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AUTOMATIC MACHINE FOR HARDENING GEARS

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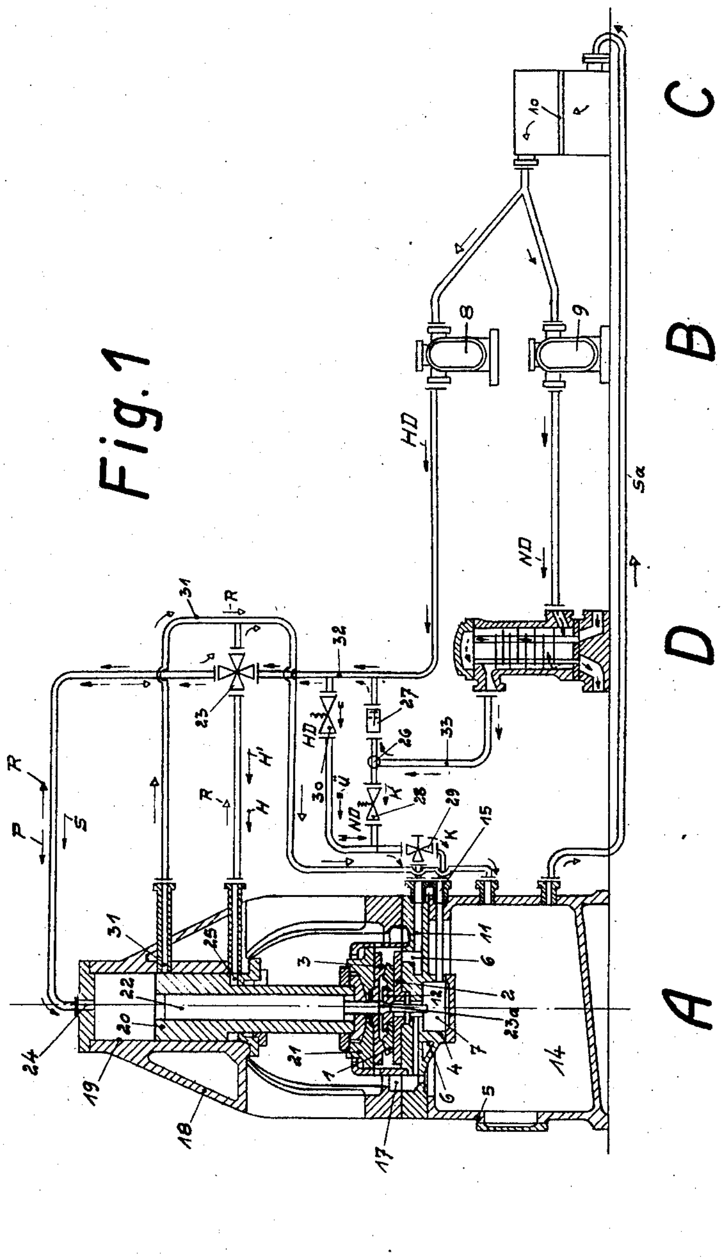

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2 Sheets-Sheet 2

Fig. 2

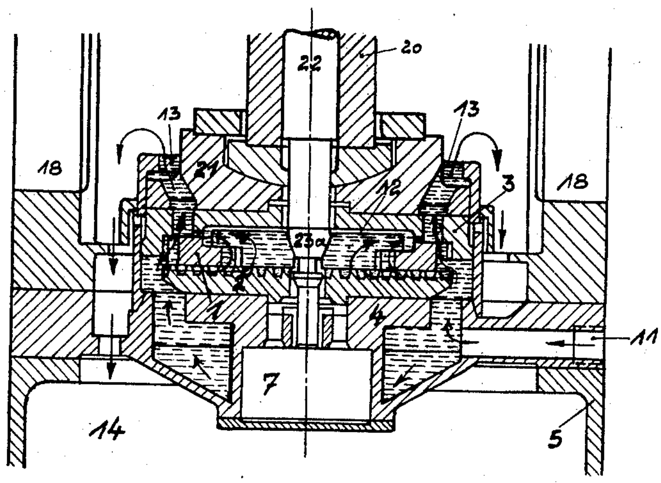
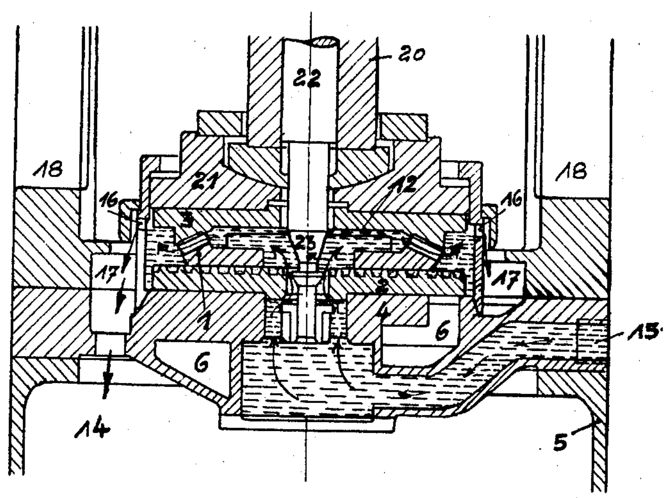


Fig. 3



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UNITED STATES PATENT OFFICE

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AUTOMATIC MACHINE FOR HARDENING GEARS

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3 Claims. (Cl. 266—6)

In hardening steel, differences of internal strains result from stresses incident to the precedent forging, pressing and mechanical machining operations, or from the unequal volume of the various hardening structures or from the uneven cooling velocity of the pieces to be hardened. These strains are made visible by the so-called "distortion effect" which appears to be especially troublesome on work pieces that are not subjected to subsequent machining operations, as e. g. the flanks of spiral-curved bevel gears. On the latter, the uneven cooling action of the pieces to be hardened has a particular influence.

