(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: 0 172 250 A1

(12) # EUROPEAN PATENT APPLICATION

published in accordance with Art. 158(3) EPC

(21) Application number: 84900872.7

(22) Date of filing: 17.02.84

Data of the international application taken as a basis:

(86) International application number: PCT/JP84/00049

(87) International publication number: WO85/03726 (29.08.85 85/19)

(51) Int. Cl.[4]: C 21 D 1/64
C 21 D 9/08

(43) Date of publication of application: 26.02.86 Bulletin 86/9

(84) Designated Contracting States: DE FR GB

(71) Applicant: KAWASAKI STEEL CORPORATION
No. 1-28, 1-Chome Kitahonmachi-Dori
Chuo-Ku, Kobe-Shi Hyogo 651(JP)

(72) Inventor: OHSIMATANI, Toshio
133-37, Aza Taniguchi
Taketoyo-cho, Chita-gun Aichi 470-23(JP)

(72) Inventor: MIMURA, Yukihiro
5-1, Hanazono-cho 2-chome
Handa-shi Aichi 475(JP)

(74) Representative: Tiedtke, Harro, Dipl.-Ing. et al,
Patentanwaltsbüro Tiedtke-Bühling-Kinne-Grupe-Pellmann-Grams-Struif Bavariaring 4 Postfach 20 24 03
D-8000 München 2(DE)

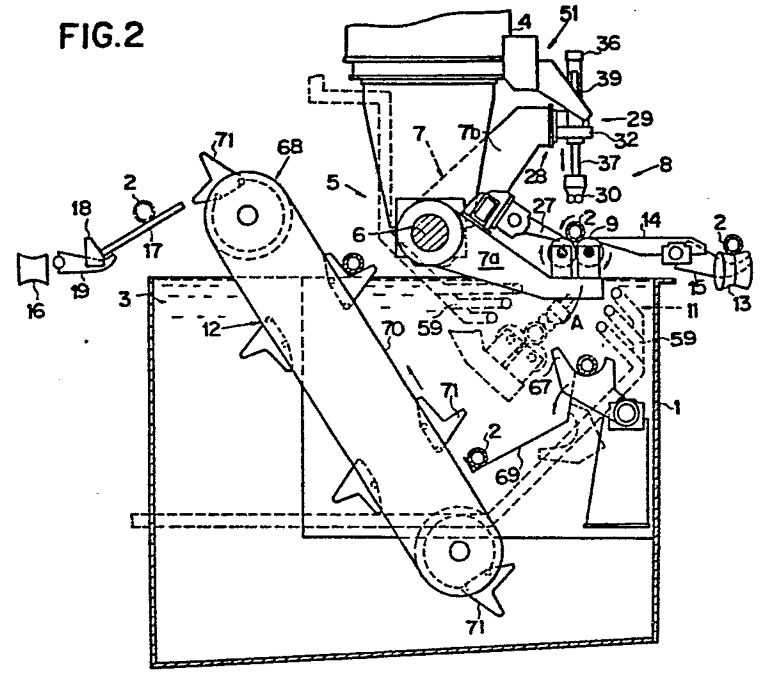
(54) ## APPARATUS FOR DIP-HARDENING METAL PIPE.

(57) A hardening apparatus is constructed so that a heated metal pipe is rotatably retained by retaining means so that it is pressed thereby from both above and below. The metal pipe is dipped into cooling water within a water tank by dipping means, and in addition, jets of cooling water are applied to both the inner and outer peripheral surfaces of the metal pipe by cooling water spraying means. After being rapidly cooled in this way, the metal pipe is transported out of the water tank by a transport means. In this apparatus, the metal pipe is not dropped from a height, so it is possible to prevent the surface of the metal pipe becoming flawed, and the rotation of the metal pipe makes it possible to promote what is effectively a stirring of the cooling water. It is also possible to constantly change the portions of the retaining means in contact with the metal pipe, so that the metal pipe can be rapidly and uniformly cooled, and therefore can be well hardened.

EP 0 172 250 A1

./...

FIG.2



4
51
36
39
29
32
37
8
30
7
7b
28
5
71
68
2
18
17
6
7a
27
2
9
14
2
16
19
3
12
70
59
A
11
59
15
13
67
1
71
2
69
71

DESCRIPTION

Apparatus for Immersion Hardening Metallic Pipe

TECHNICAL FIELD

This invention relates to an apparatus for carrying out hardening by immersing a heated metallic pipe into cooling water for quenching, and more particularly, to a hardening apparatus useful in hardening steel pipes.

TECHNICAL BACKGROUND

It is well known that hardening of steel pipes, for example, requires to quench them at a rate higher than the critical cooling rate capable of creating a Martensite structure. In the prior art, it is known as such a steel pipe quenching technique to immerse a heated steel pipe directly into cooling water. In carrying this technique into practice, simply dropping a heated steel pipe into cooling water leads to the covering of the steel pipe at the surface with a film of steam resulting from boiling of cooling water, which resultantly reduces the cooling rate to below the critical cooling rate ensuring Martensite transformation required for normal hardening, sometimes failing to achieve a hardening effect. By this reason, the immersion hardening apparatus of the type wherein a heated steel pipe is dropped into cooling water is generally equipped with nozzles for injecting cooling water toward both the inner and outer surfaces of the steel pipe. In conventional apparatus, however, cooling water injected from those nozzles for outer surface cooling agitates and fluidizes that portion of cooling water which does not directly participate in cooling of a steel pipe, leading to the problems that an excess of power is consumed and a large-sized installation is needed. In injecting cooling water to the inner side of the steel pipe, if cooling water is to be injected radially of the steel pipe, the apparatus must be constructed such that the nozzle may be moved into and out of the interior of the steel pipe, leading to the problem that the construction and control of the apparatus become complicated. Also, since such a nozzle is inserted into the interior of the steel pipe after the steel pipe is immersed in cooling water and positioned at a predetermined location, cooling on the inner side of the steel pipe is delayed, leading to problems including bending of the steel pipe, formation of soft spots, and the like. Conversely, if the apparatus is constructed to cause cooling water to flow axially on the inner side of the steel pipe, the construction and control of the apparatus would not become too complicated because it is unnecessary to move the nozzle into and out of the interior of the steel pipe. However, if the nozzle is placed in the interior of a water tank, cooling water cannot be injected from the nozzle before the steel pipe dropped into cooling water has sunk onto a destined support and has been aligned with the nozzle, undesirably delaying the cooling of the steel pipe on its inner side.

Among prior art immersion hardening apparatus, there are known apparatus of one type wherein a heated steel pipe is dropped into cooling water and apparatus of another type wherein a heated steel pipe is placed on slant skids, for example, and the steel pipe is immersed in cooling water in a tank while being supported from below by guide arms (or guide claws). The hardening apparatus of the former type has the advantage of minimized possible formation of soft spots and bending because the heated steel pipe is immersed in cooling water substantially concurrently as a whole, but has the risk that surface defects are formed on the steel pipe because the steel pipe, when dropped, severely strikes against the bottom of the tank or the support in the tank. On the other hand, in the hardening apparatus of the latter type, the risk of forming surface defects on the steel pipe is obviated because the heated steel pipe is slowly immersed into cooling water, but suffers from the possible formation of soft spots and bending because the steel pipe is progressively immersed in cooling water from the underside. Furthermore, in either type of hardening apparatus, since the steel pipe rests stationary on supports or skids in cooling water, those portions of the outer surface of the steel pipe which are in contact with the supports or skids are shielded from cooling water to reduce the rate of cooling of those portions, resulting in formation of soft spots.

It is, therefore, an object of the present invention to provide an immersion hardening apparatus capable of uniform hardening of a metallic pipe on its inner and outer surfaces without forming flaws or bending the metallic pipe.

DISCLOSURE OF THE INVENTION

An apparatus for immersion hardening a metallic pipe according to the present invention comprises a tank containing cooling water; holding means for pressing a heated metallic pipe from both upper and lower directions and holding the pipe for rotation about its central axis; immersion means for moving the metallic pipe held by said holding means downward from the ambient air above the cooling water into the cooling water; cooling water injection means for injecting cooling water on the inner and outer sides of the metallic pipe in the interior of the tank; and unloading means for receiving the metallic pipe at the end of cooling from said holding means within the tank and conveying the pipe to the outside of the tank. In the apparatus of the invention, since the metallic pipe is continuously rotated, cooling water is kept in substantially agitated state in proximity to the inner and outer surfaces of the metallic pipe, which cooperates with the injection flows from the nozzles to continuously expose the inner and outer surfaces of the metallic pipe to fresh cooling water, preventing the metallic pipe from being covered with a film of steam resulting from boiling of cooling water. The rotation of the metallic pipe allows the removal of heat by cooling water to be uniform throughout the metallic pipe. When the metallic pipe is held by rollers, the points of contact with the rollers are continuously changed because of the rotation of the metallic pipe, preventing the local shielding of the pipe from cooling water by the rollers, which also contributes to uniform hardening throughout the metallic pipe. Furthermore, since cooling water is kept substantially agitated in proximity to the inner and outer surfaces of the metallic pipe because of the rotation of the metallic pipe, the cooling water flows injected from the nozzles need not have a high pressure or high velocity in particular, and since the cooling water flows from the nozzles are not required to agitate and fluidize the entire cooling water in the tank, a mechanism for injecting cooling water may be of a smaller size and the power required may be reduced. Moreover, since the heated metallic pipe is immersed in cooling water while being held by the holding means in the apparatus of the invention, the metallic pipe does not undergo a violent shock and is thus free of surface defects. If an internal nozzle for injecting cooling water into the interior of the metallic pipe is constructed so as to move up and down in cooperation with the holding means in the apparatus of the invention, then the heated metallic pipe and the internal nozzle are continuously kept in alignment so that cooling water can be injected into the interior of the metallic pipe from the internal nozzle at the same time as the metallic pipe is immersed in cooling water in the tank, and hence, cooling of the metallic pipe can be initiated substantially at the same time on its outer and inner sides, eventually preventing bending and formation of soft spots.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a plan view schematically showing one embodiment of the metallic pipe immersion hardening apparatus according to the present invention; Fig. 2 is a cross-sectional view taken along the line II-II in Fig. 1 to illustrate the apparatus in more detail; Fig. 3 is an elevation showing a mechanism for rotating a rotating shaft, which is a component of immersion means; Fig. 4 is an enlarged view taken along the line IV-IV in Fig. 3; Fig. 5 is an enlarged view showing holding means; Fig. 6 is a perspective view showing a mechanism for rotating support rollers; Fig. 7 is a partial elevation of the holding means, taken along the arrow VII in Fig. 5, but on a reduced scale; Fig. 8 is a plan view schematically showing the mechanism for rotating support rollers; Fig. 9 is a diagrammatic view useful in illustrating the motion of support rollers and a gear box for transmitting a rotational force to the support rollers; Fig. 10 is a diagrammatic view showing the arrangement of variable position holding rollers; Fig. 11 is a perspective view showing the arrangement of an internal nozzle of cooling water injection means; and Fig. 12 is a plan view useful in illustrating the relative position of steel pipes of different size and internal nozzles replaced therefor.

