Jan. 23, 1940. B. H. URSCHEL 2,188,257

MACHINE FOR HEAT-TREATING METAL ARTICLES

Filed Sept. 4, 1937 6 Sheets-Sheet 1

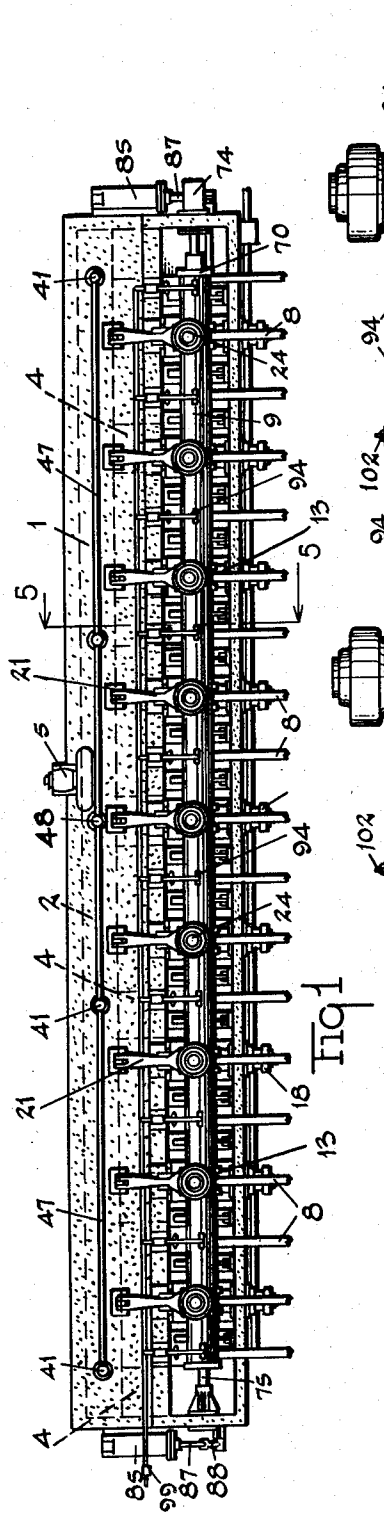


Fig 1

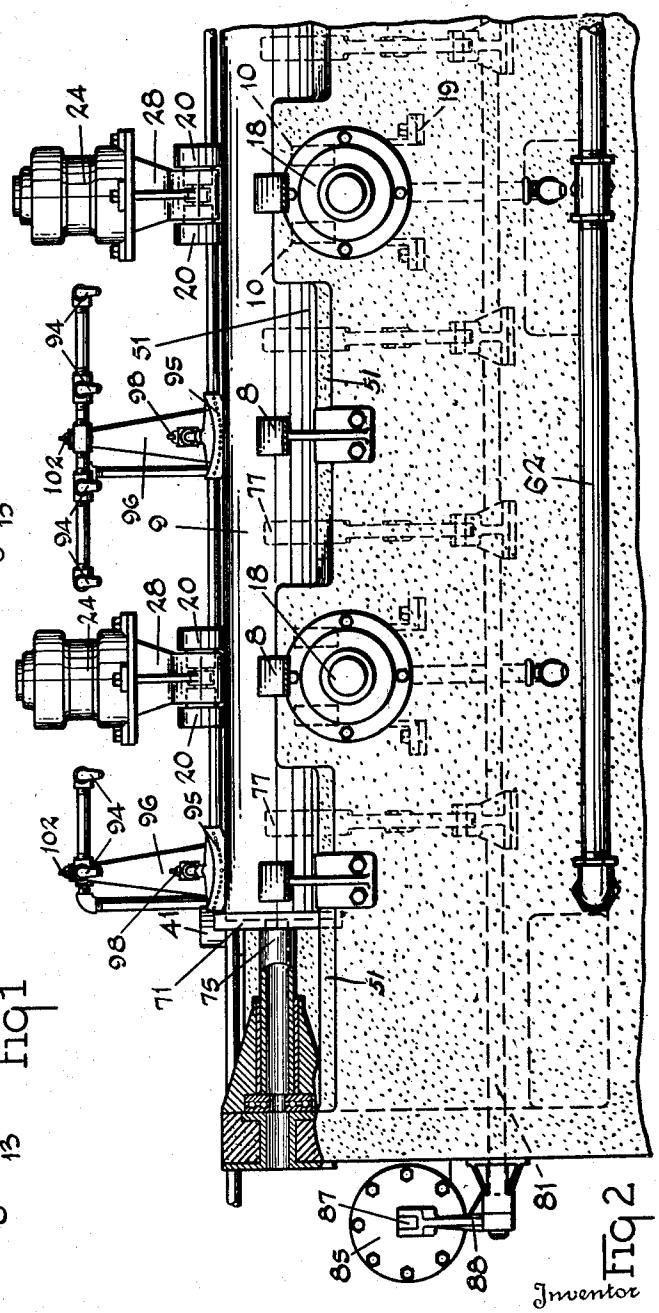


Fig 2

Inventor

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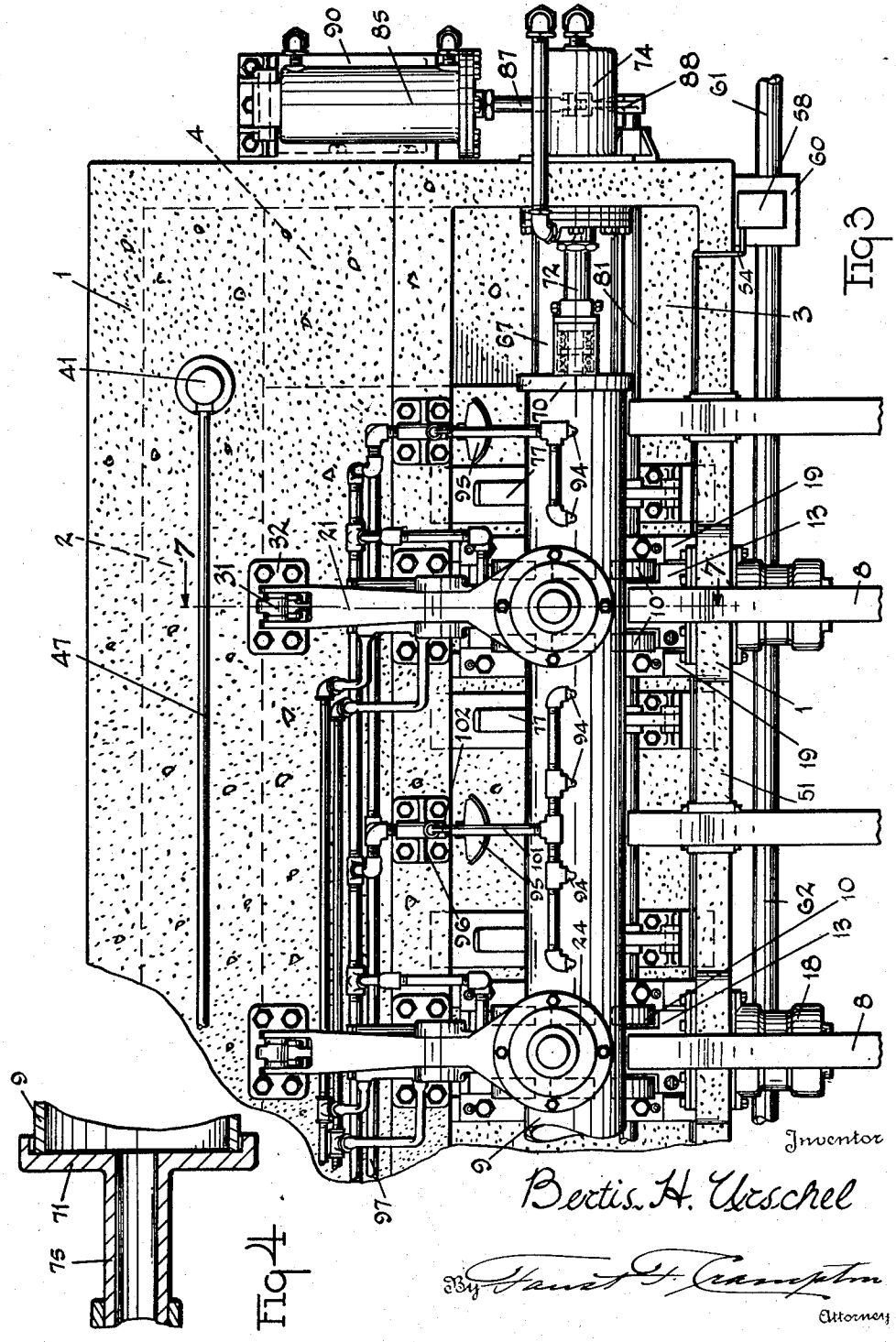
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MACHINE FOR HEAT-TREATING METAL ARTICLES

