Sept. 4, 1934. C. H. RANDOLPH 1,972,316

PROCESS OF AND APPARATUS FOR GRINDING INTERNAL SURFACES OF TUBES

Filed March 15, 1933 2 Sheets-Sheet 1

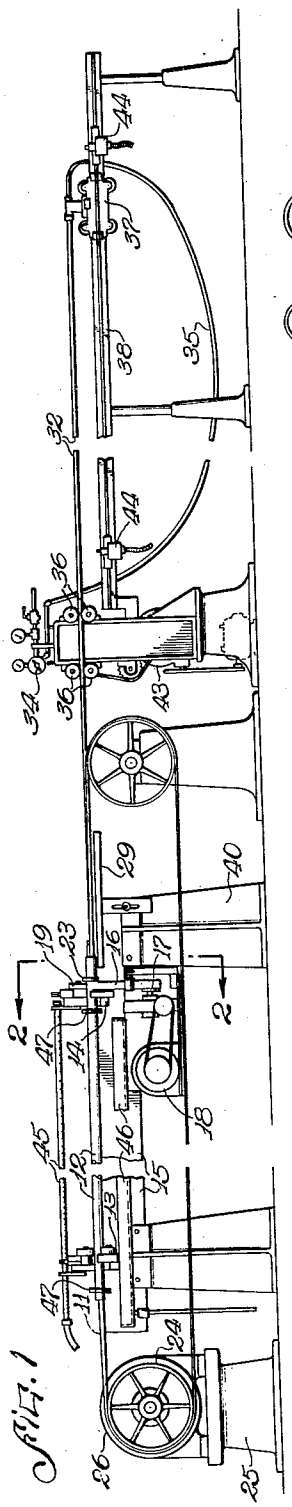

Fig. 1

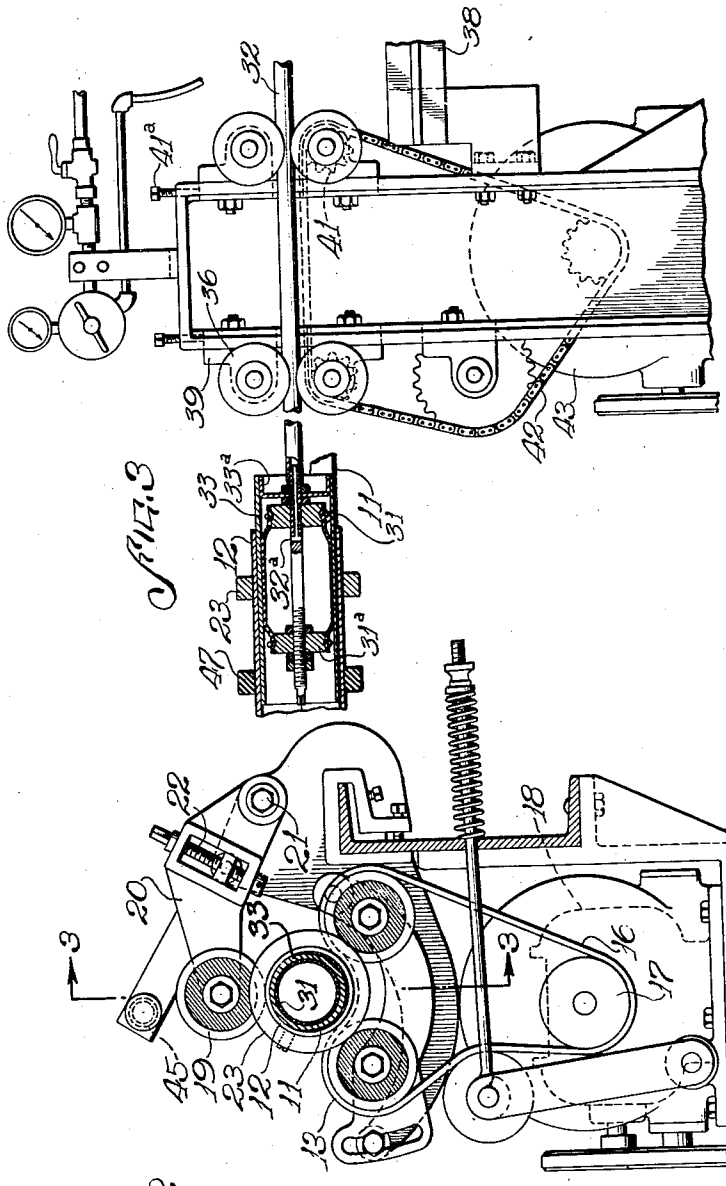

Fig. 2

Fig. 3

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Fig. 4

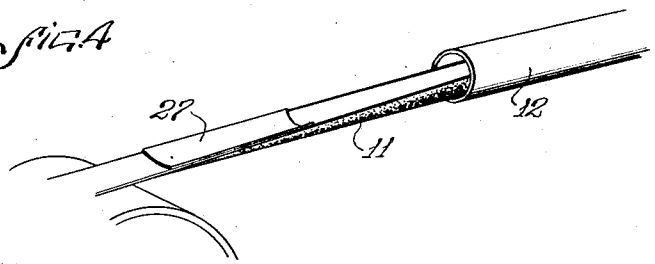


Fig. 5

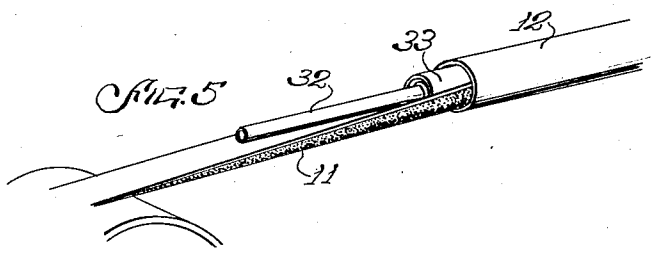


Fig. 6

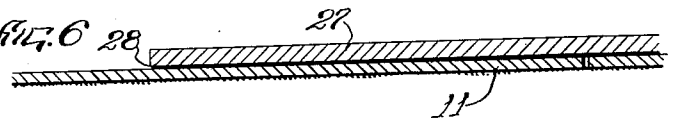


Fig. 7

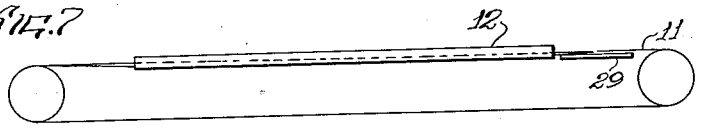


Fig. 8

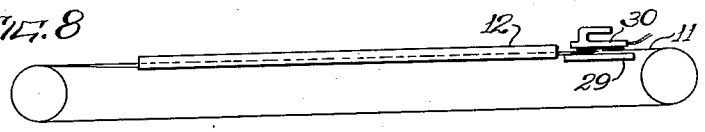


Fig. 9

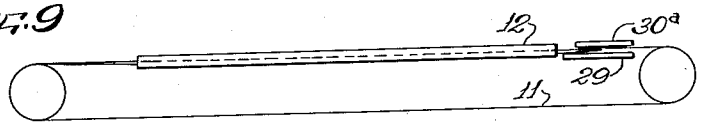
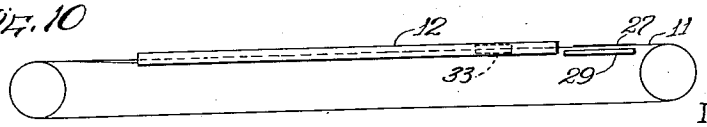


Fig. 10



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Patented Sept. 4, 1934

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UNITED STATES PATENT OFFICE

1,972,316

PROCESS OF AND APPARATUS FOR GRINDING INTERNAL SURFACES OF TUBES

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Application March 15, 1933, Serial No. 660,823

14 Claims. (Cl. 51—135)

This invention relates to the grinding of the internal surfaces of tubes to remove scale or irregularities or to polish the same, and the general object is to provide a novel process and apparatus by which a wide range of different sizes and lengths of tubes may be ground quickly, accurately and with a minimum of equipment and labor costs.

