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Continuation-in-part of application Ser. No.
504,342, Oct. 24, 1965, now abandoned.

[56]

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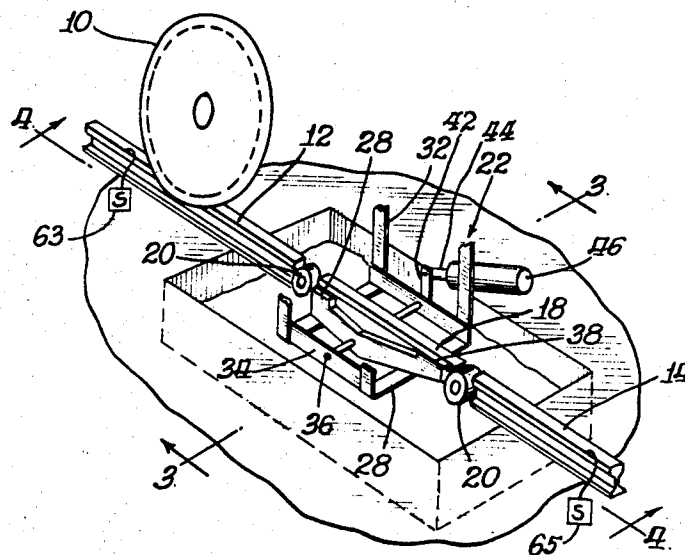
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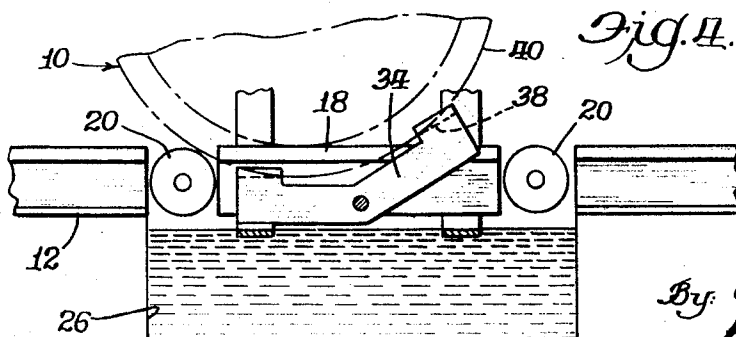
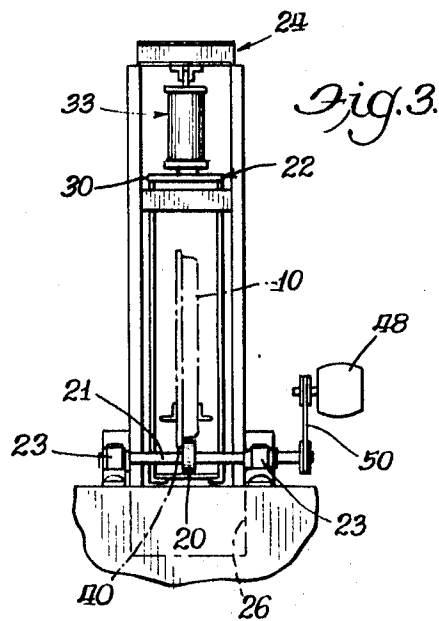
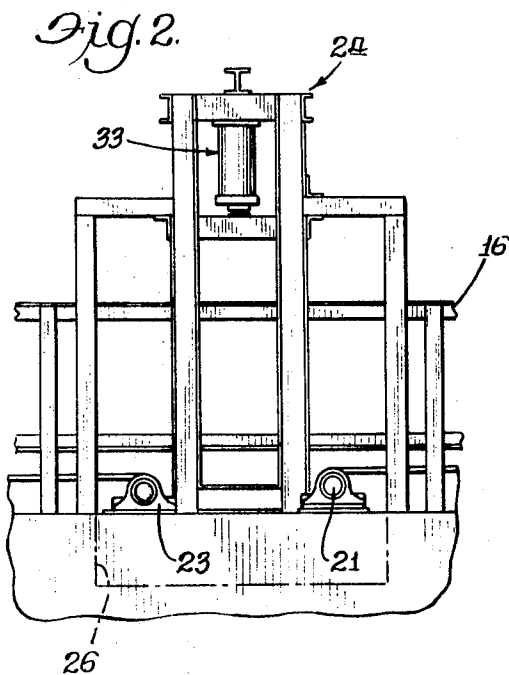
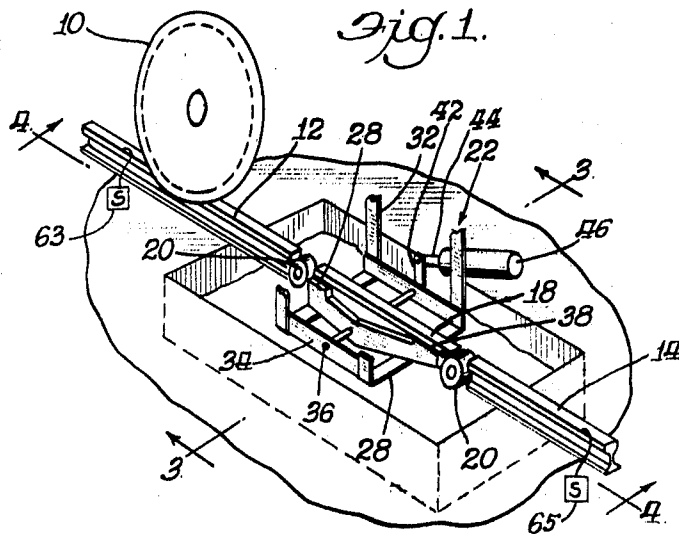
[54] **METHOD AND APPARATUS FOR MANIPULATING
AND TESTING RAILWAY WHEELS**
15 Claims, 11 Drawing Figs.