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MACHINE FOR HEAT-TREATING METAL ARTICLES

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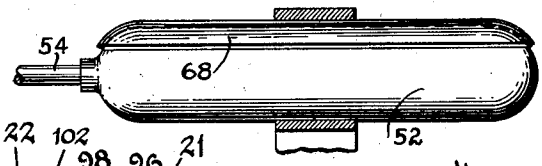


Fig. 14

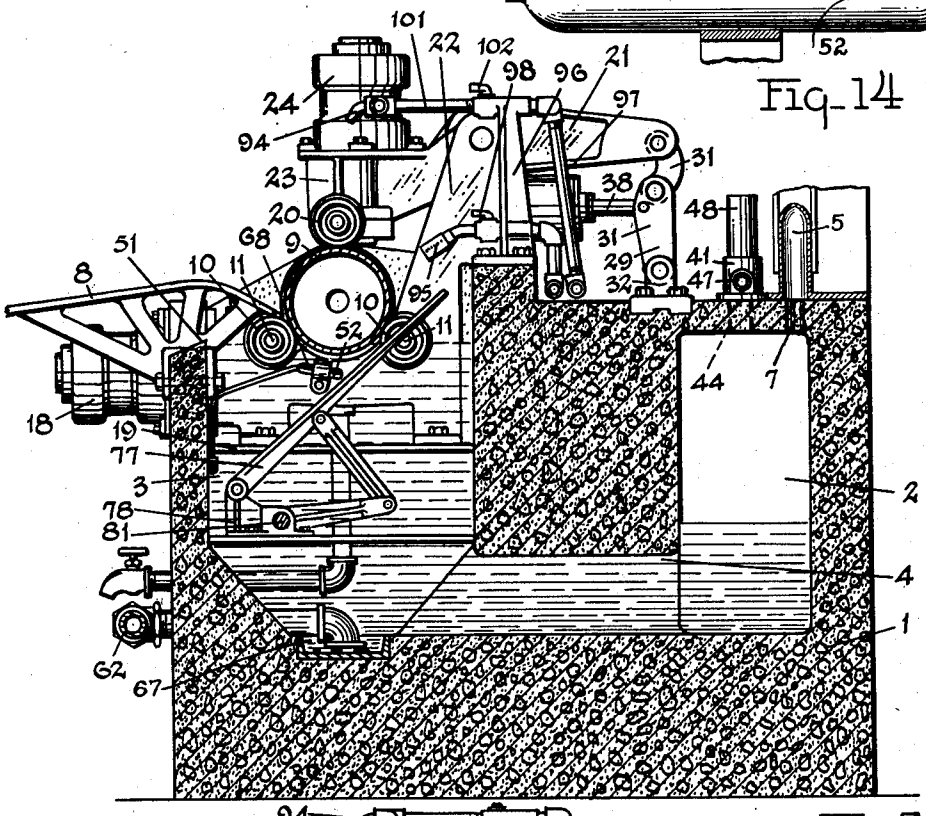


Fig 5

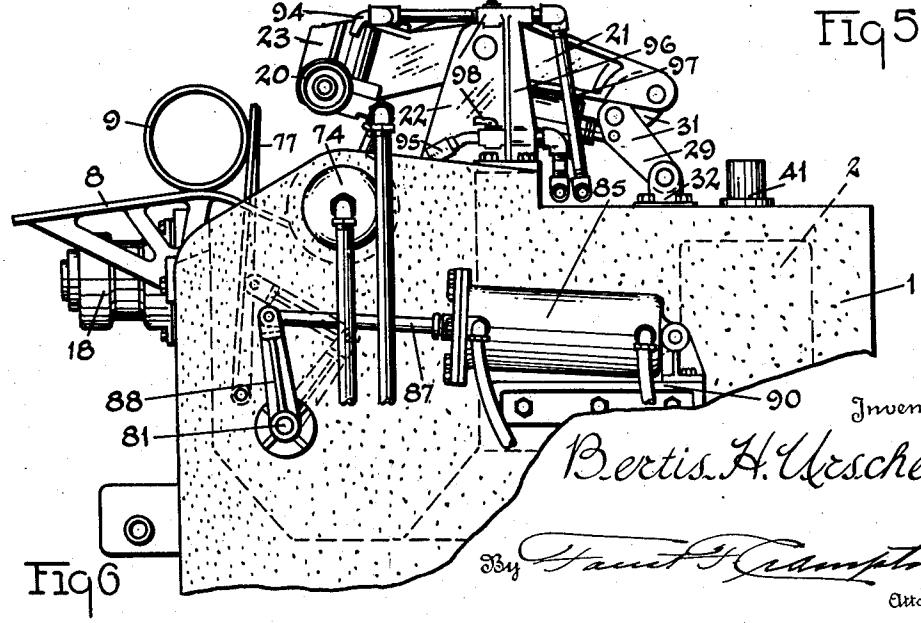


Fig 6

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MACHINE FOR HEAT-TREATING METAL ARTICLES