Another object is to provide a novel process by which the internal surface of a tube may be ground or polished by means of an abrasive carried by an elongated flexible ribbon advanced longitudinally of the tube.

A further object is to provide a novel endless grinding element of the above character and a novel process for forcing the same into operative association with the tube to be ground.

Still another object is to provide a novel machine for effecting relative movement between the tube and the abrasive element and for pressing the latter against the tube surface during grinding.

Other objects and advantages of the invention will become apparent from the following detailed description taken in connection with the accompanying drawings, in which

Figure 1 is an elevational view of a machine embodying the features of the present invention.

Fig. 2 is a sectional view taken along the line 2—2 of Fig. 1.

Fig. 3 is a sectional view taken along the line 3—3 of Fig. 2.

Figs. 4 and 5 are fragmentary perspective views illustrating the manner in which the abrasive element enters the tube to be ground.

Fig. 6 is a fragmentary sectional view of the abrasive element.

Figs. 7 to 10 illustrate diagrammatically different steps in the process contemplated by the present invention.

While the invention is susceptible of various modifications and alternative constructions, I have shown in the drawings and will herein describe in detail the preferred embodiment, but it is to be understood that I do not thereby intend to limit the invention to the specific form disclosed, but intend to cover all modifications and alternative constructions falling within the spirit and scope of the invention as expressed in the appended claims.

As exemplified in the drawings, the process contemplated by the present invention involves generally moving an abrasive ribbon or belt 11 rapidly through the tube 12 to be ground while the latter is being rotated, and simultaneously applying pressure to the ribbon within the tube preferably at successive points along the internal surface thereof. The ribbon 11 is of sufficient flexibility to conform readily to the contour of the internal surface so that the latter is ground uniformly and accurately. Abrasives of different coarseness may be used to obtain different degrees of polish.

Herein the tube 12 is ground while supported in horizontal position upon two pairs of rollers 13 rotatably supported by brackets 14 mounted on an elongated frame bed 15 along which one of the brackets may be shifted to accommodate different lengths of tubes. The rollers of each pair are also mounted for relative lateral adjustment of their axes to adapt the support to tubes of different sizes.

To rotate the tube during grinding, an endless belt 16 is extended around the rollers 13 of one pair and beneath the tube and then around a pulley 17 driven by an electric motor 18 through suitable speed reducing mechanism. Pressure for producing the necessary driving friction between the tube and the belt is applied through the medium of a roller 19 on the free end of an arm 20 pivoted at 21 and urged downwardly under the action of a manually adjustable screw 22. A collar 23 detachably secured to the tube 11 and bearing against the sides of one of the sets of rollers 13 may be employed to hold the tube against axial shifting during grinding.

The abrasive belt 11 is of a width less than the circumference of the internal surface of the tube 12 and has one side only coated with abrasive particles of the desired coarseness, the other side presenting a relatively smooth surface as is the case with most standard abrasive cloth. To permit the belt to move continuously in one direction during grinding, it is of endless character extending around two cylindrical pulleys 24 rotatably mounted on standards 25. The pulleys 24 are spaced apart a distance substantially greater than the length of the tube ordinarily ground in order to increase the length and thereby prolong the life of the belt. During grinding, the belt is advanced through the tube at high velocity. Herein this is accomplished by the use of large pulleys driven directly by an electric motor 26.

In preparing the tube for grinding by the present process, one of the ends of the belt 11 is first passed through the tube with the abrasive surface of the belt facing the internal surface of the tube and after which the two ends are united substantially at a butt joint which also possesses

sufficient flexibility to conform readily to the tube surface upon entering the latter. This is accomplished by means of a patch 27 of flexible material such as cloth placed against the smooth side of the belt 11 overlying the ends. To enable the machine to be conditioned quickly for grinding and the tube removed quickly after grinding, the patch and the ends of the belt are secured together by a heat-actuated adhesive 28 capable of softening quickly upon being heated to a moderate temperature and hardening quickly upon cooling. Preferably, the cement is carried as a coating on the fabric of the patch which has sufficient strength to withstand the stresses imposed upon the belt.