THE BEST MODE FOR CARRYING OUT THE INVENTION

The immersion hardening apparatus according to the present invention will be described in detail with reference to the accompanying drawings.

At the outset, the overall construction of one embodiment of the present invention will be briefly described with reference to Fig. 1, and various sections will be described in detail with reference to Figs. 2 to 12. Referring to Fig. 1, a water tank 1 is a rectangular tank which is longer than a metallic pipe to be hardened, for example, a steel pipe 2, and cooling water 3 is contained in the tank 1. Above the tank 1 is disposed a support beam 4 extending longitudinally of the tank 1, and immersion means 5 is suspended from the support beam 4. The immersion means 5 basically comprises a rotating shaft 6 adapted to be forward and backward rotated (or reciprocally rotated) within the range of a certain angle, and a plurality of arms 7 protruding radially from the rotating shaft 6, and holding means 8 for holding the steel pipe 2 for rotation is provided at the distal end of the arms 7. The holding means 8 includes plural pairs of support rollers 9 on which the steel pipe 2 rests, holding rollers for pressing down the steel pipe 2 (not shown in Fig. 1), and a roller drive 10 for rotating the support rollers 9, the roller drive 10 being provided outside the tank 1 in order to avoid any adverse effect by the cooling water 3. In the interior of the tank 1 is provided cooling water injection means 11 for injecting cooling water 3 on both the outer and inner surfaces of the steel pipe 2. The hardening apparatus illustrated in Fig. 1 is constructed such that the steel pipe 2 which has been cooled is taken out of the tank 1 to a position opposed to the loading position, and to this end, unloading means 12 is provided on one side (the upper side in Fig. 1) of the tank 1.

Now, a loading mechanism for carrying the heated steel pipe 2 to said holding means 8 and a delivery mechanism for delivering the cooled steel pipe 2 from the side of the tank 1 to a given location will be described. As shown in Figs. 1 and 2, a plurality of conveyor rollers 13 having a concave surface are arranged on the other side (the lower side in Fig. 1 and the right side in Fig. 2) of the tank 1, a plurality of loading skids 14 are provided on the other side of the tank 1 which extend beyond the upper end of the tank 1 toward the holding means 8, and a plurality of kick-out arms 15 are disposed between the conveyor rollers 13 and the loading skids 14 for transfer purpose. The kick-out arms 15 have a center of rotation at the base end of the loading skids 14 and a free end extending between the conveyor rollers 13. The kick-out arms 15 are constructed such that when rotated counterclockwise in Fig. 2, they take up the steel pipe 2 from the conveyor rollers 13 and cause it to tumble down onto the loading skids 14.

On the other hand, on the side opposite to the conveyor rollers 13 with respect to the tank 1, are arranged a plurality of delivery rollers 16 having the same configuration as the conveyor rollers 13. Between the delivery rollers 16 and the unloading means 12, slant skids 17 straddle beyond the upper end of the tank 1 which cause the cooled steel pipe 2 to tumble down toward the delivery rollers 16. Stops 18 are disposed at the lower end of the slant skids 17 as shown in Fig. 2, and kick-out arms 19 are provided between the lower end of the slant skids 17 at which the stops 18 are disposed and the delivery rollers 16 for transfer purpose. The kick-out arms 19 have a center of rotation on the side of the delivery rollers 16 and a free end extending to the lower end of the slant skids 17. The kick-out arms 19 are thus constructed such that when rotated counterclockwise in Fig. 2, they pick up the steel pipe 2 bearing on the stops 18 and transfer it onto the delivery rollers 16.

The immersion means 5 and the holding means 8 will be described in further detail. The rotating shaft 6 which is one of the components of the immersion means 5 is suspended from the support beam 4 to horizontally extend above the tank 1 and longitudinally of the tank 1. Each of the arms 7 which are attached to the rotating shaft 6 at given intervals consists of a lower arm 7a having a free end which will extend horizontally when positioned at the upper limit and an upper arm 7b which is extended above the lower arm 7a. One end (the left end in Figs. 1 and 3) of the rotating shaft 6 is extended outside the tank 1 and connected to a rotational drive 20. The construction of the rotational drive 20 is illustrated in Figs. 3 and 4. As shown in Figs. 3 and 4, the one end of the rotating shaft 6 is supported for rotation by a bearing on a base 21 while a radially extending lever 22 is attached to the one end of the rotating shaft 6. The lever 22 has a distal end pivoted to the upper end of a connecting rod 23 which is connected to a crank shaft 24 located adjacent the base 21. The crank shaft 24 is mounted for rotation on another base 25 and connected to a motor 26. The lever 22, connecting rod 23 and crank shaft 24 are coordinated such that when the crank shaft 24 is rotated in a given direction by means of the motor 26, the lever 22 is reciprocally rotated a given angle of ϕ about the axial center of the rotating shaft 6 via the connecting rod 23. More specifically, when the motor 26 rotates in a given direction, the intermediate portion of the crank shaft 24 makes a circular motion having a radius of R to concomitantly move the connecting rod 23 up and down. The distal end of the lever 22 thus makes a reciprocal motion having a radius of $\hat{r}$ and an angle of ϕ, and as a result, the rotating shaft 6, together with the lever 22, makes a reciprocal rotation (forward and backward rotation) within the range of an angle of ϕ.

Each lower arm 7a of the arm means 7 has a pair of support rollers 9a and 9b mounted to the upper surface of the free end thereof, which constitute the holding means 8. As shown in Figs. 5 and 6, two roller shafts 9c extend parallel to the rotating shaft 6 so as to interconnect the distal ends of the lower arms 7a at their upper surface. The support rollers 9a and 9b are mounted on the roller shafts 9c at positions corresponding to the distal ends of the lower arms 7a. Among these support rollers 9a and 9b, those support rollers 9a which are located nearer to the loading skids 14 are positioned at a higher level than those support rollers 9b which are located nearer to the rotating shaft 6. The lower arms 7a have kick-out arms 27 mounted on their upper surface and near to the rotating shaft 6 for pushing the steel pipe 2 on the support rollers 9a and 9b beyond the distal end of the lower arms 7a. Therefore, in holding the steel pipe 2 which has tumbled on the loading skids 14 under gravity between a pair of the support rollers 9a and 9b, the kick-out arms 27 serve as stops for preventing the steel pipe 2 from overrunning. In addition, since a line T connecting the centers of the support rollers 9a and 9b is at a given angle of ϕ toward the kick-out arms 27, the steel pipe 2 is prevented from moving back beyond the support rollers 9a and 9b to the loading skids 14 as a result of reaction of the steel pipe 2 striking the kick-out arms 27.

Further, as shown in Fig. 5, each upper arm 7b of the arm means 7 has holding rollers 30 mounted at its distal end through a slide mechanism 28 and a pressing means 29. The slide mechanism 28 will be first described. At the distal end of the upper arm 7b is attached a guide plate 31 extending parallel to the rotating shaft 6. A slide block 32 which is allowed to move parallel to the rotating shaft 6 is attached in mating engagement to the upper and lower edges of the guide plate 31. Locking cylinders 33 are attached to the upper and lower sides of the slide block 32 and perpendicular to the guide plate 31, and each cylinder 33 has a piston rod 34 having a recess 35 formed therein and engaged with the edge of the guide plate 31. By actuating the locking cylinder 33 to withdraw the piston rod 34, the slide block 32 is brought in close contact with the guide plate 31, thereby inhibiting movement of the slide block 32.

On the other hand, the pressing means 29 is based on a variable pressure cylinder 36 which is attached downwardly to the slide block 32 perpendicular to the line T connecting the centers of the support rollers 9a and 9b. The cylinder 36 has a piston rod 37 to the tip of which is mounted a pair of holding rollers 30 through a base plate 38. That is, the holding rollers 30 are mounted on the base plate 38 so as to rotate about their axes parallel to the axes of the above-mentioned support rollers 9a and 9b. In Figs. 5 and 7, numeral 39 designates guide rods which stand upright on the base plate 38 and are engaged for sliding motion in guide bushes 40 attached to the slide block 32.

The heated steel pipe 2 is rotated about its central axis and immersed in the cooling water 3 while it is held and clamped from its vertically upper and lower sides by means of the support rollers 9a, 9b and the holding rollers 30. The roller drive 10 for rotating the steel pipe 2 will be described with reference to Figs. 6, 8 and 9. To one end of the rotating shaft 6 is attached a gear box 41 extending in substantially the same direction as the upper arms 7b.