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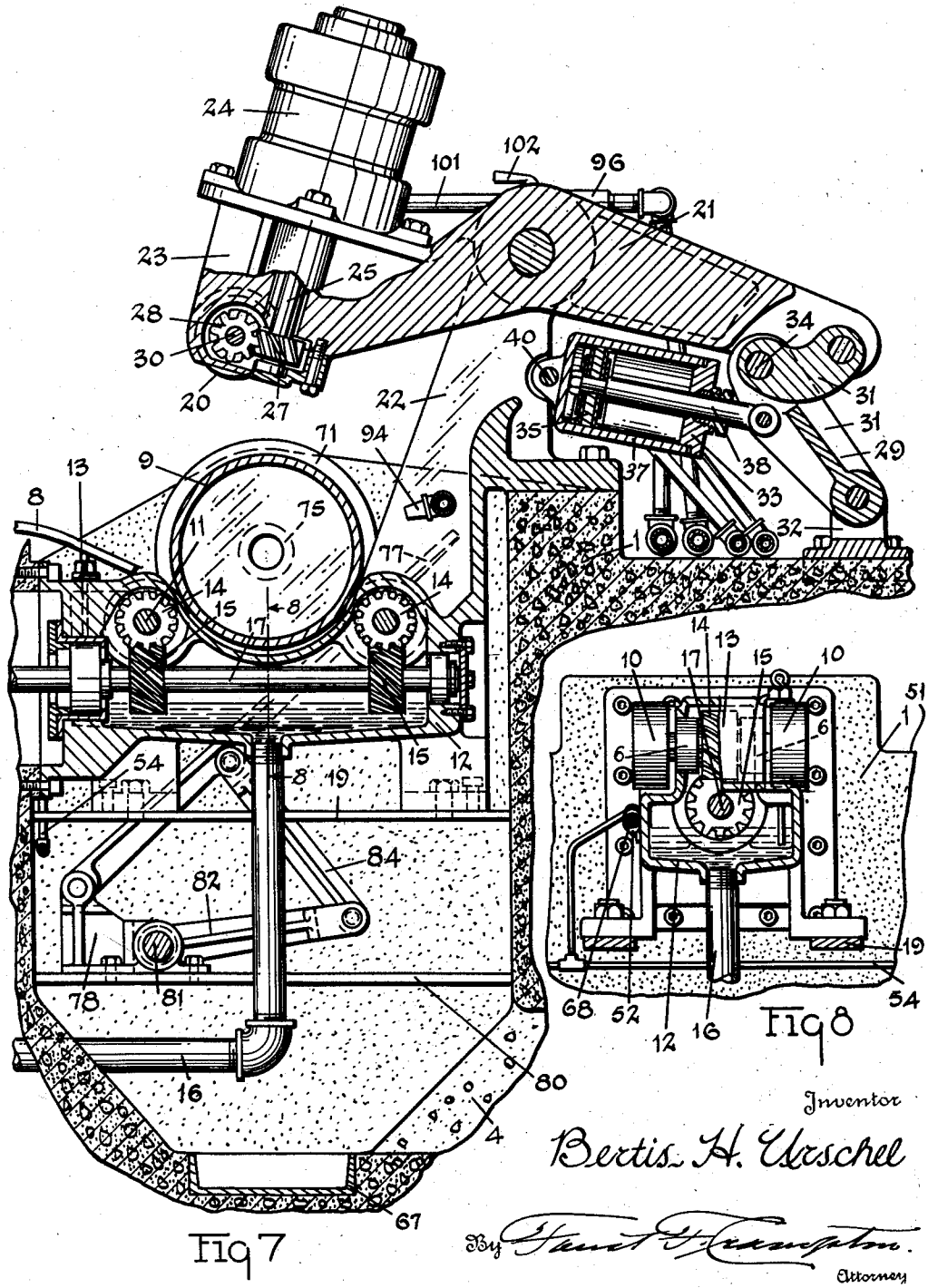


Fig 7

Fig 8

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MACHINE FOR HEAT-TREATING METAL ARTICLES

Filed Sept. 4, 1937 6 Sheets-Sheet 5

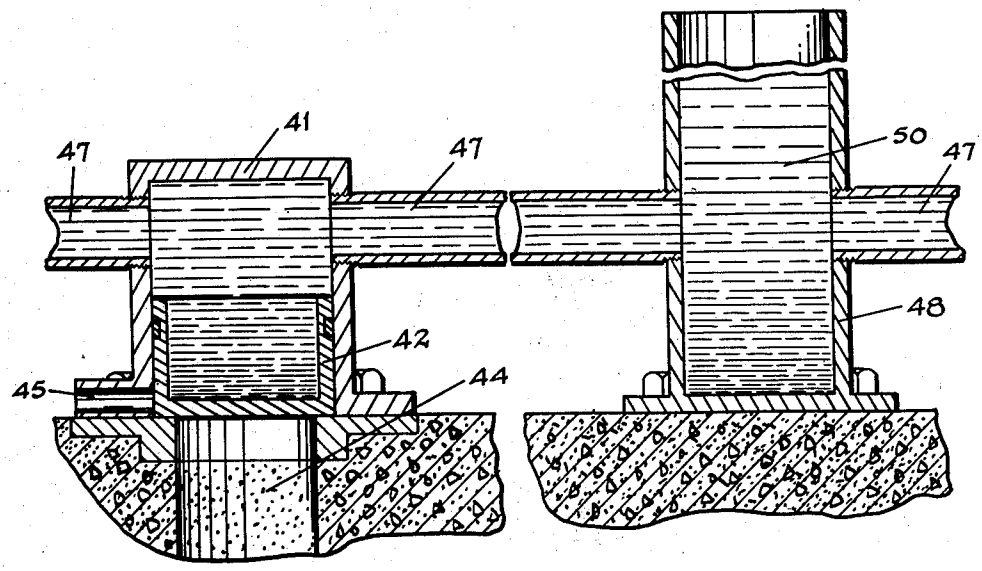


Fig 9

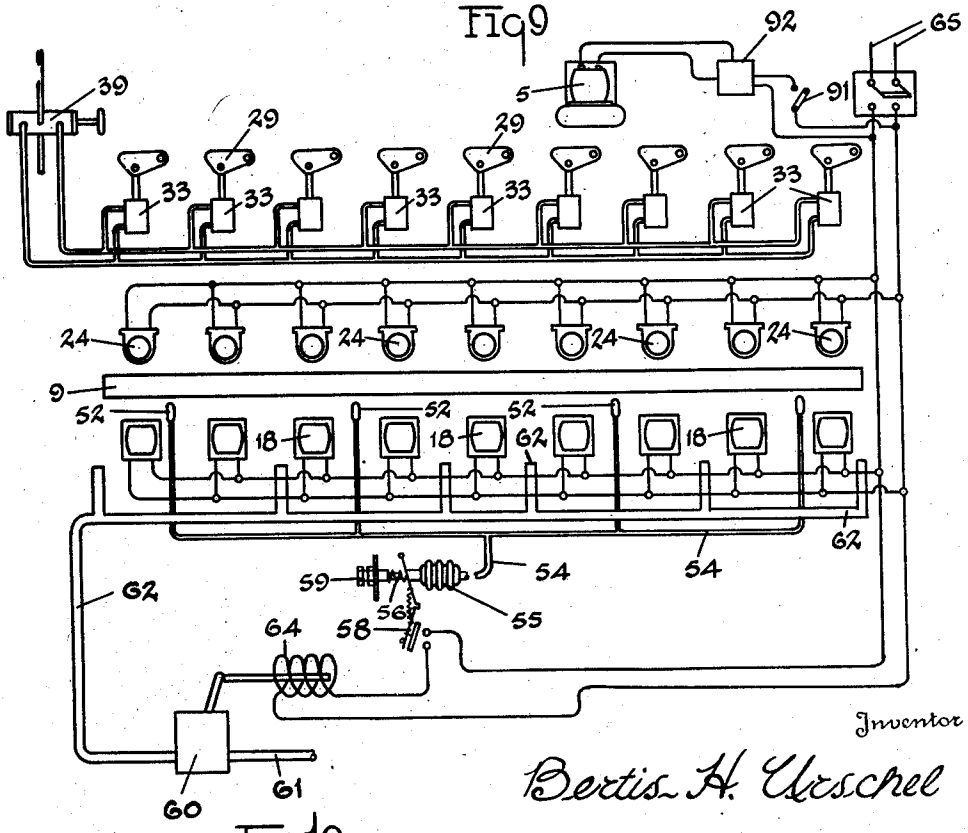


Fig 10

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MACHINE FOR HEAT-TREATING METAL ARTICLES