During formation of the joint, the ends of the belt are placed in abutment with the abrasive side down upon a table 29 and the patch is heated and pressed against the opposite surface of the belt by an electrically heated flat-iron 30 (see Fig. 8). As the cement becomes soft, the flat-iron is replaced by a cold iron plate 30a (Fig. 9) whereupon the cement cools and sets rapidly while the patch is thus pressed against the belt ends. After grinding of the tube, the flat-iron is again applied to the patch which may be stripped off readily and the belt broken as soon as the cement has softened. The ease and rapidity with which the ends of the abrasive strip may be joined together in the above manner contributes to the high productivity of the machine by minimizing the time during which the machine must be idle while a finished tube is being removed and another prepared for grinding. In addition, the patch is not bulky in character and will readily slide past the pressure-applying means now to be described.

The abrasive surface of the belt 11 is forced against the internal surface of the tube by a pressure member which is adapted to be expanded within the tube after association of the belt therewith in the manner above described. Preferably, the member is substantially shorter than the tube to be ground and is mounted for reciprocation longitudinally of the tube and independently of the belt. In the present instance, this member is in the form of an expansible plunger or shoe formed by a rubber sack or cylinder 31 fitting over one end of an elongated pipe 32 and adapted to be expanded within the tube by pressure fluid, preferably air supplied at the other end of the pipe. Herein, opposite ends of the sack 31 are clamped to spaced collars 31a threaded onto the pipe which is plugged at its extreme end but formed with holes 32a through which the pressure is communicated.

To protect the sack 31, the latter is enclosed by a cylindrical casing 33 of flexible material, preferably leather, having one end fitting snugly over and secured as by a suitable cement to a collar 33a also threaded onto the pipe 32. The plunger thus formed may be expanded within the tube 12 to press the abrasive ribbon against the internal surface of the tube. Regulation of this pressure may be effected from a point exteriorly of the tube 12 as by manipulation of a control valve 34 from which the compressed air is delivered to the pipe 32 by a flexible hose 35.

The pipe 32 is mounted for reciprocation axially of the tube 12 and also for bodily vertical adjustment to enable the pipe to be located coincident with axes of tubes of different sizes mounted on the rollers 13. For this purpose, the pipe extends between two pairs of grooved rollers 36 and the end opposite the sack 31 is secured to a carriage 37 slidable along a bar 38. The rollers 36 are mounted for individual vertical adjustment upon brackets 39 clamped to a standard. By tightening screws 41a, a friction driving connection is formed between the rollers and the pipe. A suitable reversible drive for the rollers is formed in the present instance by an electric motor 43 acting through the medium of an endless chain 42 to drive sprockets 41 fast on the shafts of the lower rollers 36. After the plunger has once been advanced onto the tube, reciprocation thereof from one end of the tube to the other is controlled automatically by limit switches 44 adjustably spaced on the bar 38 to correspond to the length of the tube to be ground and arranged to control suitable relays (not shown) governing the direction of rotation of the motor 43 and therefore the feed of the plunger.

With the abrasive cloth running through the tube at a high speed while pressed firmly against the tube surface, considerable heat is developed. To prevent deterioration of the abrasive cloth by such heat and to keep the tube cool during grinding, water sprays are directed onto the tube from suitable holes in a pipe 45, the water falling onto the tube is prevented from coming onto the abrasive belt by washers 47 preferably composed of material such as rubber encircling the tube 12 adjacent the ends thereof. Any water creeping along the tube will be thrown off from the washers by centrifugal action.

