the quenching unit, the upper frame **18** moves upwardly and its weight is transferred to the plate through the ribs **22** and in this manner the power is imparted to the lower rollers **14** by the drive mechanism **34** causing rotation of the upper rollers which are in frictional engagement with the plate. By providing ribbed rolls, spaced longitudinally of the plate, a minimum area of contact results since each of the ribs in contact with the plate establish line contact which assists in reducing transfer of heat from the plate to the rolls and consequently prevents premature partial quenching.

After the plate has reached a pre-determined position in the quenching unit **10**, an electrical circuit is energized conditioning the drive mechanism **34** to alternate the direction of rotation of the rollers **14** in order to reciprocate the plate during the quenching operation. In the form illustrated in FIG. 1, the drive mechanism **34** may include a motor **46** for drawing the plate P into the quenching unit **10** and for ejecting the plate P from the unit at relatively high speed. The motor **46** is connected to a gear reduction unit **48** on whose output shaft is mounted an electric clutch **50**. In this arrangement, the sprocket chain **32** is trained about a drive sprocket **52** which is connected to a shaft extending from the electric clutch **50** to a second electric clutch **54** which is in turn connected to the output shaft of a torque motor **56**. The motor **56** is controlled to drive the chain **32** first in one direction for a fixed period of time and then to drive the chain **32** in the opposite direction for a fixed period of time so as to move the plate P back and forth between the orifices. The direction of rotation of motor **56** and the duration of rotation in either direction can be controlled manually or automatically by limit switches and timers. The motor **56** preferably operates at a lower speed than the motor **46**.

When a plate P to be heat-treated is placed on the transport table **38** in the position shown in FIG. 1, the operator closes the switch energizing the motor **46** and the clutch **50** in a direction causing the lower rolls **14** to draw the plate into the quenching unit. As the plate progresses inwardly a sufficient distance, it encounters a limit switch which opens a circuit de-energizing the motor **46** and the clutch **50** while at the same time the torque motor **56** and the clutch **54** are energized. At substantially the same time as the motor **56** and the clutch **54** are energized, quench valves **58** are opened permitting a quenching fluid to be distributed to the upper and lower sets of spray bars. As noted above, the control circuit may include timers (not shown) of conventional design which operate to maintain the motor **56** and the clutch **54** energized for a predetermined period of time during which the plate is "waltzed" or reciprocated between selected limits in the quenching unit by periodically changing the direction of rotation of motor **56**. Upon elapse of this period of time, the timer de-energizes the motor **56** and the clutch **54**, closes the quench valves **58**, and energizes the motor **46** and the clutch **50** which now causes rotation of the lower rolls **14** in a direction which ejects the plate from the quenching unit onto the transfer table **38**. In an alternate form of drive mechanism **34** (not shown) a single two-speed motor can be arranged to produce the same function as provided by the two motors **46** and **56**.

Thus, it is seen that the quenching apparatus according to this invention is automatically operable to insure uniform and rapid quenching of a plate and at the same time prevents warping or distortion of the plate while it is being quenched.

Referring now to FIG. 3 which shows the arrangement of the quenching fluid distribution system and selected ones of the upper and lower spray bars, it will be seen that the plate illustrated in phantom outline located between the upper and lower spray bars **26** and **24**, respectively, is divided into four areas designated as Zones **1**, **2**, **3**, and **4**. In accordance with one of the basic features of this invention, the quenching fluid distribution system **36** can be conditioned for operation whereby a selected portion of each plate may be more severely quenched than the remaining portion. For example, the spray bars may be operated to apply much greater quantities of quenching fluid to Zones **1** and **3** and thereby quench a longitudinal strip of the plate which will have a value of hardness greater than the longitudinal strip defined by Zones **2** and **4**; or the quenching fluid may be distributed so that Zones **1** and **2** or **3** and **4** may be quenched more severly to thereby produce selected values of hardness. Not only are the quench valves **58** programmed to open or remain closed in the event it is desired to produce selective quenching, but the spray bars themselves are constructed in a manner which assists in producing such selective quenching.