Filed Sept. 4, 1937 6 Sheets-Sheet 6

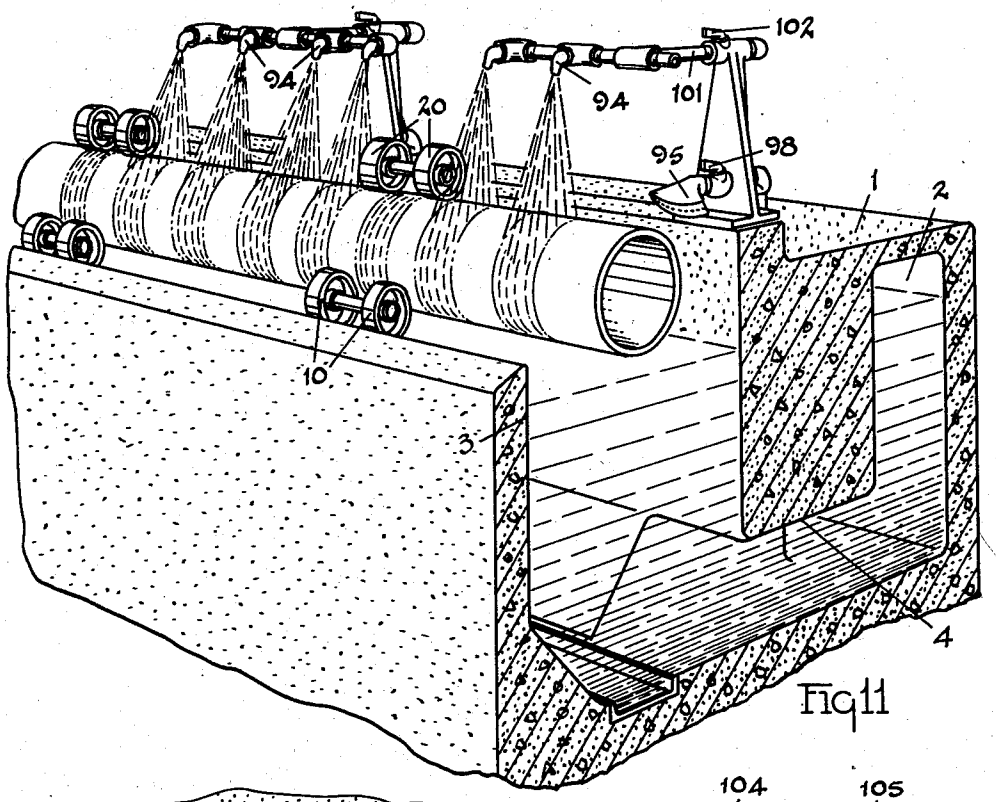


Fig11

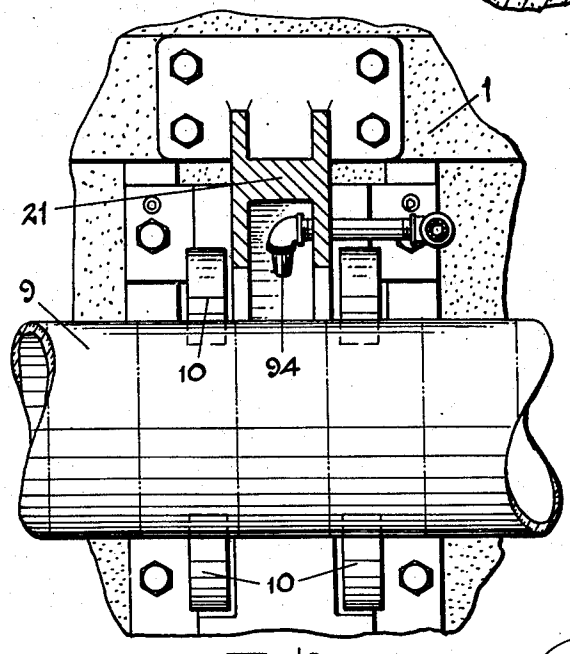


Fig12

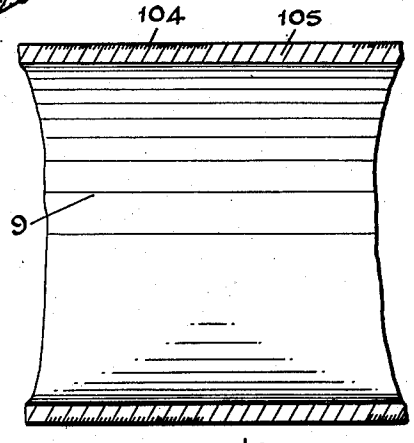


Fig13

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Patented Jan. 23, 1940 2,188,257

UNITED STATES PATENT OFFICE

2,188,257

MACHINE FOR HEAT-TREATING METAL ARTICLES

Bertis H. Urschel, Bowling Green, Ohio, assignor to Urschel Engineering Company, Bowling Green, Ohio, a corporation of Ohio

Application September 4, 1937, Serial No. 162,428

9 Claims. (Cl. 266—6)

My invention has for its object to provide a machine for manipulating heated bodies to produce desired physical properties or shapes to render them more efficient for the purposes which they are to perform or the uses to which they are to be subjected. Particularly, the invention has for its object to produce a machine for heat-treating pipes formed of steel and alloys of steel to greatly increase their strength and resistance to fracture. The invention enables the production of pipes for containing fluids of exceedingly high pressures and used for a great variety of purposes. As is well known, pipe casings, such as are commonly used in oil fields, extend to a great depth and are subjected to enormous pressures and stresses, particularly, when the greater depths are reached and also, particularly, during the downward movement of the casing as the drilling operations progress.

The invention provides means for producing a uniform rate of chilling of the walls to obtain exact and uniform chilling temperatures throughout the relatively thin wall of pipes which have been heated above the higher critical temperature, depending upon the steel content or character of alloy, and cessation of chilling, at substantially a definite steel color or temperature, such as about 1000°, to produce the required temper or hardness or strength.

The invention also provides a means for quickly submerging surface portions of the pipe to a uniform depth throughout the length of the pipe and, also, quickly emerging at the required time interval without causing splashing of the cooling liquid whereby uniform change in the temperature of the pipe throughout its length may be maintained. The invention also provides a means for surface hardening the exterior surface of the pipe, which will increase resistance to abrasion during the movement of the pipe over the rock surface as it descends within the bore during well drilling.

The invention also provides a machine whereby the pipes may be rapidly straightened, heat-treated, and cooled to rigidity while maintaining the pipes straight.

The invention also provides means for cooling the entire wall of each pipe at a uniform rate of temperature change to the proper drawing temperature, depending upon the steel characteristics or steel content, and allowing the pipe to slowly cool to a suitable temperature, such as 800° or 900° Fahrenheit, while maintaining the pipe straight to remove all internal stresses and produce uniform physical properties throughout the wall of the pipe and a straight wall structure of high resistance to all forms of strains and stresses. Thus, the invention eliminates the necessity of reheating or straightening and temperature drawing the pipes to eliminate localized hardening of wall portions of the pipes.

The invention also provides means for progressively increasing the pressure on the objects as the temperature decreases during the heat-treatment to shape or maintain form as the rigidity of the pipe well increases.

The invention also provides a method and means for producing variations of temper of portions of steel elements such as to produce tempered portions for machine cutting.

The invention also provides a method and means for hardening steel bodies along definite areas of surface portions, as in the case of pipes or rods, to harden circular surface portions and yieldable tempered intermediate portions of each element and thereby produce high resistance to strains, particularly to compression strains, and flexibility of the element as a whole.

The invention also provides a machine structure for manipulating and heat-treating large steel elements which may be made at a relatively low cost.

The invention consists in other features and advantages that will appear from the following description and upon examination of the drawings forming a part hereof. Structures containing the invention may partake of different forms and may be varied in their details and still embody the invention. To illustrate a practical application of the invention, I have selected a heat-treating and straightening machine as an example of the various structures that contain the invention and shall describe the selected structure hereinafter, it being understood that certain features of my invention may be used to advantage without a corresponding use of other features of the invention and without departing from the spirit of the invention as presented in the claims. The particular structure selected is shown in the accompanying drawings.