In grinding a tube according to the process above described, the procedure is as follows, assuming that the tube is mounted upon the rollers 13 and the ends of the belt are detached from each other. The limit switches 44 are adjusted according to the length of the tube to be ground and the supports for the drive rollers 36 are adjusted vertically to bring the pipe 32 into axial alinement with the tube. One end of the belt is first passed through the tube and positioned upon the table 29 substantially in abutment with the other end, the abrasive facing downwardly (see Fig. 7). The patch 27 is then applied as above described and illustrated in Fig. 8 and the belt led around the pulleys 24. Next the motors 18 and 26 are started and the spray water turned on.

As any section of the belt 11 approaches the end of the tube 12, it flexes laterally as shown in Fig. 4, being substantially flat as it leaves the pulley 24 but conforming to the contour of the internal surface of the tube as it enters the latter.

With the belt thus advancing and the rubber sack 31 substantially deflated, the motor 43 is started under manual control to advance the plunger into the adjacent end of the tube as illustrated in Fig. 5, after which the plunger is expanded to the desired degree by regulation of the air valve 34. The rapidly moving belt readily slips past the plunger which, owing to its flexibility, allows the patch 27 to slip by without dislocating the latter.

As the plunger continues to advance into the tube (see Fig. 10), the pressure is applied to successive longitudinal sections of the tube surface, rotation of the tube causing the entire surface to be ground. At the remote end of the tube, one limit switch 44 is engaged by the carriage 37 and the direction of rotation of the motor 43 reversed. The plunger is thus reciprocated back and forth from one end of the tube to the other under the control of the switches 44. Such reciprocation is allowed to continue until the internal surface of the tube has been ground to the desired de-

gree. If it becomes desirable to spot on an imperfection at any point along the tube surface, the plunger may be reciprocated at such point in short strokes either by hand or by manipulation of the motor switches. After completion of the grinding operation, the plunger is fully retracted out of the tube and the belt 11 stopped with the patch 27 disposed above the table 29. By applying the heated iron 30 to the patch, the cement thereof may be softened quickly permitting removal of the patch and separation of the tube and belt. If a finer and higher degree of polish is required, another belt carrying a finer abrasive or polishing material may be inserted and the process repeated.

I claim as my invention:

1. A machine for grinding the internal surface of an elongated cylindrical tube comprising, in combination, means for rotatably supporting the tube, a flexible abrasive ribbon extending through said tube, means for advancing said ribbon through said tube during rotation of the latter, and means expansible within said tube to press the abrasive surface of said ribbon against the tube surface while the ribbon is being advanced therethrough.

2. A machine for grinding the internal surface of an elongated cylindrical tube comprising, in combination, means to rotatably support the tube, an abrasive ribbon extending through said tube and having sufficient lateral flexibility to conform readily to said surface, means for advancing said ribbon continuously through said tube, a plunger adapted to enter the tube and to expand within the latter whereby to press said ribbon against the tube with the abrasive surface in contact with said tube surface, and means for moving said plunger endwise in said tube while the latter is being rotated and the ribbon advanced.

3. A machine for grinding the internal surface of an elongated cylindrical tube comprising, in combination, means to rotatably support the tube, a flexible abrasive ribbon extending through said tube, means for advancing said ribbon through said tube during rotation of the latter, and means movable within the tube independently of said ribbon and pressing the abrasive surface of said ribbon against successive longitudinal sections of said tube surface.

4. A machine for grinding the internal surface of an elongated cylindrical tube comprising, in combination, means to rotatably support the tube, a flexible abrasive ribbon extending through said tube, means for advancing said ribbon through said tube during rotation of the latter, an expansible pressure element adapted to enter one end of the tube when contracted, means controllable from a point exteriorly of the tube for expanding said element when the latter is disposed within the tube, and means for reciprocating said element back and forth within the tube while the latter is being rotated and the belt advanced.