- [52] U.S. Cl. 73/67.8
[51] Int. Cl. G01n 24/00
[50] Field of Search 73/67.5,
67.9, 41, 41.2, 146

ABSTRACT: An apparatus is provided for moving railway wheels into and out of a testing station where they are lowered into a tank containing water and rotated in an upright position. During rotation, ultrasonic devices located within the tank test the wheel for internal defects and warpage. The wheel is then ejected from the testing station.



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Fig. 7

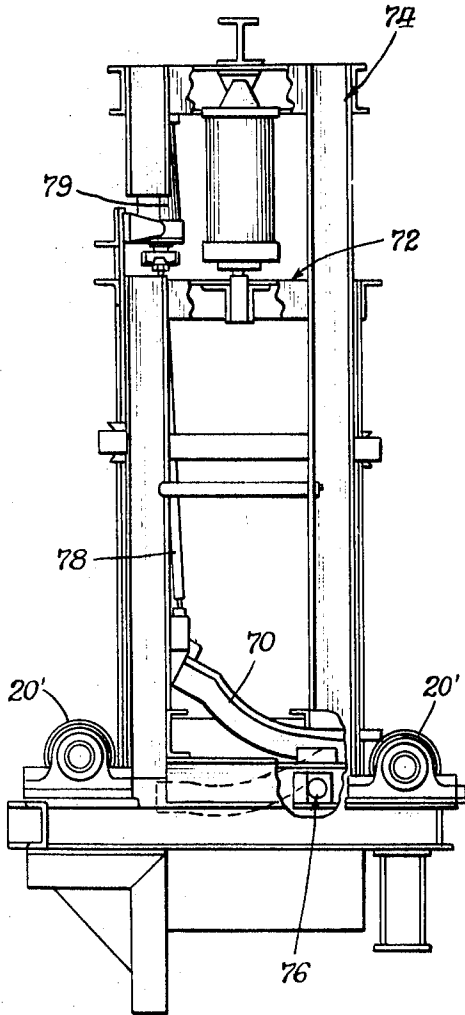


Fig. 8

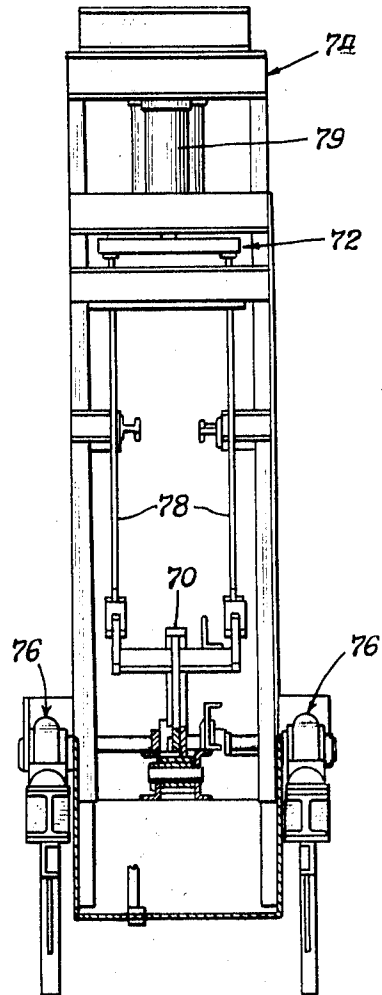
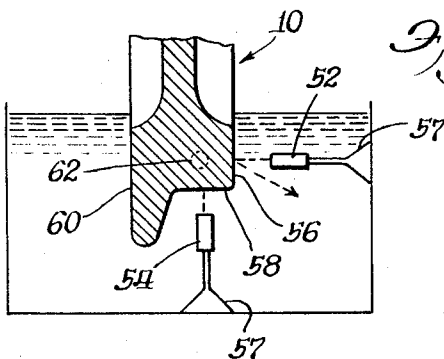