Fig. 1 of the drawings illustrates a top view of the particular machine selected as an example of embodiments of the invention. Fig. 2 is a side view of one end part of the machine. Fig. 3 is an enlarged top view of the other end part of the machine. Fig. 4 illustrates a pipe end-closing and clamping member. Fig. 5 illustrates a view of a section taken on the plane of the line 5—5 indicated in Fig. 1. Fig. 6 illustrates a view of a part of the end of the machine. Fig. 7 illus-

trates a view of a section of a part of the machine taken on the plane of the line 7—7 indicated in Fig. 3 through one of the gear housings of one of the pipe manipulating pressure units of the machine. Fig. 8 is a view of a section of the gear housing taken at right angles to the section shown in Fig. 7 and on the plane of the line 8—8 indicated in Fig. 7. Fig. 9 illustrates an enlarged broken view of one of the pressure valves of the machine and a hydrostatic pressure means for controlling the valve. Fig. 10 illustrates diagrammatically parts of the machine and the fluid pressure and electric circuits used in connection therewith. Fig. 11 is a perspective view of parts of the machine and particularly illustrates the arrangement of the nozzles and the rotated element that is heat-treated by the machine. Fig. 12 is a view of a section of a part of the machine to show the location of one of the nozzles. Fig. 13 illustrates a section of a pipe heat-treated in the machine and indicates the surface hardened portions produced in the heat-treatment. Fig. 14 illustrates a thermostatic liquid control means for controlling the temperature of the heat-treatment liquid.

The supporting structural parts or bed 1 of the machine shown in the drawings may be formed of concrete. It is provided with a closed reservoir part 2 and a trough part 3 which are connected together by a plurality of passageways 4. The parts 2 and 3 are partially filled with a liquid, such as water, and a pneumatic pressure producing means, such as blower 5 of a type sufficient to create a pneumatic pressure of 8 or 10 ounces, is connected to the reservoir part 2 through a suitable opening, such as the opening 7, for lowering the water in the reservoir part 2 by the pressure of the blower 5 and causing it to move through the passageways 4 into the trough part 3 to raise its level in the trough part when the blower operates and to return to the reservoir part and lower the level in the trough part when the blower ceases to operate or when its pressure is cut off.

The machine is designed for heat-treating and straightening pipes that may be of any length, such as from 20 to 40 feet long and 6 to 12 inches in diameter and in order to produce immediate and undisturbed transmission of the water from the reservoir part 2 into the trough part 3, a plurality of large passageways 4 are used for interconnecting the said parts of the machine. Thus, the level of the water is caused to quickly and uniformly rise in the trough part 3 without any disturbance or splashing of the water when extra-atmospheric pressure is produced in the reservoir, and to quickly return the water to the reservoir when the additional pressure ceases.

The pipes are heated by a suitable furnace to a temperature above the critical temperatures of the steel or alloys of which the pipes are formed in the manner well known in the art of steel tempering. They are directed or conveyed to the machine singly by any suitable means, such as over tracks 8 that direct each pipe 9 onto suitably aligned pairs of rollers 10 that rotatably support the pipe while in the machine.

In order to heat-treat extremely long pipes, the machine is provided with a plurality of units 13 distributed along the trough part 3 of the machine, each unit comprising a means for rotatably supporting each pipe as it is heat-treated and a pressure mechanism for straightening the pipe. The rollers 10 are supported on short shafts 11 located in the gear housings 12. The rollers 10 are located exterior the side walls of the housings and the shafts 11 are supported in suitable bearings 6 located on or formed in the side walls of the housings 12. The shafts 11 of the units are driven by gear wheels 14 that are connected to the shafts 11 and mesh with the gear wheels 15 secured to the shafts 17. The shaft 17 of each unit is rotatably supported in the end walls of the housing and is connected with an electric motor 18 supported on the bed 1 for driving the shafts 17 and 11 and rotating the rollers 10 of the units 13 and the pipe that is supported in the trough on the rollers. The units 13 are secured to cross bars 19 that may be embedded in the bed 1 and are provided with suitable flange parts that enable bolting the units to the bed, such as by stud bolts partially embedded in the concrete of the bed.

The pairs of rollers 10 of each unit are spaced apart and so as to engage the pipe at points located angularly 120° apart and pressure rollers are disposed by suitable mechanism at points intermediate the rollers 10 as measured on the circle of the exterior cylindrical surface of the pipe. The pressure rollers 20 are located on levers 21 supported on brackets 22 that may be secured to or form integral parts of the housings 12. The levers 21 are each provided with a head 23 on which an electric motor 24 is mounted. A shaft 25 is rotatably supported in the head 23 and is connected to the motor 24. A gear wheel 27 is connected to the shaft 25 and meshes with a gear wheel 28 that is secured to a shaft 30. The shaft 30 is also rotatably supported in the head 23. The pressure rollers 20 are located on the ends of the shafts 30 of the units so as to engage the pipe 9 when the heads 23 are lowered by the movements of the levers 21. The motors 18 and 24 coact to rotate the pipe at a relatively high speed to insure, through the rollers, uniformity of bending in straightening and uniformity of chilling in heat-treating the pipe.

A suitable means is provided for independently manipulating the levers and exerting pressures that are transmitted through the rollers 20 to the pipe. In the form of construction shown, one end of each lever is provided with a toggle joint 29 comprising the links 31, one of which is pivotally connected to a bracket 32 that is secured to the bed of the machine. The links 31 are connected together by a suitable pin 34 which forms the central joint of the toggle construction. A pneumatic pressure means 33 may be used for manipulating the pressure rollers 20 through the operation of the toggle 29. Inasmuch as the pairs of rollers 10 of the machine are located in axial alignment, the pressure of the rollers 20 on the heated pipe will operate to progressively axially align the parts of the pipe and thus straighten the heated pipe as they engage it by the operation of the pneumatic pressure devices.

Each of the pneumatic pressure devices 33 comprises a piston 35 and a cylinder 37. The piston 35 is connected by means of the piston rod 38 with one of the links 31 to exert a pressure to move the central joint of the toggle toward a position of alignment with the pivot points of connection with the lever 21 and the bracket 32 and thus progressively force the parts of the pipe in axial alignment and straighten the pipe. The cylinder 37 is pivotally connected by means of the pin 40 with the bracket 22 to enable oscillatory movements of the cylinder 37 and the piston rod 38 in conformity to the swinging movements of the link 31 to which the piston rod 38 is connected. The cylinders 37 of the units of the machine are con-

nected to a source of supply of fluid under pressure that may be manually controlled by a suitable valve 39. The passageways from the control valve to the cylinders may be suitably restricted to produce simultaneous movements of the levers 21 to move the rollers 20 against the pipe located in the machine with a relatively light initial pressure to prevent denting the heated wall of the pipe.

When the heated pipe is disposed on the rollers and has been straightened, the blowed 5 is operated to raise the level of the liquid and produce contact between the liquid and pipe or to cause submergence of the pipe in part during its rotation. The liquid is held in contacting relation with the pipe until the temperature of the pipe is reduced to below the higher critical temperature, such as to about 1000° Fahrenheit, depending upon the steel characteristics of which the pipe is formed, whereupon the operation of the blower is discontinued and the level of the liquid in the trough is lowered. Any warping by reason of the chilling operation of the pipe is overcome by the pressure of the rollers 10 and 20 and rotation of the pipe. The pipe is held straight, as its rotation continues, until the temper of the pipe is drawn, that is, until the pipe has cooled in air to about 800° or 900° Fahrenheit. Rotation of the pipe continues until the wall becomes rigid. When the temperature of the pipe is substantially at the critical temper drawing temperature, the central joints of the toggles 29 approach alignment with the pivot points of connection of the outer ends of the links, and consequently, as the pipe cools during its rotation to temper the steel, the toggles 29 are automatically extended by the reduction in the diameter of the pipe while being subjected to the pneumatic pressure in the cylinders 37. The toggles thus produce a progressively increased magnification of the pneumatic pressure of the cylinders in the transmission of the pressure to the rollers 20 as the walls of the pipe contract and increase in rigidity. The slight extension of the toggles permitted by the reduction of the diameter of the pipe when the central joint approximates alignment with the other centers of the toggles produces a pressure that is sufficient to prevent warping during cooling. The increasing pressure overcomes the resistance to straightening of the pipe as its rigidity increases.