5. A machine for grinding the internal surface of an elongated cylindrical tube comprising, in combination, means to rotatably support the tube, an endless abrasive belt extending through said tube with the abrasive surface thereof in contact with said internal surface, said belt having sufficient lateral flexibility to conform readily to the contour of said internal surface, means for driving said belt, and means within said tube expansible against said belt and the tube surface whereby to press said abrasive surface against said tube surface during rotation of the tube and movement of said belt therethrough.

6. A machine for grinding the internal surface of an elongated cylindrical tube comprising, in combination, means to rotatably support the tube, an endless abrasive belt extending through said tube with the abrasive surface thereof in contact with said internal surface, said belt having sufficient lateral flexibility to conform readily to said internal surface, means for driving said belt and for rotating said tube, an expansible shoe within said tube, and means for reciprocating said shoe within the tube during rotation of the latter and movement of the belt therethrough.

7. A machine for grinding the internal surface of an elongated cylindrical tube comprising, in combination, means to rotatably support the tube, a flexible abrasive ribbon extending through said tube, means for advancing said ribbon endwise through said tube at high velocity with the abrasive surface of the ribbon contacting said internal surface, a pressure shoe adapted to enter said tube in contact with the side of said ribbon opposite said abrasive surface, said shoe being expansible within the tube and adapted to permit continued advance of said ribbon, and means for reciprocating said shoe longitudinally of said tube at a velocity slower than that of said ribbon.

8. A machine for grinding the internal surface of an elongated cylindrical tube comprising, in combination, means to rotatably support the tube, an abrasive ribbon extending through said tube with the abrasive surface thereof in contact with said internal surface, and having sufficient lateral flexibility to conform readily to the contour of said internal surface, means for advancing said ribbon endwise at high velocity, means within said tube expansible against said ribbon and the tube surface whereby to press said abrasive surface against said tube surface during advance of the ribbon and rotation of the tube.

9. A machine for grinding the internal surface of an elongated cylindrical tube comprising, in combination, means to rotatably support the tube, a flexible abrasive ribbon extending through said tube, means for advancing said ribbon through said tube at high velocity during rotation of the latter, a pressure element shorter than said tube adapted to enter the latter and to be expanded therein whereby to press said ribbon against the tube surface, means for rotating said tube, and means for reciprocating said element back and forth within the tube while the latter is being rotated and said ribbon advanced through the tube.

10. The process of grinding the internal surface of a tube with an elongated flexible ribbon having an abrasive surface on one side thereof, said process comprising moving said ribbon endwise through said tube with said surfaces facing each other, and applying pressure to the opposite surface of the ribbon progressively from one end of the tube to the other.

11. The process of grinding the internal surface of a tube comprising, moving endwise through the tube an abrasive carrying ribbon having sufficient flexibility to conform readily to said surface, and simultaneously applying pressure to said ribbon within the tube.

12. The process of grinding the internal surface of a tube comprising, moving endwise through the tube an abrasive carrying ribbon having sufficient flexibility to conform readily to said surface, and simultaneously reciprocating an expansible pressure element in engagement

with said ribbon within said tube while said ribbon is being advanced at a rapid rate and the tube rotated.

13. A machine for grinding the internal surface of an elongated tube comprising, in combination, means rotatably supporting said tube, a flexible abrasive ribbon extending through the tube, means for advancing said ribbon through the tube at high velocity, means for directing a stream of cooling liquid onto the external surface of the tube during grinding at points spaced from the ends of the tube, and means rotatable with said tube and located between said ends and the points of application of said liquid for centrifugally throwing off the fluid creeping along the tube to prevent the fluid from reaching said ribbon.

14. In a machine for grinding the internal surface of an elongated tube, the combination of means for rotatably supporting said tube, abrasive means extending through the tube, means for moving said abrasive means longitudinally of the tube at a high velocity, means for directing a stream of cooling fluid against the external surface of the tube, and means for limiting the distance said fluid may creep along the tube to prevent said fluid from reaching said abrasive means comprising a collar fitting snugly against the external surface of the tube and rotatable therewith, said collar centrifugally throwing said liquid off from said tube.

CHALMERS H. RANDOLPH.