Fig. 5



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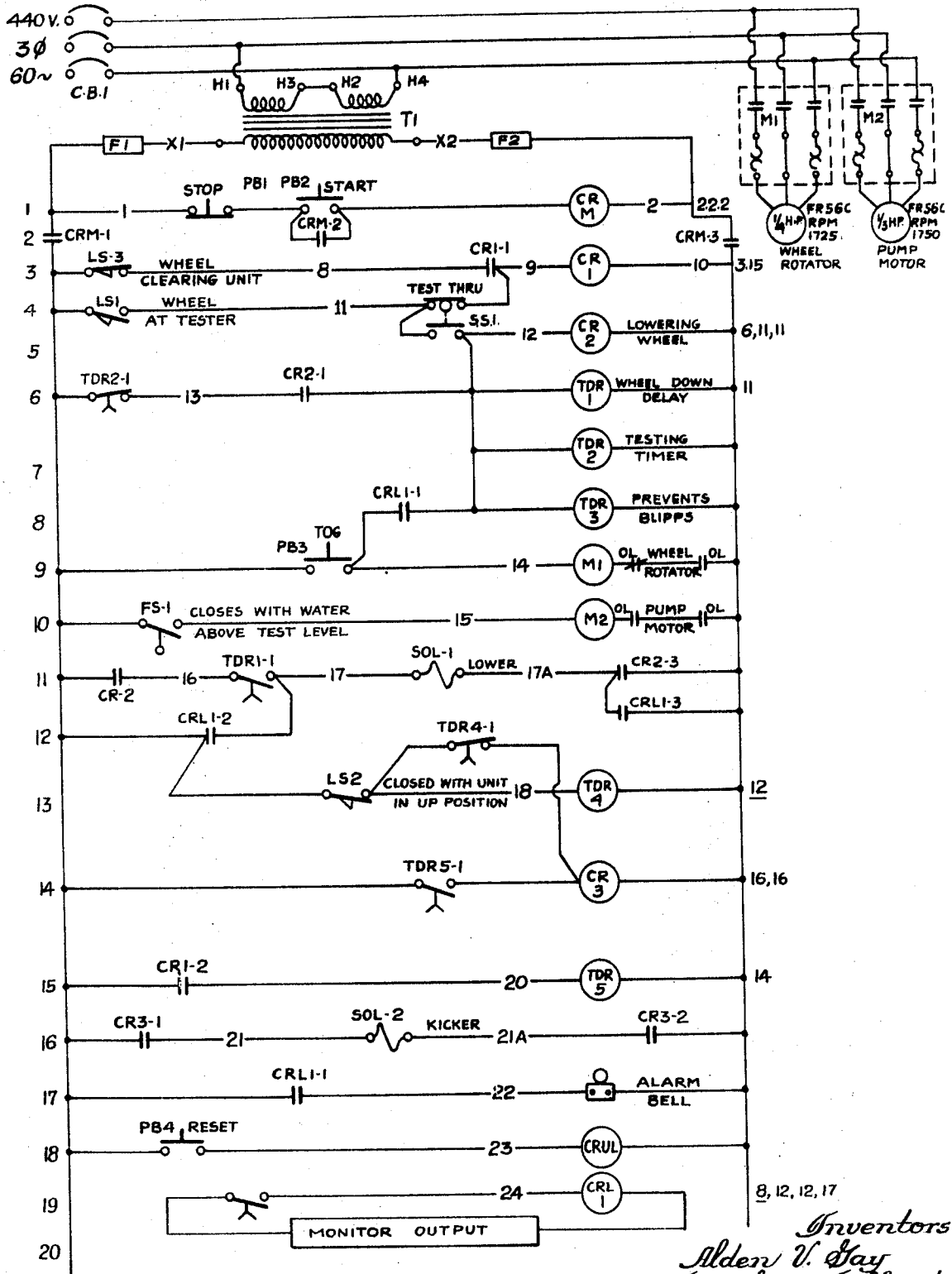


Fig. 6.