In order to raise the level of the water to the same predetermined depth in the trough in each succeeding operation and to maintain the level during the pressure of the pneumatic pressure producing means, a plurality of valves 41 are disposed at spaced points along the bed 1 of the machine above the reservoir part 2. The valves 41 are provided with suitable pneumatic pressure actuatable elements, such as the pistons 42, that are slidably supported in the casings of the valves. The valves are connected to the reservoir part 2 of the machine through the openings 44 to operate the pistons 42 by the pressure produced in the reservoir by the blower 5. The valves are provided with ports 45 that are uncovered by the movement of the pistons 42. The movements of the pistons 42 are resisted, preferably, by a means that will produce substantially the same resistance to such movements in all of the valves 41 connected to the reservoir. Thus, the valves 41 are connected together by pipes 47 and to a standard or container 48 of suitable height and containing a liquid 50 that fills the spaces of the pipes and the parts of the valve casings above the pistons 42 and to a desired depth in the container 48 to produce a desired head of the liquid 50 in the container 48 and thus a desired hydrostatic pressure that will produce a uniform counterpressure to opening movements of the valves 41 and limit the extent of the pneumatic pressure produced by the pneumatic pressure producing means in the reservoir and thus limit the rise of the level of the water in the trough part 3 of the machine. The liquid 50 may be any suitable liquid, preferably oil is used, and its head may be readily varied by addition or removal of oil to produce desired limiting pressures in the reservoir 2 and thus control the depth of the partial submergence of the pipe by the rise of the water.

The level of the liquid used for cooling the pipe 9 is necessarily raised above the rollers 10 which support the pipe. In case of leakage of the water, where water is used as the cooling liquid, through the bearings of the shafts 11 that rotatably support the rollers, the level of the oil in the housings 12 will be raised which may be ascertained by a suitable depth-indicating guage rod and if there is an indication of rise in level of the oil, water within the housings may be withdrawn through pipes 16 that extend exterior of the bed 1. The pipes 16 may be provided with suitable valves for removing the water from the housings.

To increase the differential between the temperature of the pipe and the temperature of the liquid used for cooling the pipe, the temperature of the liquid in the vicinity of the pipe may be lowered by the introduction of a cooling liquid into the trough. When water is used for cooling the pipe, the trough 3 is provided with a plurality of outlets or recesses located along the upper outer edge of the trough, such as the recesses 51 whereby the introduction of additional water will cause the discharge of the heated water located in proximity to the pipe from the trough part 3 of the machine. Thus, the valves 41 connected to the reservoir part 2 may be used to maintain the level of the liquid when raised in the trough part in close proximity to the edges of the outlets or recesses 51 and prevent loss of liquid within the parts of the bed of the machine. The valves operate to produce the desired rise of the liquid or depth of submergence of the pipes. The overflow of the surplus liquid at the point that produces the desired depth of submergence of the pipe maintains a constant working quantity of the liquid in the machine.

In order to maintain a desired cooling temperature of the water with reference to the heated pipe, the supply of the cooling water is thermostatically controlled. A plurality of thermostatic bulbs 52 are disposed beneath and in proximity to the pipe and,consequently, in the region of the portion of the water in close proximity to the wall of the pipe when the level of the liquid is raised. The bulbs 52 are spaced along the pipe and are connected together by the pipes 54 having a small bore and to the sheet metal bellows 55. The bulbs 52 of the thermostats, the pipe 54 and the bellows 55 are filled with a liquid having a low boiling point that normally gasifies at a temperature somewhat below the temperature at which it is desired to maintain the temperature of the portion of the water in proximity to the surface of the pipe when the pipe is partially submerged. The vaporization or gasification of the liquid in the bulbs produces a marked expansion and the pressure created by the expansion is transmitted through the portion of the liquid in the pipes 54

to the liquid of the bellows 55 to cause its expansion. A spring 56 is adjustably secured to a suitable anchor by a screw 59 which resists expansion until the pressure reaches a desired point at which a suitable snap switch, that controls the flow of the cooling water, is operated.

The bellows 55 operates a switch 58 which is closed by the rise in the temperature of the portion of the liquid in proximity to the pipe to a predetermined point to close the circuit of an electromagnetically operated valve 60. The valve 60 is connected to a source of supply of relatively cool water by means of the pipe 61 and is operative to connect a plurality of pipes 62, that open into the bottom of the trough part 3 of the bed 1 of the machine, with the pipe 61. The pipes 62 are distributed along the trough to direct the flow of the cooling water at different points beneath the pipe 9 that is being heat-treated in the machine to maintain a uniform cooling temperature along the pipe 9. The valve 60 may be operated by a suitable solenoid 64 that is connected to a source of supply of electric current, such as from a commercial circuit. Thus, the solenoid 64 and the switch 58 may be connected to the main lines 65 of such a circuit and upon closure of the switch 58, the circuit of the solenoid 64 is completed with the source of supply of electric current to operate the valve 60 and connect the trough part 3 of the machine with the source of supply of water through the pipes 61 and 62.

Preferably, the outlets of the pipe 62 are directed toward a baffle means that produces distribution along the pipe 9 that is being heat-treated, the baffle being so disposed as to direct the cooling water through the water of the trough and toward the pipe 9. Preferably, a channel iron 67 is located in the bottom of the trough part 3 beneath the heated pipe and the outlets or nozzles of the pipes 62 are so disposed as to direct the stream of the cooling water downward toward the channel iron 67 which reverses the flow from each of the nozzles and causes it to be deflected upward and also freely lengthwise of the channel to produce uniform distribution of the liquid stream which is introduced under pressure upward toward the heated pipe and the bulbs. When the temperature of the bulbs is sufficiently reduced, the valve 60 is closed and the flow of the cooling water ceases. Thus, the cooling water is distributed along substantially the central vertical plane through the axis of the heated pipe, and, by the control of the thermostat, a desired chilling temperature differential is maintained.

In order to prevent flow of the cooling water into the reservoir in advance of the rise of the level in the trough produced by the pneumatic pressure created in the reservoir, each thermostatic bulb 52 is provided with a suitable heat insulating shield 68, (Fig. 5), located intermediate the heated pipe and the bulb to prevent the intense heat from the pipe when first positioned in the machine from causing the actuation of the valve 60 and flow of the cooling liquid in advance of the rise of the liquid in the trough produced by the operation of the blower 5.

When the heated pipe is first introduced into the machine in advance of raising the level in the liquid, its ends are closed by means of clamping members 70 and 71 that cover the ends of the pipe 9 and prevent the entrance of the liquid of the trough into the pipe when the level of the liquid is raised by the pressure produced in the reservoir 2. The clamping member 71 is rotatably supported in one end wall of the trough part of the machine and in substantially axial alignment with the pipe 9 when it has receiver its initial straightening immediately subsequent to the introduction of the pipe into the trough. The clamping member 70 is connected to and rotatably supported on a piston rod 72 by a suitable coupling. The piston rod 72 is actuated by a piston located in a cylinder 74. The cylinder 74 is located in the other end wall of the trough part and may be pneumatically operated to press the clamping member 70 against one end of the pipe during the rotation of the pipe, and shift the pipe lengthwise to engage the clamping member 71. Both ends of the pipe are covered by the clamping members and prevent entrance of the water into the interior of the pipe which would, otherwise, prevent uniformity of the temperature control. Thus, the exterior surface only of the pipe contacts with the water which operates to surface-harden the pipe. This is of particular advantage in connection with pipes that are used for well casings since damage by abrasion during well drilling as the casing descends during the boring operations is prevented. In order to prevent collapse of the pipe while extremely hot and during the initial chilling, the clamping member 71 has a stem or tubular part 75 that extends through the end wall of the trough part 3 in which the clamping member 71 is rotatably supported which enables air to enter the pipe through the tubular part 75 of the clamping member and maintains atmospheric pressure within the pipe during the heat-treatment.