In the gear box 41, a drive gear 42 and two driven gears 43 and 44 are sequentially arranged from the side of the rotating shaft 6, and these gears 42, 43 and 44 are in meshing corporation via intermediate gears 45 intervening therebetween such that the drive gear 42 and the driven gears 43 and 44 rotate in the same direction. The drive gear 42 is coupled to a motor 46 located outside the tank 1 through universal joints 47 and a propeller shaft 48 while the driven gears 43 and 44 are coupled to the roller shafts 9c and 9c through connecting rotating rods 49 and 49 and universal joints 50, respectively. The connecting rotating rods 49, 49 are at a given angle of α with respect to the roller shafts 9c, 9c as shown in Fig. 6 such that the gear box 41 may be positioned above the surface of cooling water 3 even when the support rollers 9a and 9b are immersed in cooling water 3 as a result of angular rotation of the rotating shaft 6 as shown in Fig. 9. To avoid complexity, the upper arm 7b and associated members are omitted in Fig. 6.

In order to accommodate steel pipes 2 of different length or metallic pipes having different pipe end configuration such as upset pipes, positioning means 51 is provided for adjusting the position of the holding rollers 30. The positioning means 51 is constructed as shown in Figs. 5 and 7. That is, a horizontal slide guide 52 is attached to the side of the support beam 4 and a slider 53 is mounted for horizontal motion to the slide guide 52. The slider 53 has substantially a plate shape as shown in Figs. 5 and 7 and has a feed nut 54 attached to the rear surface thereof. A feed screw 55 attached horizontally to the side of the support beam 4 is threadably engaged with the feed nut 54. A pair of push arms 56 and 56 are projected from the front surface of the slider 53 which extend to those positions facing the opposite sides of the slide block 32 having the pressing means 29 attached thereto. The spacing between the push arms 56 and 56 is set to be wider than the width of the slide block 32 so as to leave gaps between the push arms 56 and the slide block 32. The feed screw 55 is connected to a motor 57 through a reduction gear 58, the motor 57 being attached downward to the side of the support beam 4. By actuating the motor 57, the feed screw 55 is rotated to concomitantly move the slider 53 horizontally. Then the push arm 56 pushes the slide block 32 and the holding rollers 30 are moved with the slide block 32, changing the position of the holding rollers 30. Since such positioning of the holding rollers 30 is required only near the end of the steel pipe 2 to be hardened, in the apparatus including eight (8) pairs of holding rollers 30, Nos. 1 to 8 as shown in Fig. 10, for example, the positioning means 51 may be provided in association with the No. 1 holding rollers 30 located at one end of the steel pipe 2 and the two pairs of Nos. 7 and 8 holding rollers 30 located at the other end of the steel pipe 2.

Next, the cooling water injection means 11 will be described. The cooling water injection means 11 comprises a plurality of external nozzles 59 for injecting cooling water 3 to the outer surface of the steel pipe 2 in the tank 1, and an internal nozzle 60 for injecting cooling water 3 to the inner surface of the steel pipe 2. The external nozzles 59 will first be described. Since the steel pipe 2 held in place by the support rollers 9a, 9b and the holding rollers 30 are arcuately turned down from the ambient air into cooling water 3 as the arm means 7 are rotated with the rotating shaft 6, a plurality of external nozzles 59 are arranged on opposite sides of the turn-down path of the steel pipe 2 so as to face the steel pipe 2. The arrangement of the external nozzles 59 is shown by dotted lines in Fig. 2. These external nozzles 59 are communicated with a feed water pipe not shown.

On the other hand, the internal nozzle 60 is designed to rotate with the above-mentioned rotating shaft 6 such that it can inject cooling water 3 into the interior of the steel pipe 2 at the same time as the steel pipe 2 is immersed in cooling water 3. More specifically, as shown in Fig. 11, a nozzle supporting arm 61 is projected from the end of the rotating shaft 6 like the lower arms 7a. The internal nozzle 60 is removably attached to the free end of the arm 61 such that the nozzle 60 may be aligned with the steel pipe 2 on the support rollers 9a, 9b. A construction for feeding cooling water 3 to the internal nozzle 60 is described below. A rigid pipe 62 for feed water is positioned outside the tank 1 on an extension of the rotating shaft 6 and in alignment with the rotating shaft 6, and a connecting pipe 63 which is bent twice like a crank is connected to the end of the feed water pipe 62 through a rotary joint 64. The connecting pipe 63 is bent at a position inside the tank 1 and the other end thereof is removably connected to the internal nozzle 60. A feed water hose 65 is connected to the rear end of the feed water pipe 62. With this arrangement, the steel pipe 2, when rested on the support rollers 9a, 9b, is aligned with the internal nozzle 60, and the steel pipe 2 and the internal nozzle 60 are moved down into the cooling water 3 in the tank 1 while keeping their mutual alignment. It is to be noted that the connecting pipe 63 which is formed of a highly rigid material, for example, a steel pipe need not have an extra length and is substantially free of fracture or rupture by the high pressure of cooling water, resulting in a very compact structure as a whole.

The cooling water to be injected from the internal nozzle 60 are preferably under considerably high pressure, and cooling water is preferably injected from the internal nozzle 60 to the inner surface of the steel pipe 2 at the same time as the steel pipe 2 is immersed in cooling water 3 in the tank 1, in order to concurrently initiate cooling on the outer and inner sides of the pipe. Since sudden injection of cooling water may have adverse effects such as water hammering, the system is constructed such that cooling water is continuously injected from the internal nozzle 60. On the other hand, to shield the steel pipe in the ambient air from injection splash of cooling water from the internal nozzle 60, a baffle 66 is disposed above the surface of cooling water 3 and between the internal nozzle 60 and the steel pipe 2 on the support rollers 9a, 9b as shown in Fig. 10.

As the internal nozzle 60, there is also prepared another nozzle designed such that the axis of its tip portion is offset from the axis of its rear portion to be connected to the connecting pipe 63 as shown by broken lines in Fig. 12. When a steel pipe to be hardened has a larger diameter than the previous one as shown in Fig. 12, the nozzle may be replaced by the other internal nozzle having an offset tip portion so as to align the nozzle with the steel pipe.

Next, the unloading means 12 for unloading the cooled steel pipe 2 from the tank 1 will be described with reference to Fig. 2. The unloading means 12 includes catch arms 67 for receiving the steel pipe 2 from the holding means 8 in the tank 1, conveyor units 68 for taking the steel pipe 2 from within the cooling water 3 to above the tank 1, and underwater skids 69 for transferring the steel pipe 2 from the catch arms 67 to the conveyor units 68. The catch arm 67 is located within the tank 1 so that it may be reciprocally swung between a position proximate to the lower limit of the holding means 8 and a lower position. On the other hand, the conveyor unit 68 includes an endless chain 70 having a plurality of hooks 71 attached thereto at given intervals and is obliquely extended from the center of the bottom of the tank 1 toward the upper end of the afore-mentioned slant skid 17. The underwater skid 69 is inclined downward from a position slightly below the upper limit of the catch arm 67 toward the conveyor unit 68.

In carrying out hardening of the steel pipe 2 by means of the apparatus of the above-mentioned arrangement, the rotating shaft 6 is rotated to position the lower and upper arms 7a and 7b at their upper limits shown by solid lines in Fig. 2 and the holding rollers 30 are upwardly withdrawn by the cylinder 36. The steel pipe 2 which has been heated to a predetermined temperature is transported to the side of the tank 1 by means of the conveyor rollers 13, and transferred therefrom onto the loading skids 14 by rotating the kick-out arms 15 for transfer counterclockwise as viewed in Fig. 2 to hold up the pipe from the conveyor rollers 13. The steel pipe 2 trundles along the loading skids 14 onto the support rollers 9. At this point, the steel pipe 2 comes in collision with the kick-out arms 27 attached to the lower arms 7a, which prevents the pipe from overrunning, and since the support rollers 9a on the side of the loading skids 14 are set at a somewhat higher level, the steel pipe 2 is also prevented from trundling back to the loading skids 14 beyond the support rollers 9 by the reaction of collision with the kick-out arms 27. After the steel pipe 2 becomes stationary on the support rollers 9, the steel pipe 2 is retained between the support rollers 9 and the holding rollers 30 by lowering the holding rollers 30. At this point, the holding force by the holding rollers 30 is adjusted to be relatively low (for example, on the order of 100 kg) in order to prevent deformation of the steel pipe 2. While being retained in this way, the steel pipe 2 is rotated about its axis by rotating the support rollers 9 by means of the roller drive 10. Cooling water is continuously injected from the external and internal nozzles 59 and 60. Although the retention of the steel pipe 2 on the support rollers 9 places the steel pipe above the same axis as the internal nozzle 60, the baffle 66 shields the steel pipe 2 from the internal nozzle 60 above the surface of the cooling water 3 in the tank 1, preventing the steel pipe 2 from being cooled on its inner surface before it is immersed in the cooling water 3 in the tank 1 as well as preventing any adverse effect by water hammering caused by starting suddenly and vigorously injecting cooling water through the internal nozzle 60 or the like.