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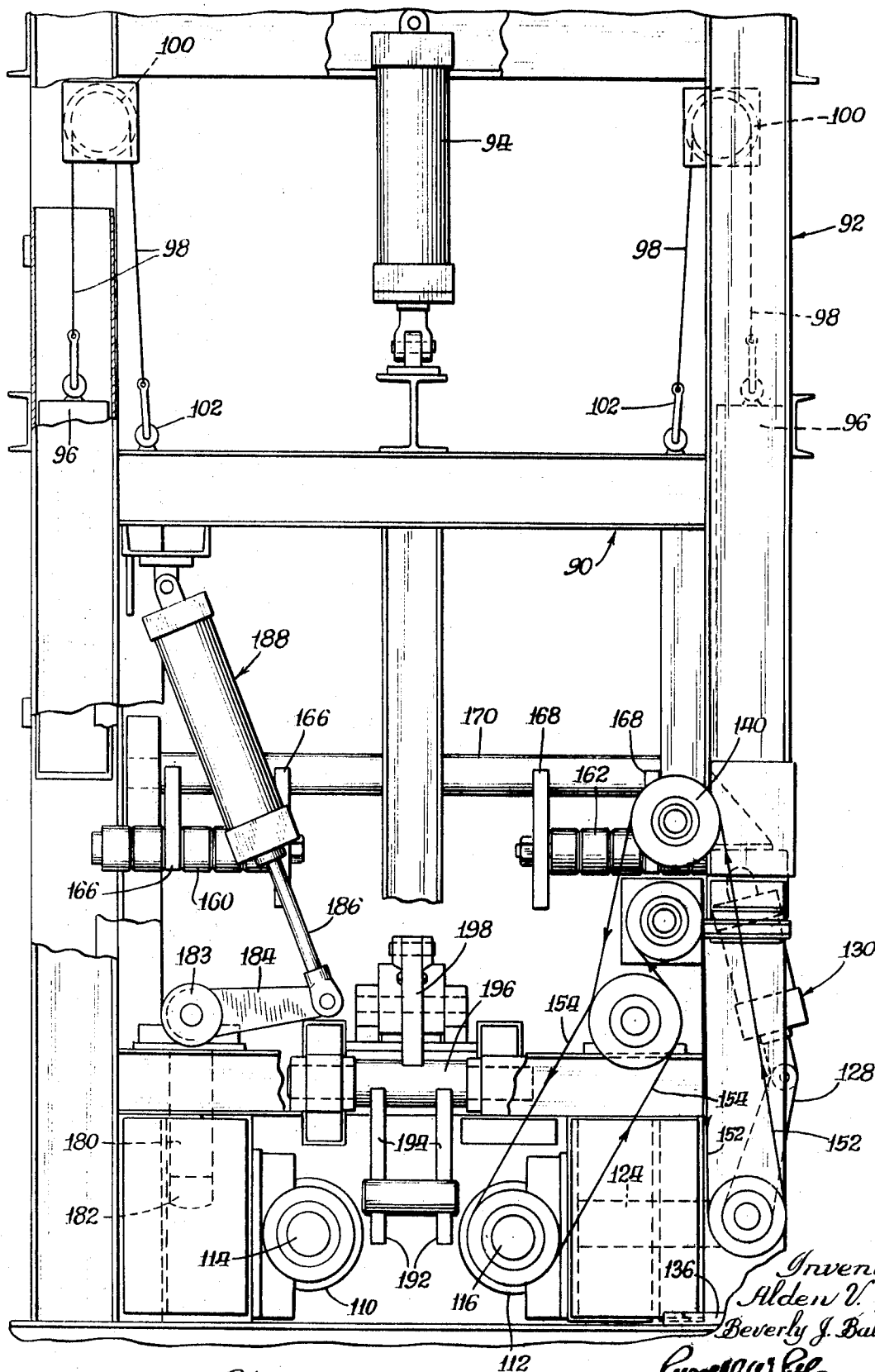
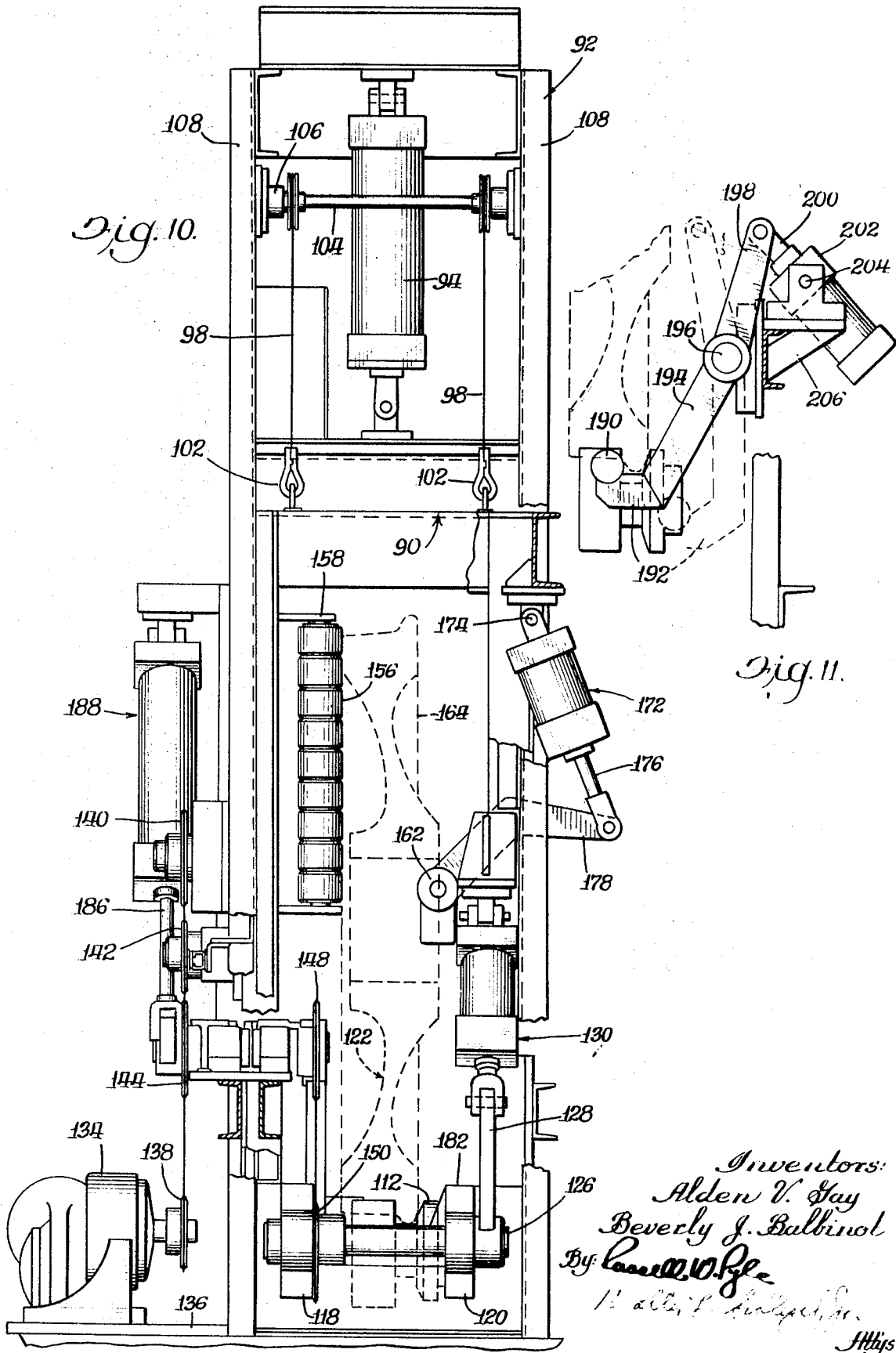


Fig. 9.

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METHOD AND APPARATUS FOR MANIPULATING AND TESTING RAILWAY WHEELS

This is a continuation-in-part of copending application Ser. No. 504,342, filed Oct. 24, 1965 now abandoned. The invention relates to a method and apparatus for manipulating and testing railway wheels and more particularly to such a method and apparatus especially suitable for use in a production line operation wherein the wheels are to be tested for internal defects and warpage.

In the production of railway wheels by conventional casting methods, defects have sometimes been found to occur near the outer periphery of the structure, which might further result in faults under actual prolonged service conditions. Railway wheels and other similar objects, because of their high weight and unusual shape, have heretofore been difficult to manipulate in such a manner as to be efficiently and rapidly tested in a production line operation.

Accordingly, an object of this invention is to provide a fully automatic method and device for manipulating and testing wheels in a production line operation.

Another object is to provide an automatic apparatus for stopping such a wheel at a testing station, lowering the wheel into a tank, rotating the wheel in coordination with an ultrasonic transducer, and thereafter raising and ejecting the wheel from the testing station.