When the heat-treatment is completed, the pipe may be discharged by a suitable mechanism for raising the pipe 9 from the rollers 10 and moving it on to the ends of the tracks 8. In the particular construction shown, a plurality of oscillatable arms 77 are pivotally supported upon suitable brackets 78 secured to the cross bars 88 having end parts that may be embedded in the concrete of which the bed 1 is formed. The arms 77 are operated by means of a shaft 81 to which are connected a plurality of arms 82. The arms 82 are connected to the arms 77 by means of links 84. The shaft 81 is actuated by means of pistons located in cylinders 85 that are located at opposite ends of and exterior to the trough part 3 of the machine. The cylinders 85 operate the piston rods 87 which are connected to the shaft 81 by means of arms 88. The cylinders 85 are connected to brackets 90 supported on the ends of the bed 1 to enable the cylinders to oscillate in accordance to the oscillation of the arms 88 upon operation of the shaft 81. The cylinders 85 may be connected with a source of supply of air under pressure by suitable valves that may be manually actuated to operate the shaft 81 when it is desired to eject the pipe 9 from the machine and dispose it on the tracks 8. Preferably, the tracks 8 are inclined from the points in the tracks to which the pipe is moved by the arms 77 to enable it to roll from the trough.

Thus, in the operation of the machine, the pipes to be heat-treated are sequentially placed on the rollers 10 and air is introduced into the cylinders 37 to produce gradual depression of the heads 23 as the rollers 10 and 20 are rotated by the motors 18 and 24, to gradually axially align the parts of the heated pipe 9 and to dispose the ends of the pipe in alignment with the clamping members 70 and 71. Air under pressure is then introduced into the cylinder 74 which closes one end of the pipe by the clamping member 70 and operates to move the pipe axially against the

clamping member 71 which covers the other end of the pipe. The clamping member 71 is mounted on the end of a hollow shaft 75, which connects the interior of the pipe with the atmosphere exterior to the trough. The electric motor of the blower 5 is then connected to a source of supply of electric current by means of the switch 91. Preferably, the switch 91 is connected to a timer 92, of a type well known in the art, for producing flow of the current to the blower 5 for a desired predetermined period. The switch 91 is subsequently opened or may be, if desired, also opened by the timer. Thus, the timer 92 may be adjusted to limit the period of the chilling operation. At the expiration of the predetermined time as determined by the operation of the timer, the blower is disconnected and the production of the pneumatic pressure in the reservoir part ceases and the level of the liquid in the trough part is lowered by the difference in the head of the liquid in the trough and the reservoir, both being subject to atmospheric pressure. When the blower ceases to operate, air, at atmospheric pressure, will readily pass through the blower to the reservoir.

Thus, the pipes may be heated to a given temperature and chilled during the definite period of partial insertion and rotation of the pipe in a liquid having a definite and constant cooling temperature as thermostatically determined. The temperature of the cooling liquid is thermostatically maintained substantially constant by means of the bulbs 52 that are interconnected through the pipes 54 with the sheet metal bellows 55 that contains a suitable low boiling point liquid to produce a marked rise in pressure in the bellows 55 to cause the operation of the switch 58. The switch 58 is connected to the source of supply of electric current to complete a circuit through the solenoid 64 and cause the operation of the valve 60. The valve 60 operates to direct the flow of a cooling liquid from a source of supply of the liquid to the pipes 62 that direct the flow of the liquid against the channel iron 67 which reverses the direction of the flow and spreads the liquid along the trough and directs it upward toward the heated pipe and the thermostatic bulbs located in the vicinity of the pipe. By the introduction and the upward movement of the cooling liquid into the trough, the heated liquid in the vicinity of the pipe is caused to flow to the outlets or recesses of the edge portion of one of the side walls of the trough. Thus, the excess of the liquid occurring by the introduction of the cooling liquid into the trough flows through the recesses 51. The overflow thus produced may be directed to a suitable trough and discharged from the machine.

During the drawing of the temper of the steel and to prevent warping during the cooling of the pipe, the contraction of the wall of the pipe operates automatically to magnify the pressure exerted by the pistons on the toggles 29 to resist the distortion that might otherwise occur during the contraction of the pipe as rigidity of the pipe wall increases.

The pipe is ejected by the operation of the arms 77 which are actuated by the shaft 81 that is operated by means of the cylinder 85 that is connected to the shaft through the arm 88. The pipe is raised from the rollers 10 and disposed on the tracks 8 and thus may be rolled from the machine.

If desired, spray nozzles may be located at desired points along the trough for chilling the rotating heated element. Mist-producing nozzles may be used and the nozzles may be formed to distribute the cooling liquid over desired lengths of the element, or they may be located at different points around the element to produce a distribution of sprayed liquid or cooling mist over substantially the whole surface of the element; or the nozzles may be located at certain points for producing localized increased hardness of the element, or the liquid flow from the nozzles may be varied either as to quantity discharged or as to steam flow or mist formation to produce desired cooling effects on the heated rotating element to control the temper produced in the element. Also, if desired, the sprays may be used in conjunction with the cooling liquid in the trough and the liquid from the nozzles and that in the trough manipulated to produce the desired chilling rate or variation in the chilling rate at different points along the element. Thus, where pipes are heat-treated, the ends may be formed softer than the body walls of the pipes to enable machining the ends to provide means for interconnecting the pipes.

In the form of construction shown, the nozzles 94 are located above the pipe and the nozzles 95 are located along the side of the pipe. They are mounted on brackets 96 supported on the bed 1. The nozzles 95 are connected to a source of supply of a cooling liquid, such as water, by the pipes 97. The flow of the liquid from each of the nozzles 95 may be controlled by the valves 98. If desired, the valves 98 may be set to produce the desired quantity flow from each nozzle 95 and a valve 99 may be used for opening and closing the connection with the source of supply of water to produce substantially simultaneous flow of the liquid from all of the nozzles, and produce desired variation of the chilling rate of portions of the pipe according to the adjustment of the valves 98.

If desired, spray nozzles may be formed to chill limited spaced areas of the heated steel element and produce by the heat-treatment spaced, hardened portions. Thus, where steel elements are heat-treated, surface hardened portions separated by softer tempered portions will be formed. Where pipes or rods are heat-treated, "ring" hardened portions may be formed which will withstand large radially diected strains and the softer tempered portions will enable subsequent limited bending of the rod or pipe.

The spray nozzles 94 are formed to produce narrow streams either in mist form or as a continuous liquid flow and are located to direct a cooling liquid over spaced surface portions of the rotating heated pipe, when it has been straightened by rotation of the pipe and the pressure of the pressure rollers, to produce narrow bands or rings of surface chilled areas of the pipe which results after completion of the heat-treatment in exceedingly hard ring portions separated by softer or tempered steel portions. The nozzles may be arranged and mounted in any suitable way to produce the desired "ring" hardened areas of the pipe. They may be distributed circularly with respect to the heated pipe and spaced lengthwise along the trough as may be desired. They are preferably located 10 or 16 inches apart, measured in the direction of the length of the pipe, where large pipes are heat-treated, and the liquid flow delivered from the nozzles may be varied in width. The nozzles 94 are connected through the pipe 101 with a source of supply water. The flow of the water to the nozzles 94

is controlled by the valves 102, and the valves may be connected to a source of supply of liquid through a suitable master valve.