While the steel pipe 2 is retained and rotated as mentioned above, the motor 26 of the rotational drive 20 as shown in Figs. 3 and 4 is started to rotate the rotating shaft 6 clockwise as viewed in Fig. 2, causing the upper and lower arms 7a and 7b and the nozzle arm 61 to rotate with the rotating shaft 6 in the direction of arrow A in Fig. 2. As a result, the steel pipe 2 is moved down along an arcuate path about the axis of the rotating shaft 6 and thus immersed into the cooling water 3. At this point, since the gear box 41 for transmitting a rotational force to the support rollers 9 is placed at a higher level than the lower arms 7a, the gear box 41 is never immersed in the cooling water 3 even after the support rollers 9 are lowered below the surface of cooling water 3. Since the steel pipe 2 and the internal nozzle 60 are lowered below the baffle 66 at the same time as the steel pipe 2 begins immersing in cooling water 3 in the tank 1 in this way, the cooling water is injected into the inner side of the steel pipe 2 from the internal nozzle 60, and consequently, the steel pipe 2 begins to be cooled from both its inner and outer sides substantially at the same time. The steel pipe 2 is eventually lowered to the position shown by broken lines in Fig. 2, and during this progress, cooling water is injected to the outer surface of the pipe from the external nozzle 59, cooling water is continuously injected to the interior of the pipe from the internal nozzle 60, and the steel pipe 2 itself is being rotated about its axis so that cooling water 3 flows in vigorously agitated state in essence in proximity to the inner and outer surfaces of the steel pipe 2, allowing the entire steel pipe 2 to be rapidly and uniformly cooled without an obstruction by steam resulting from boiling of cooling water 3. Since the steel pipe 2 is rotating, the steel pipe 2 comes in contact with the rollers 9 and 30 at continuously varying points thereof, preventing soft spots from being formed due to the local delay of cooling rate. Since the relative motion between the steel pipe 2 and the cooling water 3 is facilitated by rotating the steel pipe 2, the cooling water 3 can be substantially fully agitated and fluidized without particularly increasing the injection pressure of the cooling water injection means 11, succeeding in reducing the power consumption and the size of the cooling water injection means 11.

While the steel pipe 2 is being cooled as described above, the steel pipe 2 is reduced in temperature and increased in hardness, and hence, a force applied by the holding rollers 30 to hold the steel pipe 2 in a stable manner is now preferably increased to about 500 kg, for example. It is also preferable to change the direction of rotation of the support rollers 9 at given intervals because when the axes of the support rollers 9 and the holding rollers 30 are not parallel to the steel pipe 2, the steel pipe 2 can be axially moved back and forth, eventually leading to more uniform cooling.

When the support rollers 9 and the holding rollers 30 retaining the steel pipe 2 reach the lower limit shown by broken lines in Fig. 2, the holding rollers 30 are moved up by means of the cylinder 36 to cancel the retention of the steel pipe, and then the kick-out arms 27 pivoted to the lower arms 7a kick the steel pipe 2 toward the catch arms 67 to place the steel pipe 2 on the catch arms 67. Thereafter, the rotating shaft 6 is rotated in the reverse direction as opposed to the previous process to return the arms 7 with the support rollers 9 and the holding rollers 30 to the original upper limit where the rollers are ready for reception of a subsequent steel pipe 2. The catch arms 67 are rotated counterclockwise in Fig. 2 to transfer the steel pipe onto the underwater skids 69 and the steel pipe 2 trundles on the underwater skids 69 toward the conveyor units 68. Since the conveyor units 68 continue to operate in the direction of an arrow in Fig. 2, the steel pipe 2 is conveyed from the underwater skids 69 to above the water surface and then onto the slant skids 17. The steel pipe 2 which has been hardened is placed on the slant skids 17, once stopped by collision with the stops 18, and thereafter, transfered onto the delivery rollers 16 by means of the kick-out arms 19, for delivery to the destined location.

Accordingly, in the above-mentioned apparatus, the steel pipe 2 is not dropped from a high level and does not undergo a violent shock during a series of operations as mentioned above, the formation of surface defects on the steel pipe 2 can be substantially completely avoided.

By repeating the above-described procedure, a number of steel pipes 2 are successively hardened. When steel pipes 2 having a different length are hardened, the holding rollers 30 are relocated in the following manner. First, the locking cylinder 33 shown in Fig. 5 is operated to release the slide block 32. Then the motor 57 is actuated to rotate the feed screw 55 to move the slider 53 to the right or left, and the corresponding push arm 56 urges the slide block 32 to relocate the holding rollers 30. After the holding rollers 30 are relocated, the locking cylinder 33 is actuated to bring the slide block 32 in close contact with the guide plate 31 to lock the slide block 32 while the slider 53 is slightly moved reversely to leave gaps between the push arms 56 and the slide block 32. Then, galling between the slide block 32 and the push arms 56 is prevented from occurring when the slide block 32 is rotated with the rotating shaft 6 and the upper arm 7b.

INDUSTRIAL APPLICABILITY

The apparatus of the invention is useful in carrying out hardening of metallic pipes such as steel pipes and the like, particularly in carrying out hardening of seamless steel pipes of small and intermediate diameters.

CLAIM

1. An apparatus for immersion hardening a metallic pipe, characterized by comprising a tank containing cooling water; holding means for pressing a heated metallic pipe from both upper and lower directions and holding the pipe for rotation about its central axis; immersion means for moving the metallic pipe held by said holding means downward from the ambient air above the cooling water into the cooling water; cooling water injection means for injecting cooling water on the inner and outer sides of the metallic pipe in the interior of the tank; and unloading means for receiving the metallic pipe at the end of cooling from said holding means within the tank and conveying the pipe to the outside of the tank.

2. The metallic pipe immersion hardening apparatus as set forth in claim 1, characterized in that said holding means comprises plural pairs of support rollers arranged in a row in the axial direction of the metallic pipe, a roller drive for rotating the support rollers in a common direction, a plurality of holding rollers disposed for vertical motion above each pair of support rollers, and press means for pressing said holding rollers against the metallic pipe on said support rollers.

3. The metallic pipe immersion hardening apparatus as set forth in claim 2, characterized in that said press means is designed such that the pressing force applied by the holding

rollers to the metallic pipe is light in the ambient air and heavy in the cooling water.

4. The metallic pipe immersion hardening apparatus as set forth in claim 2, characterized in that said plural pairs of holding rollers are arranged at given intervals in the axial direction of the metallic pipe, and positioning means is provided for moving those of said holding rollers corresponding to at least one end of the metallic pipe in the axial direction of the metallic pipe.

5. The metallic pipe immersion hardening apparatus as set forth in claim 1 or 2, characterized in that said immersion means comprises a rotating shaft disposed above said tank and parallel to the metallic pipe, a rotational drive for reciprocally rotating said rotating shaft within the range of a given angle, and a plurality of arms attached to and extending radially from said rotating shaft and having said holding means attached to the distal end thereof.

6. The metallic pipe immersion hardening apparatus as set forth in claim 5, characterized in that said arm includes a lower arm disposed above said tank and standing by at a position for reception of the metallic pipe above said tank and an upper arm disposed above said lower arm, the support rollers on which the metallic pipe rests are attached to

the distal end of said lower arm, and the press means for pressing said holding rollers against the metallic pipe on said support rollers is attached to said upper arm.

7. The metallic pipe immersion hardening apparatus as set forth in claim 6, characterized in that the support rollers attached to the upper side of the distal end of said lower arm are two closely arranged rollers capable of rotating about an axis parallel to said rotating shaft, and one of said two rollers which is nearer to said rotating shaft is placed at a lower level than the other roller.

8. The metallic pipe immersion hardening apparatus as set forth in claim 5, characterized in that said roller drive comprises a gear box attached to one end of said rotating shaft and extending in the same direction as said arm, drive gears and driven gears received in the interior of said gear box and to rotate about their axes parallel to said rotating shaft, a motor disposed outside said tank and connected to said drive gears through universal joints, roller shafts extending parallel to said rotating shaft and having said support rollers attached thereto, and rotating/connecting rods connecting said roller shafts to said driven gears through other universal joints.

9. The metallic pipe immersion hardening apparatus as set forth in claim 1, characterized in that said cooling water injection means comprises an internal nozzle for injecting cooling water into the inner side of the metallic pipe in its axial direction, in the interior of said tank, and external nozzles for injecting cooling water toward the outer side of the metallic pipe in the interior of said tank.

10. The metallic pipe immersion hardening apparatus as set forth in claim 5, characterized in that said cooling water injection means includes an internal nozzle for injecting cooling water to the inner side of the metallic pipe in its axial direction in the interior of said tank, a crank-shaped connecting pipe having said internal nozzle attached thereto, and a water feed hose connected to said connecting pipe through a rotary joint, and said internal nozzle is attached to a nozzle arm projecting from said rotating shaft such that the internal nozzle is aligned with the metallic pipe on said support rollers, and said water feed hose is disposed on an extension of said rotating shaft such that the water feed hose is aligned with the rotating shaft.