Referring to FIG. 5 which shows a longitudinal section of a typical spray bar, which for matter of convenience has been chosen as one of the upper spray bars **26**, it will be seen that it includes a transverse disc shaped wall **60** to which is attached oppositely extending longitudinally aligned tubes **62** being provided with a series of orifices **64** through which issue the quenching fluid. Quenching fluid is admitted to either of the tubes **62** by a separate manifold which is part of the quenching fluid distribution system. In this way, it is readily apparent that when the appropriate quenching valve **58** is open communicating quenching fluid to one of the tubes **62**, no fluid will flow through the other tube if the corresponding quenching valve is closed.

Referring again to FIG. 3, it will be seen that by opening the quenching valves **58** supplying quenching fluid to the spray bars overlying and underlying zones **1** and **3** while the quenching valves supplying the spray bars overlying and underlying Zones **2** and **4** are closed, selective quenching of the plate occurs.

Referring to FIG. 4 which shows an enlarged longitudinal section of a portion of the quenching unit with the plate located between the lower and upper rolls, it will be seen that sufficient distance is provided between the sets of rolls to accommodate two spray bars. Each of the spray bars is provided with three rows of orifices **64** to produce a spray pattern which substantially evenly distributes equal amounts of quenching fluid per unit of area of the plate. Upon initiation of the quenching operation, quenching fluid is distributed in streams produced by each orifice **64** but shortly thereafter the orifices become submerged since the quenching unit is constructed to actually flood the plate. Flooding of the area above and below the plate and submerging of the spray bar orifices is accomplished by the spacing of the spray bars and rollers associated with the roller frames **12** and **18** (FIG. 2). During the quenching operation, the area adja-

cent the upper and lower plate surfaces fills with the quenching fluid submerging the plate and the orifices **64** of spray bars **24** and **26**. In order to prevent rapid escape of quenching fluid along the lateral sides of the quenching unit **10**, baffle plates **66**, supported by the roller frame **18**, and overlapping baffle plates **68** are supported on the stationary frame **12**.

Accordingly, during the quenching operation which occurs while the plate is being "waltzed" or reciprocated between the desired selected limits. the quenching fluid issuing through the orifices **64** of the upper and lower spray bars is of sufficient quantity to submerge all orifices **64**. It has been found that a value of pressure of 50 pounds per square inch at each of the orifices **64** produces a high degree of turbulence or wiping of the quenching fluid which in turn assures a substantially uniform and rapid rate of heat transfer from the plate being treated.

Thus, according to this invention, it will be seen that a quenching procedure is obtained which holds a plate to assume a planar configuration and while being so held, the plate is "waltzed" or reciprocated and quenched for a pre-determined period of time.

I claim:

1. Apparatus for quenching steel plates comprising spaced support rollers arranged to support the plate to be quenched at intervals throughout the plate's entire length and width, pressure rollers disposed above the plate and registering with the support rollers to hold the plate flat, a plurality of integral circumferential ribs spaced axially along the length of said support rollers and upper rollers and wherein the outer circumferential surfaces of said ribs contact said plate, means to rotate said support rollers in opposite directions during sequential periods of time to cause the plate to reciprocate while being confined between the support and pressure rollers, and perforated tubes for liquid quench arranged between some of the pressure rollers to spray quench downwardly against the plate as it reciprocates, and similar tubes between some of the support rollers simultaneously to spray quench upwardly against the plate, and the spacing between the said support and pressure rollers and the quench tubes associated therewith being limited such as to retard the flow of quenching fluid to the extent that the entire plate is immersed during the quenching operation.

2. Apparatus for quenching steel plates comprising spaced support rollers arranged to support the plate to be quenched at intervals throughout the plate's entire length and width, upper rollers disposed above the plate and registering with the support rollers to maintain the plate flat, a plurality of integral circumferential ribs spaced axially along the length of said support rollers and upper rollers and wherein the outer circumferential surfaces of said ribs contact said plate, means to rotate at least said support rollers in opposite directions during sequential periods of time to cause the plate to reciprocate while being confined between the support and upper rollers, and perforated tubes for liquid quench arranged between some of the upper rollers to spray quench downwardly against the plate as it reciprocates, and similar tubes between some of the support rollers simultaneously to spray quench upwardly against the plate.

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CHARLES N. LOVELL, Primary Examiner

U.S. Cl. X.R.

148—131, 153, 155, 157; 266—6