Other objects will become apparent from an examination of the following description and appended claims taken in connection with the accompanying drawings wherein:

FIG. 1 is a perspective schematic view of one of the principal components of the apparatus for handling the wheels in the testing operation;

FIG. 2 is an elevational view of structure and mechanism shown in FIG. 1;

FIG. 3 is a transverse vertical view taken at line 3-3 of FIG. 1;

FIG. 4 is a view taken at line 4-4 of FIG. 1;

FIG. 5 is an enlarged fragmentary sectional view showing the positions of the wheel and sensing head in the water tank;

FIG. 6 is a schematic of an electrical circuit which may be used in connection with the present invention;

FIG. 7 is a side view of another embodiment of the present invention;

FIG. 8 is an end view of the structure shown in FIG. 7;

FIG. 9 is a side view of a further embodiment of the invention;

FIG. 10 is an end view of the embodiment shown in FIG. 9; and

FIG. 11 is a detailed view of a portion of the device shown in FIG. 9.

It is known that certain crystals, such as quartz or lithium sulfate exhibit piezoelectric properties which may be used in various ways. The application of a pulsating electric current to such a crystal at a given frequency will result in excitation or vibration of the crystal at the same frequency. In the same manner, reflections of such sound waves back from a solid object cause mechanical pressures to be imposed upon such a crystal, thereby producing small electrical pulses which may be amplified and accurately measured. By measuring such reflections received from an exterior surface and possibly an interior surface in the form of an echo of a solid object, it is possible to detect internal voids and other defects, which give rise to intermediate signals that are out of phase with the signal normally received.

It has been found that in many applications, ultrasonic vibrations cannot be effectively transmitted through air, and an appropriate medium must be employed. One technique involves direct contact of the crystal against the object to be tested which has been coated with an appropriate coupling medium, such as grease, oil or glycerine. This method has been found to be inefficient for the testing of large objects, and the grease, oil or other couplant, in the usual case, must be removed after completion of the test.

The present invention contemplates an apparatus for automatically testing such large objects by immersion wherein the ultrasonic waves are conducted through the medium of water without the necessity of contacting the object with the crystal. Such an apparatus is shown schematically and in a highly simplified form in FIGS. 1-3.

FIGS. 1-3 illustrate a production line testing station for railway wheels wherein a single wheel 10 is shown rolling along a production line track including an entrance rail 12 and an exit rail 14. Suitable means, such as fixed horizontal guard rails 16 (FIG. 2), are provided to maintain the wheel in an upright position, although it is desirable to maintain the wheel in a balanced state on the rail. A short segment 18 of rail is positioned in alignment between the rails 12 and 14, and rollers 20 are interposed between both ends of rail segment 18 and the respective opposing ends of rails 12 and 14. As shown in FIG. 3, the rollers 20 are each mounted on a shaft 21 journaled at both ends in bearing supports 23 secured on the stationary framework 24, mentioned below.

A vertically movable carriage 22, provided within a stationary framework 24, is used for immersing the rim of the wheel in a water pit 26 located below the carriage. The carriage 22 includes a bottom framework 28 and a top framework 30 interconnected by a plurality of vertical supporting members 32. A power hydraulic cylinder 33 is connected between the top of stationary framework 24 and the carriage 22 for reciprocation of the carriage into and out of the water pit 26.

A bar 34 secured at its midpoint to a shaft 36 journaled in the carriage 22 and movable therewith, is provided to stop and thereafter eject the wheel from the testing station. As shown in FIGS. 1 and 4, the ends of the bar 34 have upwardly extending V-shaped notches 38 which receive the flange 40 (FIG. 3) of a wheel 10 traveling on rail segment 18. The ends of the bar 34 are inclined upwardly to provide clearance between the middle portion thereof and the wheel flange 40. A crank 42 (FIG. 1) is secured at one end of the shaft 36, and the piston rod 44 of a power cylinder 46 is pivotally connected to said crank for rotation of the shaft and bar.

As best illustrated in FIGS. 1 and 4, a wheel 10 entering a testing station rolls off entrance rail 12 onto rail segment 18 whereupon the wheel is stopped by engagement of its flange 40 with the notches 38 of the bar 34. The bar 34 is rotated and the carriage is lowered to bring the wheel 10 into engagement with the rollers 20, one of which is driven by a motor 48 operatively connected by means of drive belts 50 to the corresponding roller shaft 21 (FIG. 3). When the wheel is resting on the rollers 20, its position is such that the rim of the wheel is immersed in the water-filled pit 26. The wheel is tested during rotation in the manner previously described and then raised by actuation of the power cylinder to the level of the exit rail 14. Power cylinder 46 (FIG. 1) is then actuated to rotate the shaft 36 and bar 34, whereby the wheel is ejected onto the exit rail 14 and away from the testing station.

As shown in FIG. 5, the rim of the wheel 10 is immersed in water during the testing operation, the water acting as a couplant for the ultrasonic waves emitted from one or more transducers containing piezoelectric crystals, such as those shown at 52 and 54. The transducers 52 and 54 are located below the water level and are aimed at an exterior surface of the wheel. A source of pulsating electric current (not shown) having a frequency in the range of 100 to 1000 cycles per second is connected to the transducers 52 and 54 in order to produce the desired signal.

The transducers 52 and 54 are most advantageously positioned in a perpendicular relationship to one another, with one 52 being parallel to the axis of the wheel aimed at the back face 56 of the rim, the other being perpendicular to the axis of the wheel and aimed at the tread 58 thereof. The transducers are also capable of receiving the signals reflected from the wheel, and such signals may be monitored by any suitable conventional device, such as an oscilloscope.