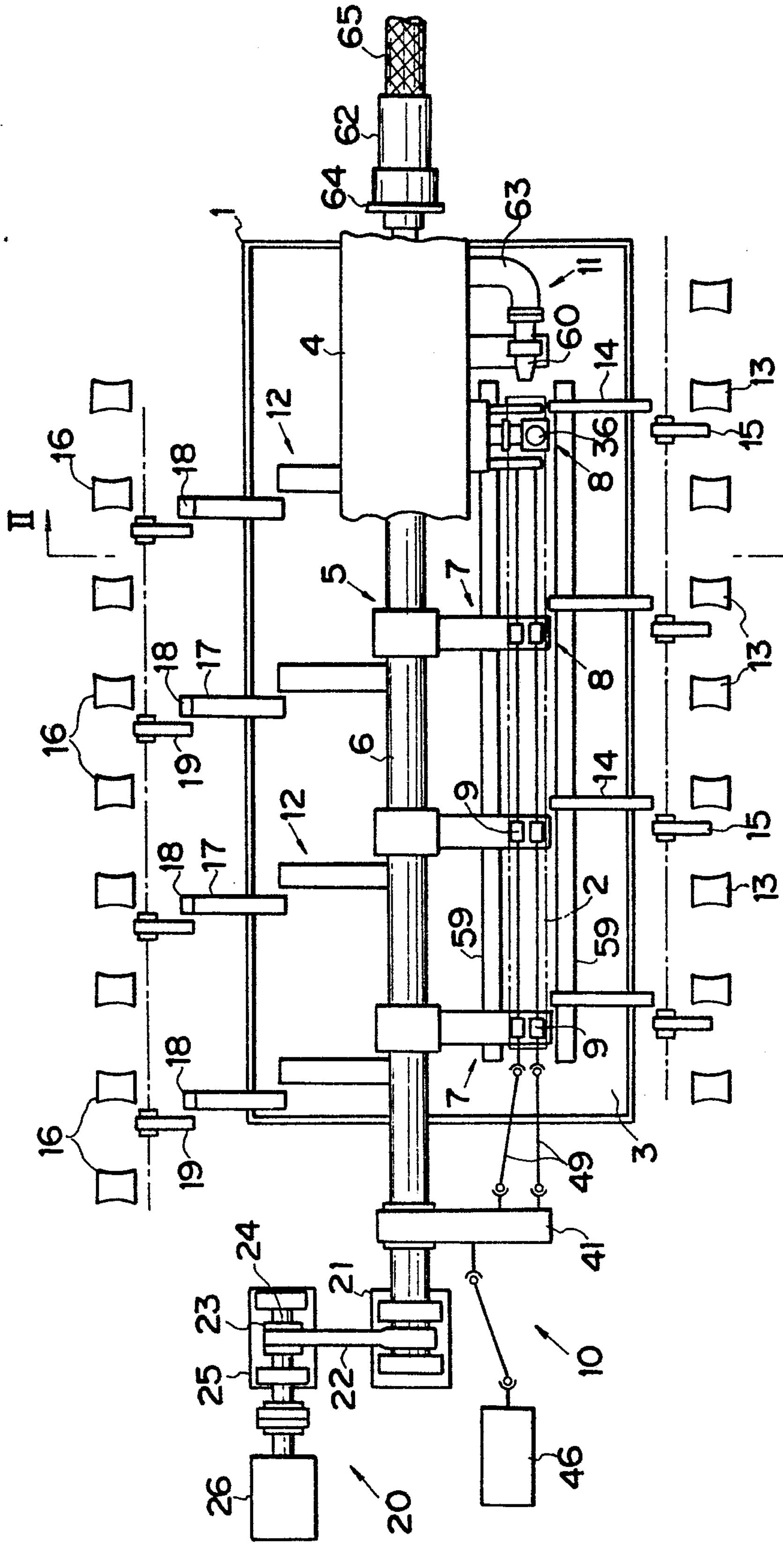
11. The metallic pipe imersion hardening apparatus as set forth in claim 10, characterized in that said internal nozzle is removably attached to said connecting pipe and said nozzle arm.

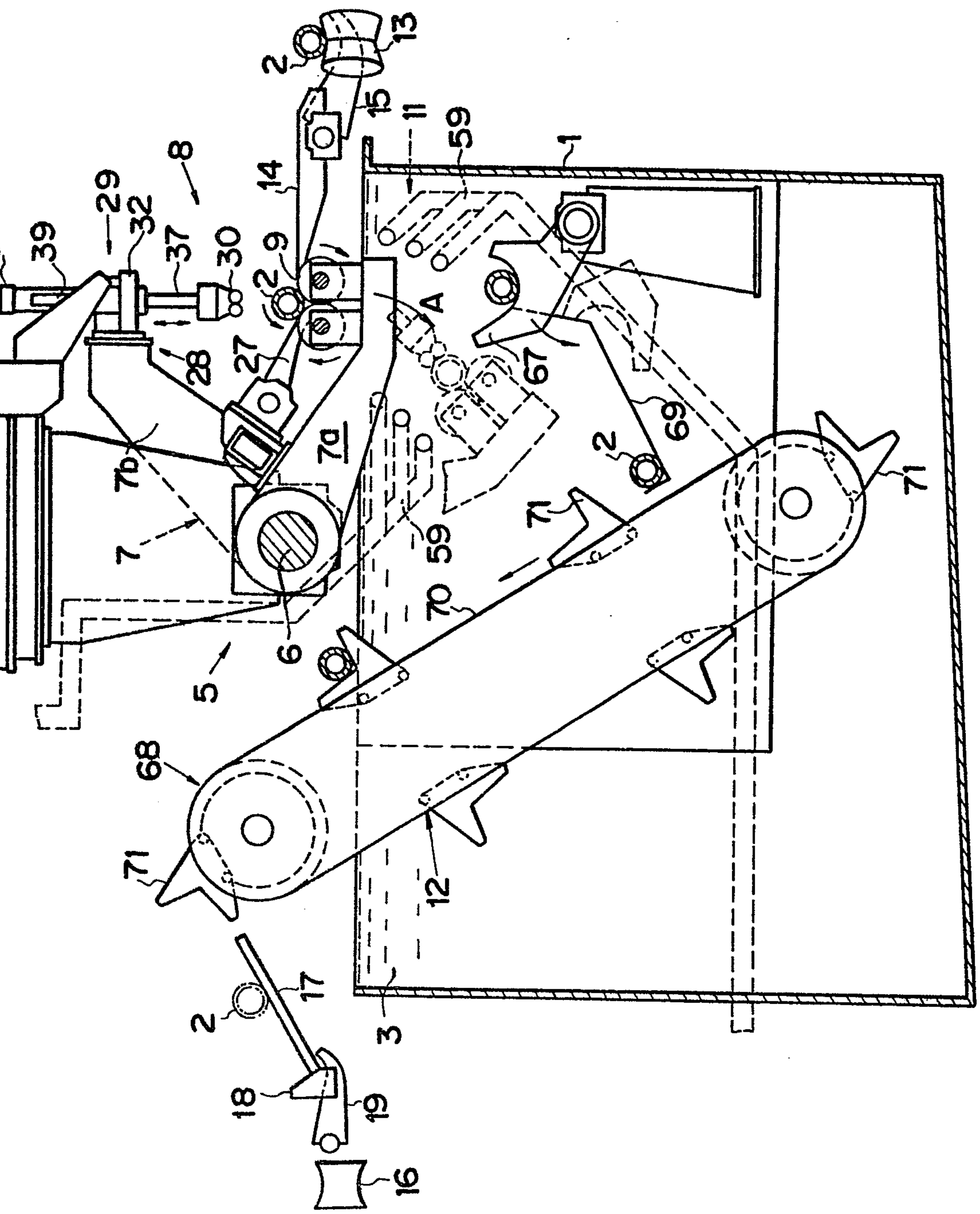
12. The metallic pipe immersion hardening apparatus as set forth in claim 10, characterized in that said internal nozzle has a tip portion whose central axis is offset from the central axis of a rear portion.

13. The metallic pipe immersion hardening apparatus as set forth in claim 10, characterized in that a spacing of a given dimension is left between the tip portion of said internal nozzle and the metallic pipe on said support rollers, and a baffle is disposed above the surface of cooling water in said tank to intervene between the tip portion of said internal nozzle and the metallic pipe.

14. The metallic pipe immersion hardening apparatus as set forth in claim 9, characterized in that said plurality of external nozzles are arranged on the opposite sides of the path along which the metallic pipe is moved down into the tank while being held by said holding means, and oriented toward the metallic pipe.

FIG.1





13
2
15
11
59
1
14
8
29
32
37
30
36
39
9
2
51
A
27
28
67
4
7a
69
2
7b
71
71
59
7
70
6
5
68
71
12
17
2
3
18
19
16