If desired, either or both sets of nozzles may be used in the heat-treatment of the elements and with or without submergence entirely, or in part, in the water of the trough. When the two sets of nozzles are used to heat-treat the element, the water from the nozzles 94 first chills separated portions of the heated rotated element, and then water from the nozzles 95 is sprayed over the entire length of the element and the element may be removed from the machine or may be further chilled by submergence in the trough as hereinbefore described. The liquid from the nozzles 94 may also be first directed onto the rotating heated element to "ring" chill the element and the liquid is raised to contact the element to temper the portions of the element intermediate the ring-hardened portions.

In Fig. 13 is indicated the "ring hardening" produced by localized chilling by contact of the water that flows through the nozzles 94 onto the rotating heated pipe and which are separated by softer tempered portions which greatly sustains the strains to which the pipe may be subjected and yet the pipe 9, as a whole, may be bent curvedly. The surface hardened portions are indicated at 104 which are separated by the softer, yet tempered, intermediate portions 105.

In the operation of the machine and use of nozzles, the heated pipe is first straightened by the rollers as described above and while hot and during its rotation, and then, if desired, water is directed to produce localized hardening, or the valve 99 is opened to direct the water through the nozzles 95 over the entire surface of the heated pipe. The valves are soon closed and preferably while the water in the trough is rising toward the pipe to produce submergence of a part of the pipe as the flow of the water from the nozzles ceases. Variation in the manipulation of the chilling liquid may be followed to produce desired chilling effects on the heated steel. The level of the liquid is lowered after chilling to the required temperature such as below the lower critical temperature, and when the rotating pipe has sufficiently cooled, the pipe is discharged from the machine as described above.

I claim:

1. In a machine for heat-treating elements, the machine having a trough part and a reservoir part for containing a liquid and a passageway connecting the said parts below the level of the liquid, a pneumatic pressure producing means for pressing liquid from the reservoir part into the trough part through the passageway to raise the level of the liquid in the trough part, means for regulating the pressure produced by the pressure producing means to regulate the level of the liquid in the trough part, and means for supporting an element in the trough part of the machine and submerged in part by the rise in the level in the trough part.

2. In a machine for heat-treating elements, the machine having a closed reservoir part and a trough part and passageways for connecting bottom portions of the said parts and containing a liquid, a pneumatic pressure producing means for forcing the liquid from the reservoir part into the trough part for varying the level of the liquid in the said parts, a pressure control means for limiting the pressure to a desired constant pneumatic pressure in the reservoir part by the pneumatic pressure producing means for raising the level of the liquid in the trough part to a predetermined point, and means for supporting an element above the normal level of the liquid in the trough part of the machine and submerged in part by the rise in the level of the liquid in the trough part.

3. In a machine for heat-treating pipes, the machine having a trough part for containing a liquid, means for rotatably supporting and rotating a pipe in the trough part, means for contacting the pipe and the liquid, a pair of rotatable pipe clamps for clamping and closing the ends of the pipe, means for actuating one of the clamping members to clamp a pipe end-wise.

4. In a machine for heat-treating pipes, the machine having a trough part for containing a liquid, a plurality of supporting rollers for supporting the pipe and a plurality of pressure rollers for pressing the pipe against the supporting rollers, means for rotating the rollers and the pipe, a pair of rotatable pipe clamps for clamping and covering the ends of the pipe to prevent entrance of liquid into the pipe, means for actuating one of the clamping members to clamp the pipe end-wise, one of the clamping members having an opening for connecting the interior of the pipe to the exterior atmosphere.

5. In a machine for heat-treating elements, the machine having a reservoir part and a trough part for containing a liquid and a passageway connecting bottom portions of the said parts, a pneumatic pressure means for raising the pneumatic pressure in the reservoir part and raising the level of the liquid in the trough part, means for supporting an element above the normal level of the liquid in the trough part and submerged in part by the rise of the liquid in the trough part, a plurality of valves connected to the reservoir part for reducing the pneumatic pressure in the reservoir part upon opening of the valves, means operated by pneumatic pressure in the reservoir for opening the valves and means interconnecting the valves for maintaining a substantially constant yielding resistance to their opening movement.

6. In a machine for heat-treating elements, the machine having a closed liquid reservoir part and a trough part and passageways for connecting bottom portions of the said parts, a pneumatic pressure producing means for raising the pneumatic pressure in the reservoir part and raising the level of the liquid in the trough part, means for supporting an element above the normal level of the liquid in the trough part and submerged in part by the rise of the liquid in the trough part, a plurality of valves for controlling the pneumatic pressure in the reservoir part, each of the valves connected to the reservoir part, each of the valves having a movable valve element responsive to the pressure in the reservoir part and an outlet opened by the valve element for an escape of gas from the reservoir part, a container for a liquid, means for hydraulically connecting the valves to the container for maintaining a constant yielding pressure according to the head of the liquid in the container for controlling the pressure in the reservoir part.

7. In a machine for heat-treating pipes, the machine having a closed reservoir part and a trough part for containing liquid, and a plurality of passageways interconnecting the bottom portions of the reservoir part and the trough part, a plurality of supporting rollers for supporting a pipe, a plurality of pressure rollers for pressing the pipe against the supporting rollers, means

for rotating the rollers and the pipe, a pneumatic pressure producing means connected to the reservoir part for raising the level of the liquid in the trough part to submerge the pipe, a plurality of valves connected to the reservoir part, means connected to the valves for yieldingly resisting opening of the valves to maintain a predetermined pressure in the reservoir part and a substantially constant level of the liquid when raised in the trough part, a plurality of thermostats located in the liquid when the level of the liquid is raised and in proximity to the pipe, a source of supply of a cooling liquid, means conjointly controlled by the thermostats for directing the flow of the cooling liquid into the liquid in the trough part and means for distributing the cooling liquid toward the submerged portions of the pipe, the trough having outlets for removing the heated liquid as the cooling liquid is introduced into the trough, for maintaining a substantially predetermined cooling temperature at the submerged portion of the pipe.

8. In a machine for heat-treating pipes, the machine having a trough part for containing a liquid, means for rotatably supporting a pipe in the trough part, means for rotating the pipe and means for contacting the pipe and the liquid, a pair of rotatable pipe clamps for clamping and covering the ends of the pipe for preventing entrance of the liquid within the pipe, means for actuating one of the clamping members to clamp the pipe endwise, and means for rotatably supporting the pipe clamps extending through the walls of the trough, one of the pipe clamp-supporting means having a passageway connecting the interior of the pipe with the atmosphere.

9. In a machine for heat-treating pipes, the machine having a trough part for containing a liquid, a plurality of sets of supporting rollers for supporting the pipe and a plurality of pressure rollers, the plurality of pressure rollers substantially located in the plane of the supporting rollers disposed at right angles to the axes of the rollers for pressing the pipe against the supporting rollers, a motor means located exterior to the trough and including a shaft extending through the wall of the trough for operating each set of supporting rollers for rotating the rollers and the pipe, a pair of rotatable pipe clamps for clamping and covering the ends of the pipe to prevent entrance of water into the pipe, means extending through the walls of the trough for rotatably supporting the pipe clamps, and means located exterior to the trough for operating one of the said clamp-supporting means for actuating one of the clamping members to clamp the pipe against one of the other of said clamps, one of the clamping members having an opening for connecting the interior of the pipe to the exterior of the trough through the said clamp-supporting means.

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