By rotating the wheel for at least one complete revolution, it is possible to inspect the entire wheel for internal defects. The

signals received from the transducer 52 parallel to the axis of the wheel will normally be of two pulses: that pulse directly reflected from the external surface 56 of the wheel and a pulse, in the form of an echo, reflected from the opposing internal surface 60. The presence of an internal defect, such as indicated at 62, will cause a separate, intermediate signal to be produced, which may be monitored by the use of an appropriate monitoring device. The other transducer 54 will receive a direct reflection from the tread 58 and will also receive a secondary pulse when a defect is encountered. The use of two or more transducers makes it possible to inspect the entire outer periphery of the wheel in areas where defects are most likely to occur. The transducers are preferably adjustably mounted in suitable brackets, such as that schematically shown at 57, so as to enable universal positioning relative to any size wheel.

The electric circuit enabling the device to operate in an automatic manner is illustrated in FIG. 6. Upon closing circuit breaker 1, 440 vac., 60 c.p.s. 3 phase, is made available and 110 vac., 60 c.p.s., 1 phase, is made available to the control circuit by means of stepdown transformer T-1.

The incoming wheel to be tested trips a strategically located limit switch LS1 (shown at 63 in FIG. 1), which energizes relay CR2, time delay relays TDR1, TDR2 and TDR3, as well as starter motor coil M1, thereby causing one of the rollers 20 to rotate and rotate the wheel supported thereon. TDR1 is set for a sufficient length of time to allow a short delay before the wheel is lowered. TDR2 is set for the time required to lower and thereafter rotate the wheel for about $1\frac{1}{4}$ revolution. TDR3 is set for a time sufficient to enable the wheel to become stabilized and lowered.

In a preferred sequence, the circuit operation is as follows: the wheel in the station is lowered with the activation of CR2 through contact CR2-1 after a short period of time for which TDR1-1 is set, by opening solenoid valve SOL-1 (cylinder 34). During this time, TDR3-1 closes (after stabilization of the wheel), which completes the circuit to a conventional monitoring device. One such device is the "Transigate E-550," manufactured by Sperry Products of Danbury, Connecticut. The TDR3 contact therefore prevents spurious signals emitted from the monitoring device from entering the circuit until the wheel is rotating in the testing pit.

As mentioned previously, ultrasonic signals are transmitted from the transducers 52 and 54 to the wheel and reflected therefrom. If a defect is encountered, an intermediate signal will be received which may be selectively detected by the monitor. Such an intermediate signal is amplified to produce an electric pulse sufficient to energize the latching control relay CRL1, whereupon the following occurs: CRL1-1 opens immediately opening a conductor 14 to deenergize M-1, whereby wheel rotation is stopped; CRL1-2 and CRL1-3 close to hold the wheel in a lowered position notwithstanding the normal sequence of events, since SOL-1 is held open; and alarm bell on conductor 22 sounds.

If desirable, the operator may then rotate the wheel in steps by depressing the "JOG" PB-3, which activates M1. By visually observing signals on an oscilloscope, the operator may thereby determine the exact location of the defect. In order to re-activate the alarm circuit, PB-4 ("RESET") is depressed to unlatch CRL1 through unlatching control relay CRUL on conductor 23.

If no defect is encountered, the wheel continues to rotate in a lowered position until TDR2 deenergizes the lowering circuit through its contact TDR2-1, which opens. SOL-1 closes and the carriage moves into its upper position. LS2 is a switch mounted in any convenient location on the apparatus, which closes when the carriage is in up position. Meanwhile, TDR5 through contact TDR5-1 activates CR3 and TDR4. CR3 operates SOL-2 through CR3-1 and CR3-2, which causes the kicker (power cylinder 46 in FIG. 1) to eject the wheel from the testing station. TDR4 through contact TDR4-1 maintains SOV-2 activated until the wheel clears the testing station. The unit is now in readiness for the next wheel. FS1 is a float

switch which energizes M2 of a pump motor when the water in the pit is below a predetermined level.

The device may also be operated to automatically eject the incoming wheels without testing. For this purpose, SS1 is set in the "thru" position. The incoming wheel closes LS1, and CR1 activates CR1-1 and CR1-2, whereupon the kicker circuit is utilized to eject the wheel through TDR5 and CR3 and their contacts as hereinbefore described. Upon exit, the wheel trips a strategically located switch LS3 (shown at 65 in FIG. 1) whereby the kicker circuit is reset for the next wheel.

FIGS. 7 and 8 show an alternate apparatus for accommodating the wheel in the testing station and lowering it into the water pit. An arcuate segment 70 is provided which performs the combined function of rail segment 18 and bar 34 in the first embodiment. Segment 70 directly supports the wheel in the testing operation, and is actuated to eject the wheel after the testing operation is completed. Segment 70 is incorporated in a carriage 72 mounted for vertical reciprocation in a stationary frame structure 74 which is similar to the structure 24. One end of segment 70 is pivoted in suitable bearing means 76; the other end of said segment is free and is connected to a pull rod 78 actuated by a power device 79. At the start of the testing cycle, the segment 70 is in the position shown by dotted lines in FIG. 7. The wheel is rolled onto segment 70 and the carriage 72 is lowered until the wheel rests on rollers 20'. The testing operation is then performed as hereinbefore described. After testing, the carriage 72 is raised and the power device 72 is actuated, thereby lifting the free end of the segment 72 to the position shown, causing the wheel to roll out of the testing station.

FIGS. 9-11 illustrate a more sophisticated version of the devices hereinbefore described, which is designed to accommodate railway wheels of various sizes, is capable of testing for warpage, and contains other features which will hereinafter be more fully described.