FIG.2

FIG.3

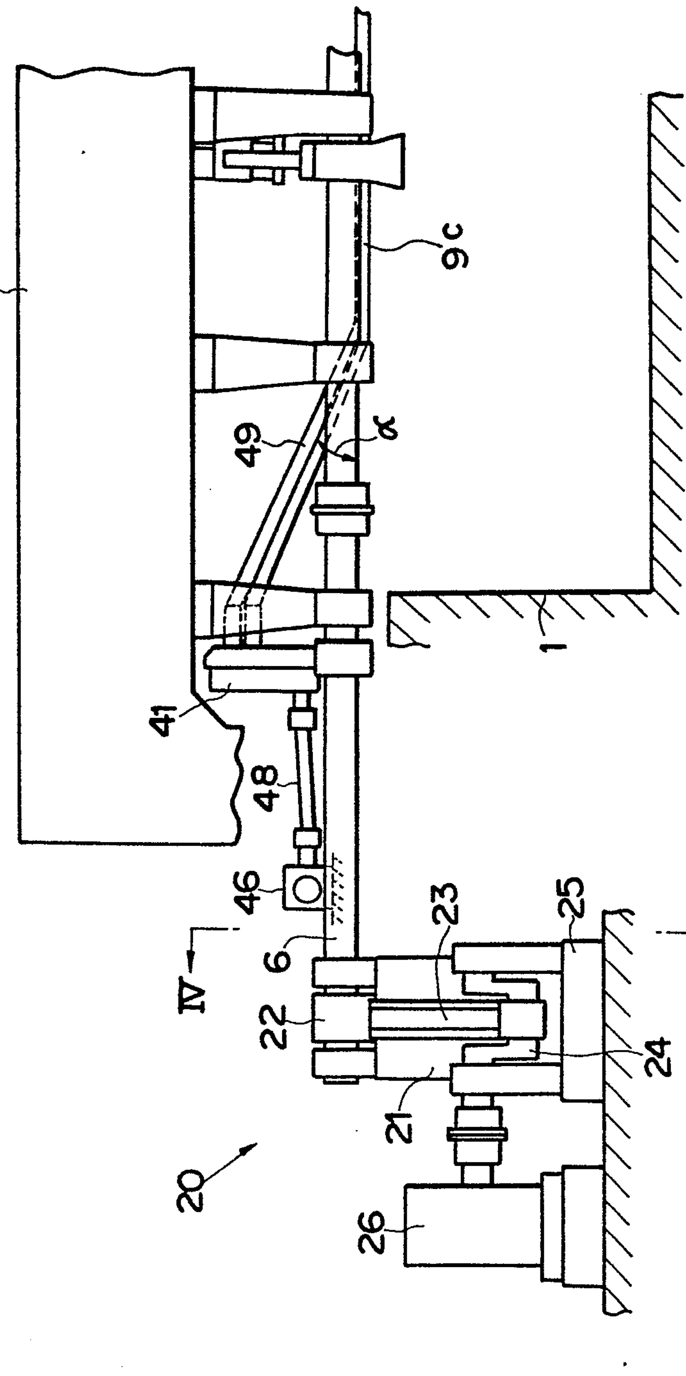


FIG.4

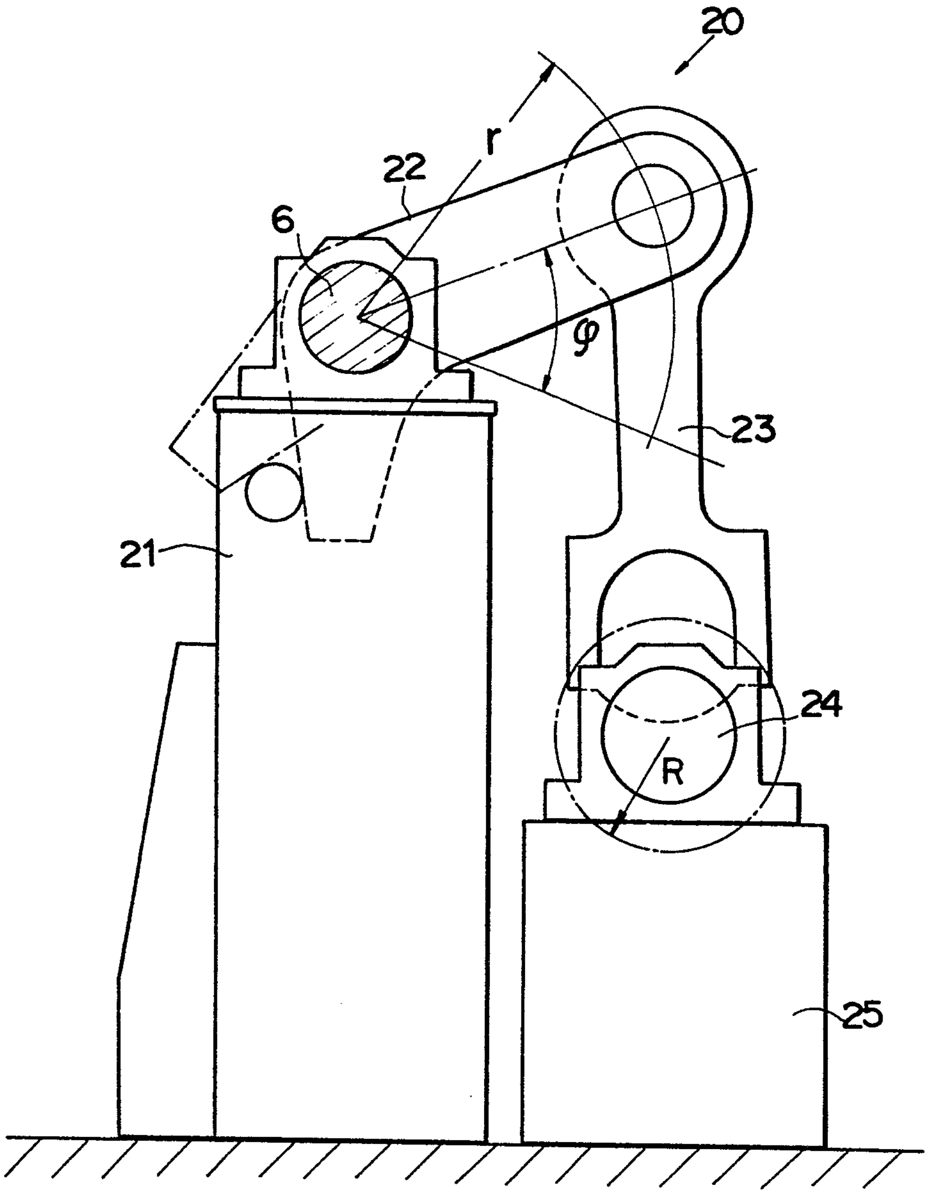


FIG.5

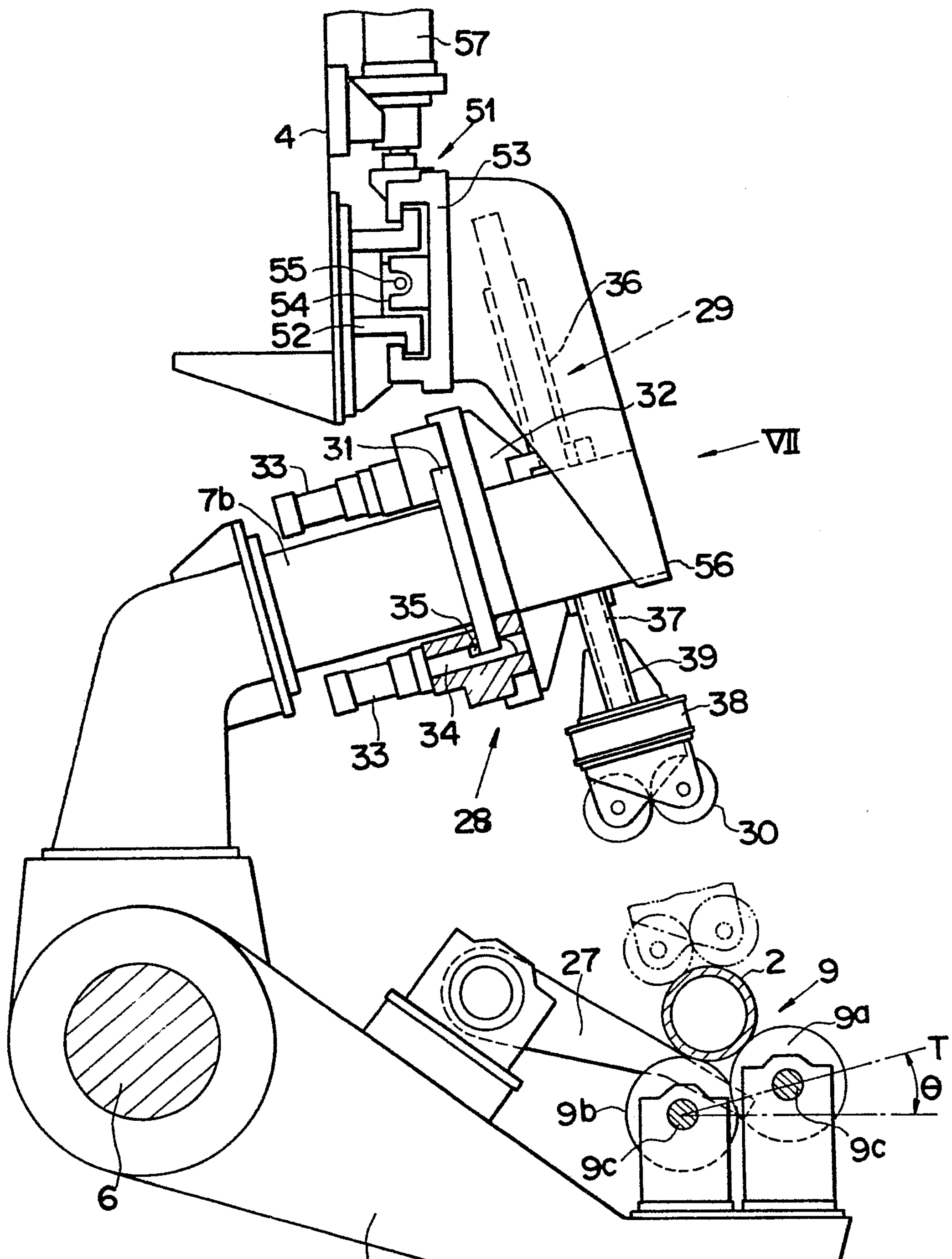

57
4
51
53
55
54
52
36
29
32
VII
31
33
7b
56
35
37
39
38
33
34
28
30
27
2
9
9a
T
θ
9b
9c
9c
6
7a