As shown in FIGS. 9 and 10, a vertically movable carriage 90 is again provided within a stationary framework 92 with a hydraulic cylinder 94 connected therebetween for actuation of the carriage. In this instance, the hydraulic cylinder 94 is assisted by means of counterweights 96 connected by cables 98 over rotatable pulleys 100 to the carriage 90 by thimble clamps 102. As shown in FIG. 10, a pair of pulleys 100 are mounted at each side on a common shaft 104 rotatably mounted at its ends in opposed bearings 106 secured to opposing vertical members 108 of the stationary framework 92.

Wheels enter the testing station from the left of FIG. 9 whereupon they roll upon a pair of spaced rollers 110 and 112 mounted on respective shafts 114 and 116 journaled at both ends in bearings, such as 118 and 120 (FIG. 10) secured to the movable carriage 90. This arrangement is distinguishable from those previously described, in that the roller assemblies move with the carriage. It may be seen from FIG. 10 that the rollers 110 and 112 have a contour adapted to the shape of the wheel 122.

Means are provided to stop the wheel 122 as it enters the testing station. A substantially horizontal arm 124 is secured near the center of a shaft 126 pivotally mounted in the carriage. A second arm 128 is secured near one end of the shaft 126, and the other end is pivotally connected to a hydraulic cylinder 130, activation of which pivots the horizontal arm 124 up to stop the incoming wheel.

After the wheel has been stopped on the rollers 110 and 112, the carriage is lowered into the water tank 132 by extension of the hydraulic cylinder 94. Means are provided to rotate one of the rollers 112 while in such position, including a motor 134 mounted upon a stationary support 136 and operatively connected to the shaft 116 of said roller by the following means: a sprocket 138 on the shaft of the motor 134 is in alignment with a second sprocket 140 rotatably mounted in the stationary framework 92, and third and fourth sprockets 142 and 144, respectively, are mounted in the same plane on the movable carriage 90. As shown in FIG. 10, the shaft of the fourth sprocket 144 extends within the carriage and an inner

sprocket 148 is connected thereto for driving the sprocket 150 of the roller 112. As schematically shown in FIG. 9, an endless chain 152 is connected from the motor sprocket 126 around the second sprocket 140 on the fixed framework, wrapped around the fourth sprocket 144 and up over the third sprocket 142 and back down to the motor sprocket. A second endless chain 154 interconnects the inner sprocket 148 with the sprocket 150 of the roller 112.

The foregoing arrangement allows the motor 134 to be mounted stationary relative to the movable carriage, which is a desirable feature, in that vibrations from the motor might otherwise interfere with the ultrasonic test.

Means are also provided in the apparatus to maintain the wheel in a vertical position during rotation, in order that the wheel may be tested ultrasonically for warpage. A vertical roller 156 is rotatably mounted in a suitable bracket 158 secured to the movable carriage 90. It may be seen in FIG. 10 that the vertical roller 156 is so positioned to engage the back face of the wheel 122 in the testing station and is relatively long to accommodate various wheel sizes.

A pair of horizontal rollers 160 and 162 is provided at each side of the device in such a position as to be engageable with the outer periphery 164 (FIG. 10) of the wheel 122 on the side thereof opposite to that engaged by roller 156 and in a position transverse thereto. As shown, these rollers are also of a sufficient length as to be compatible with a complete range of wheel sizes to be tested. Rollers 160 and 162 are each rotatably mounted in respective brackets 166 and 168 secured to an interconnected by a horizontal shaft 170 journaled at both ends in the carriage 90. Means are provided to urge the rollers 160 and 162 against the wheel 122, such as at least one hydraulic cylinder 172 (FIG. 10) pivotally connected to the movable carriage 90 at 174 and having a piston rod 176 pivotally connected to a lever 178, which is connected to the shaft 170. Extension of hydraulic cylinder piston rod 176 will thus cause the rollers 160 and 162 to move inwardly toward the vertical roller 156 to hold the wheel in a vertical position during rotation and testing.

The wheel-ejecting mechanism includes an arm 180 having a lateral projection 182 at the lower end thereof located in the same vertical plane as the wheel 122, said arm being secured at its upper end to a shaft 183 journaled in a bearing block 185 secured to the carriage 90. A second arm 184 located outside of the plane of the wheel 122 is also secured to the shaft 183 at its lower end and pivotally connected at its upper end to the piston rod 186 of a hydraulic cylinder 188 pivotally connected at the cylinder end thereof to the carriage 90. It will be noted that when in a normal position, the kicker arm 180 extends downwardly, and actuation of the hydraulic cylinder 188 rotates said arm upwardly whereupon the lateral projection 182 contacts the wheel in a generally upward and longitudinal direction.

Bridge means are also provided in the present device to allow the wheel to pass through the testing station without being tested. For this purpose, as shown in FIGS. 9 and 11, a cylindrical segment 190 is secured upon the upstanding extensions 192 of a pair of arms 192 secured to a shaft 196 journaled in the carriage 90. Another arm 198 is secured to the shaft 196, the other end being pivotally connected to the piston rod 200 of a hydraulic cylinder 202 which is pivotally mounted at 204 in a suitable bracket 206 secured to the carriage 90. The arrangement is so designed and located such that in a normal position the cylindrical segment 190 is swung away below and to one side of the wheel 122, so as not to interfere with the testing operation. Actuation of the cylinder 202 will cause the cylindrical segment 190 to swing up into a position in line with the top of the rollers 110 and 122, thereby allowing the wheel to pass through the station.