FIG.6

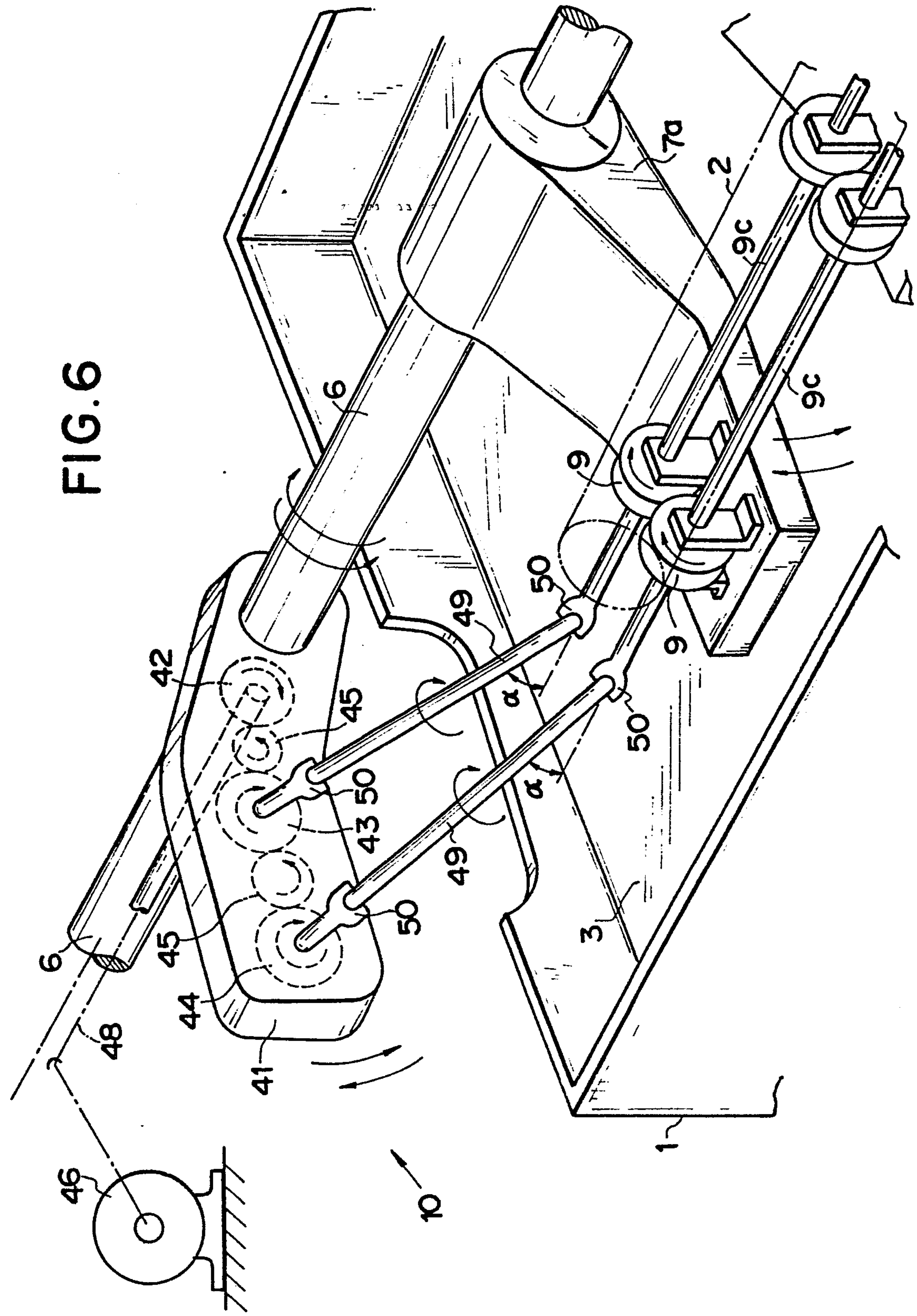


FIG.7

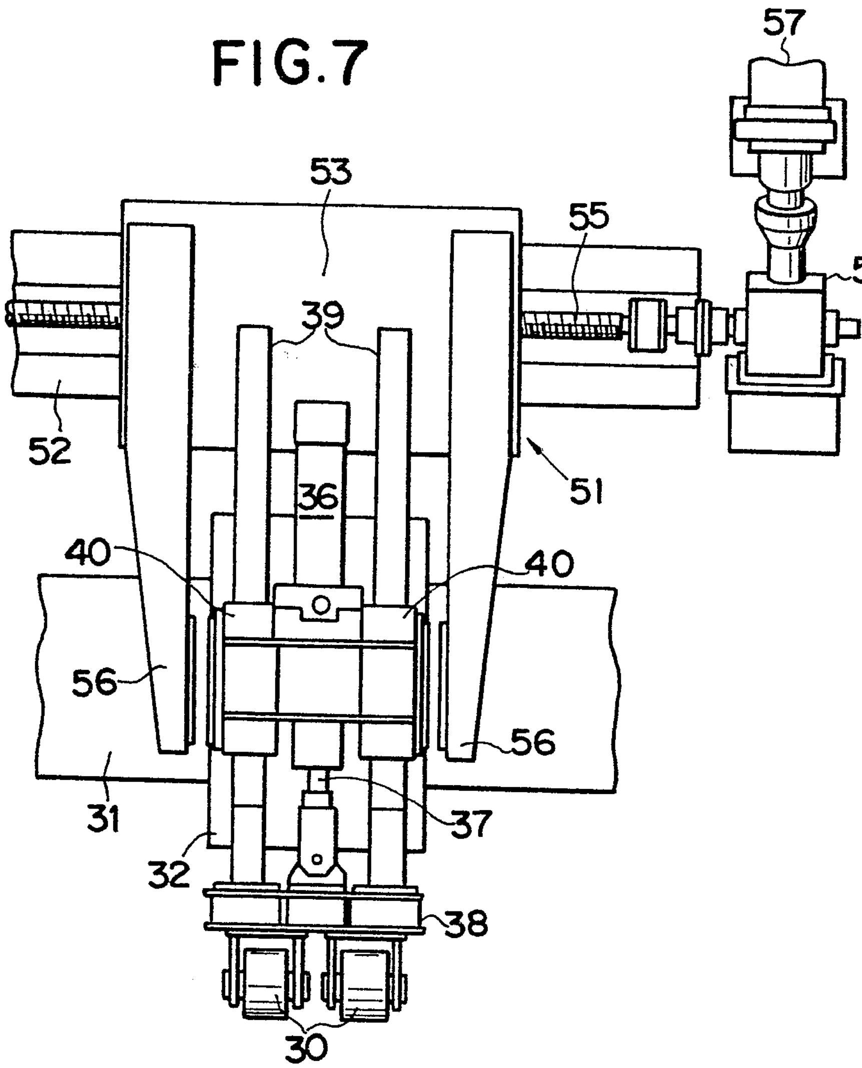

57
53
55
58
39
52
51
36
40
40
56
56
31
37
32
38
30

FIG.8

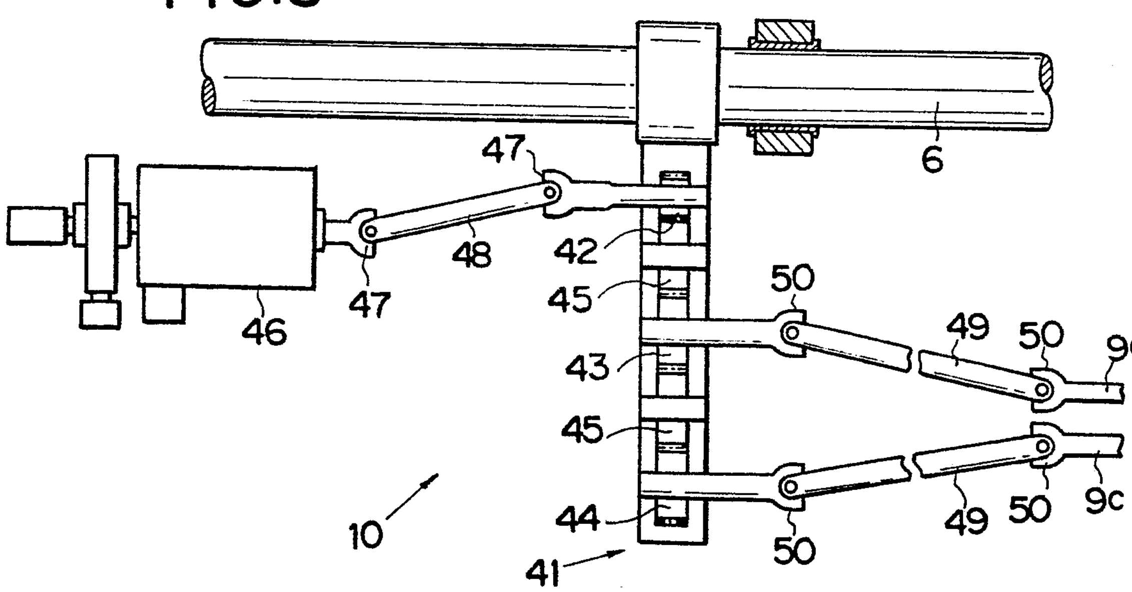

6
47
47
48
42
45
46
50
49
50
9c
43
45
9c
44
10
49
50
50
41

FIG.9

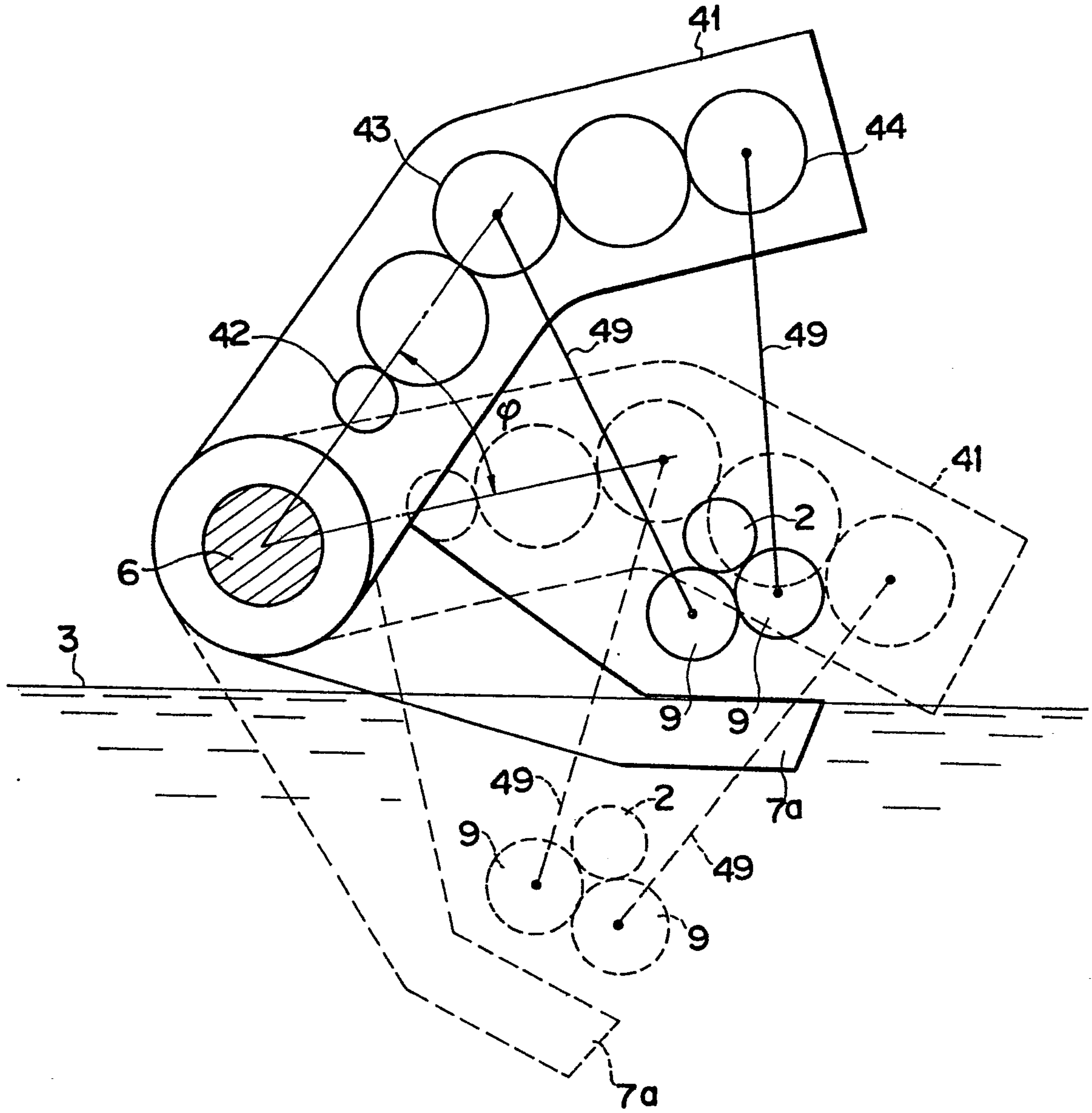


FIG. 10

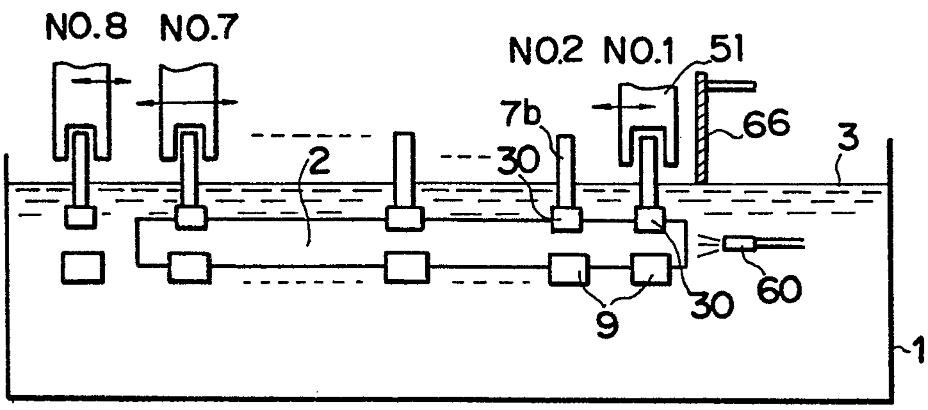
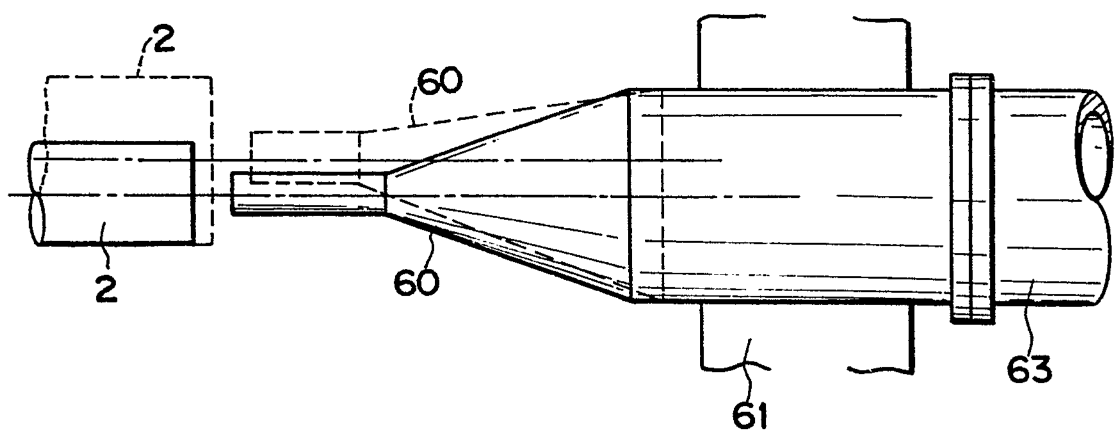


FIG. 12



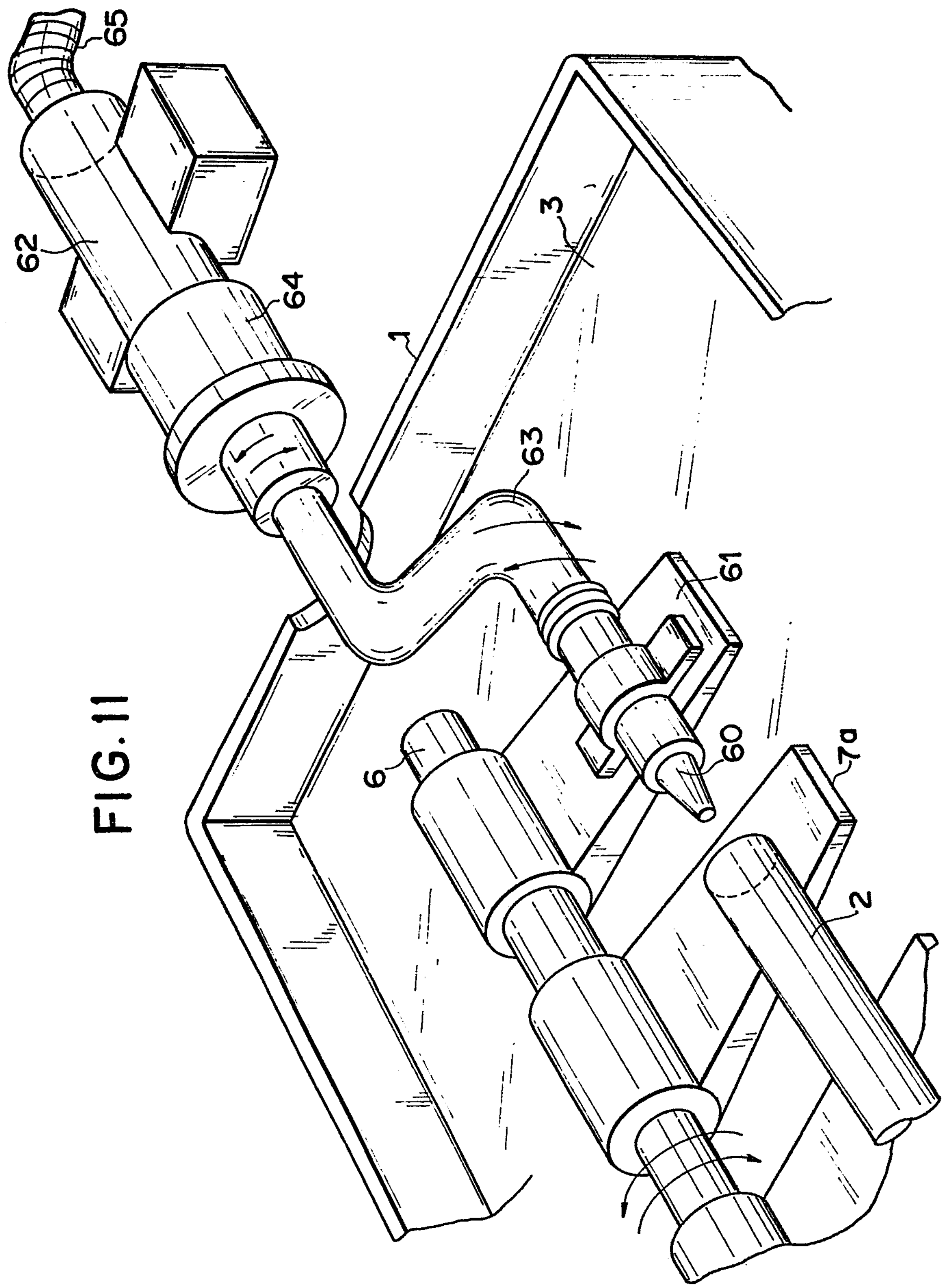


FIG.11

INTERNATIONAL SEARCH REPORT

0172250

International Application No. PCT/JP84/00049

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [3]

According to International Patent Classification (IPC) or to both National Classification and IPC

Int. Cl^3 C21D 1/64, 9/08

II. FIELDS SEARCHED

Minimum Documentation Searched [4]

Classification System	Classification Symbols
IPC	C21D 1/64, 9/08

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [5]

Jitsuyo Shinan Koho	1926 - 1984
Kokai Jitsuyo Shinan Koho	1971 - 1984

III. DOCUMENTS CONSIDERED TO BE RELEVANT [14]

Category*	Citation of Document, [16] with indication, where appropriate, of the relevant passages [17]	Relevant to Claim No. [18]
X	JP, A, 59-23819 (Kawasaki Steel Corp.) 7 February 1984 (07. 02. 84) Page 2, lower left column, line 4 to page 3, lower left column, line 20	1-3, 9, 11, 14
E	JP, A, 59-35627 (Kawasaki Steel Corp.) 27 February 1984 (27. 02. 84) Page 1, lower left column, lines 6 to 16	1, 2, 5, 6, 9, 13, 14
A	JP, A, 53-83910 (Nippon Steel Corp.) 24 July 1978 (24. 07. 78) Page 2, upper left column, line 8 to page 3, upper left column, page 2 & FR, A1, 2375922 & US, A, 4116716 & GB, A, 1550526	1 - 14

* Special categories of cited documents: [15]

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search [2]	Date of Mailing of this International Search Report [2]
May 2, 1984 (02. 05. 84)	May 14, 1984 (14. 05. 84)
International Searching Authority [1]	**Signature of Authorized Officer [20]**
Japanese Patent Office	