From the foregoing description, the overall operation of the device may be understood. In order to test the wheel for warpage, reference is again directed to FIG. 5 showing the position of transducer 52 with respect to the wheel. This transducer may be carefully aimed such that warpage of the wheel

will cause the returning signal to be deflected at an angle as illustrated. The monitoring device can be set to emit an electrical impulse to the circuit of the device in the absence of a continuous signal.

We claim:

1. Apparatus for manipulating and testing a railway wheel comprising a testing station, an entrance and exit rail leading respectively to and from said station, means for stopping a wheel as it enters the testing station from the entrance rail and thereafter ejecting the wheel from the testing station onto the exit rail, a tank containing a liquid below said testing station, transducer means within said liquid, means to energize said transducer means so as to transmit an ultrasonic test wave to said wheel, means to analyze signals received by said transducer means upon reception of a reflected wave, means for lowering the rim of said wheel in an upright position into said liquid in coordination with said transducer means and thereafter raising the rim of the wheel out of the liquid, and means for rotating the wheel while performing the ultrasonic test.

2. The apparatus according to claim 1 wherein the means for lowering and raising the wheel comprises a stationary framework, a carriage, means for supporting said wheel in said carriage, and power cylinder means connected between said stationary framework and said carriage for vertical reciprocation of said carriage relative to said framework.

3. The apparatus according to claim 1 wherein the means for stopping and ejecting the wheel comprises an arm pivotally mounted in the carriage intermediate the ends of said arm, and means for pivoting said arm relative to said wheel.

4. The apparatus according to claim 1 wherein means are provided to allow the wheel to pass through the testing station without being stopped and tested.

5. The apparatus according to claim 4 wherein the means to allow the wheel to pass through the testing station comprises a rail segment between the entrance and exit rails, said rail segment being swingable into and out of alignment with said entrance and exit rails.

6. The apparatus according to claim 1 wherein means are provided to prevent the wheel from tilting away from upright position during rotation, said means comprising a vertical roller rotatably mounted in the carriage and engageable with the backface of the wheel, a pair of horizontal rollers engageable with the wheel on the other side thereof, and means for urging said horizontal rollers against said wheel.

7. The apparatus according to claim 1 wherein means responsive to the analyzing means are provided to automatically stop the wheel in a lowered position when a defect is analyzed.

8. The apparatus according to claim 7 wherein means are provided to rotate the wheel by manual control after the wheel has been stopped in a lowered position.

9. The apparatus according to claim 1 wherein means are provided to eject the wheel from the testing station before it is lowered into the liquid.

10. The process of automatically manipulating and testing a railway wheel in a production line operation including a testing station and an entrance and exit rail leading respectively to and from said station, said testing station including a tank containing a liquid with at least one transducer mounted therein, comprising rolling a wheel in an upright position on the entrance rail into the testing station, stopping the wheel at the testing station, and thereafter in automatic sequence, immersing the rim of the wheel in said liquid and rotating the wheel therein, energizing said transducer so as to transmit an ultrasonic test wave to said wheel, analyzing signals received by said transducer upon reception of a reflected wave, raising the rim of the wheel out of the liquid, and ejecting the wheel from the testing station onto the exit rail.

11. In an apparatus for manipulating and testing railway wheels including a tank containing a liquid with a transducer mounted in said tank, means for supporting and rotating the rim of a single wheel in said liquid, roller means contacting

both sides of said wheel for restraining tilting movements of said wheel from vertical position during rotation thereof, said transducer being aimed at the rim of the wheel on a line substantially parallel to the rotational axis thereof, means to energize said transducer so as to transmit an ultrasonic test wave to said wheel, and means to analyze signals received by said transducer upon reception of a reflected wave.

12. In an apparatus for manipulating and ultrasonically testing railway wheels, a tank containing a liquid, a stationary framework above said tank, a carriage supported by said framework and movable vertically with respect thereto, a pair of spaced rollers rotatably mounted in said carriage and adapted to support a wheel, means for moving the carriage up and down to the extent that the rim of a wheel supported on the rollers is immersed in said liquid, power means for rotating one of said rollers, said power means being mounted stationary relative to vertical movements of said carriage, means for connecting said power means to said one roller and operative at any vertical position of the carriage, a transducer mounted in said tank, means to energize said transducer so as to transmit an ultrasonic test wave to said wheel, and means to analyze signals received by said transducer upon reception of a reflected wave.

13. The apparatus according to claim 12 wherein the means for connecting said power means to said one roller comprises a first sprocket on said power means and rotatably driven thereby, a second sprocket rotatably mounted on said sta-

tionary framework, third and fourth sprockets rotatably mounted on said carriage below said second sprocket and in alignment therewith, said fourth sprocket being located below said third sprocket, and an endless chain connected from said first sprocket around the second sprocket, wrapped around the fourth sprocket, up and over said third sprocket and back to said first sprocket.

14. A method of manipulating and testing a railway wheel comprising rotating the rim of a wheel around its axis in a liquid on a pair of spaced rollers, contacting the wheel on both sides with other rollers to prevent the wheel from tilting toward its axis during rotation, aiming a transducer within said liquid at said rim along a line substantially parallel to said axis, energizing said transducer so as to transmit an ultrasonic test wave to the side surface of the rim of said wheel, and analyzing signals received by said transducer upon reception of a wave reflected from said surface to determine deviations of said wave from a line substantially parallel to said wheel axis.

15. In an apparatus for manipulating and testing railway wheels, means for supporting and rotating a single wheel in an upright vertical position, roller means contacting both sides of said wheel for restraining tilting movements of said wheel from vertical position during rotation thereof, and means for performing an ultrasonic test on an outside side surface of said wheel to detect warpage therein.

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