With the customary quenching methods which, in principle, consist of immersing or plunging the red-hot pieces into an oil bath and moving them to and fro or dipping them up and down, it will be unavoidable that the oil, coming into contact with the work, will have or will assume uneven temperatures. On bevel gears, e. g., the oil is supplied to and discharged from, the flat surfaces much more rapidly than from between the teeth. At the latter points, the oil cannot flow as rapidly as at the other portions, and accordingly, it is more heated by contacting with the red-hot teeth than with the other surfaces. The lack of uniformity of oil temperature causes unevenly distributed strains, and consequently hardening distortions. The dipping method, furthermore, prevents the cooling medium from passing at high and uniform velocity across the work to be hardened, since, as a consequence of suction or formation of eddies, the quenching oil fails to get loose from the side opposite to the momentary direction of movement, so as to form a crust by being burnt away. This crust acts as an intermediate insulating layer which carries off the heat of the work to the cooling medium with a rate that varies at the different zones. This trouble has not been overcome by applying hardening methods in which the work clamped between dies or fixtures is plunged up and down in an oil bath. With this method, a stoppage of the oil flow will be observable at each end of a stroke and this stoppage results in uneven oil temperatures.

This invention relates to both a method and a machine by which a perfectly uniform, rapid cooling action with regulable cooling speed may be obtained so that even work pieces with complicated profiles, such as essentially flat bevel gears with curved teeth, may be so hardened that any re-straightening operations may be dispensed with and that any stretching of the curved teeth which otherwise will be caused by uneven cooling action, may be eliminated.

Substantially, the method is characterized by the work 1 (Figs. 1–3) being clamped under variable pressure between two dies 2 and 3 which are accurately fitted to the shape of the work so that it will be in a fixed position while the hardening operation is proceeding. The lower die 2 is secured to the table 4 which is connected to the machine bed 5. The work is placed on the lower die and held under hydraulic pressure by means of the upper die 3. As soon as the pressure which has been adjusted to the work to be hardened and acts upon the upper die 3 becomes active, the quenching medium starts to be forced with an ample flood over the work, the oil, however, being fed along predetermined paths, to suit the kind of work. This feeding system takes its way from a special pressure oil distributing member which provides for flooding the total work surface with uniformly cooled down oil.

The mentioned pressure oil distributor comprises the two distributing chambers 6 and 7 in the table, the two dies and the work itself which; in part, forms the walls of the oil distributing channels so that it is placed completely within the circuit of the pressure oil. By this means, it will be possible to accommodate the main part of the pressure oil distributor to the work shape.

Fig. 1 shows the complete hardening plant. The station at A is the hardening press proper, the station at B shows the pump set consisting of the high-pressure pump 8 and the low-pressure and quantity-delivery pump 9, while C is the cleaning station with the strainers 10 and D the cooling station.

Fig. 2 shows the pressure oil distributor, arranged for external circulation of oil around a spur gear work, the arrows indicating the direction of oil circulation.

Fig. 3 shows the distributor arranged for internal circulation of oil for quenching a bevel gear.

As will be seen from the figures, the pressure-oil is so directed that it completely flows round the work so that there will be no possibility of causing any stoppage or damming up of the oil flow at any point of its path. In Fig. 2, the oil flow enters the outer annular distributing chamber 6 through the channel 11. Thence, the oil following the arrows runs through the tooth spaces of the spur gear as well as through the grooves of the lower die 2 and across the bottom side of the gear, and the segmental centering member 12 causes the oil to flow through slots on to the inner and top surfaces of the gear. Through the collecting channels 13 the heated oil escapes into the container 14, whence it enters (Fig. 1) the cleaning and cooling stations. From Fig. 3, it will be observed that the main branch of the pressure oil entering through the channel 15 is fed through the inner distributing chamber 7 and through the bore of the bevel gear across the upper surface of the latter to its teeth so as to cause a rapid, intensive cooling action. Another branch of the oil flow is outward following the grooves of the lower die on the back side of the gear. The heated oil escapes through the openings 16 into the collecting ring 17 and runs back into the container 14 whence it passes to the cleaning and cooling stations.

The hardening press A is illustrated in Fig. 1 by a sectional drawing representing one of the several feasible embodiments. The hardening press consists of a bed 5 forming a container for receiving the cooling agent, such as oil, while the table 4 which forms the pressure oil distributor is secured to the bed. The table carries the lower die 2 which is provided with a large number of spiral-curved grooves crossing each other. Figs. 2 and 3, these grooves serving for uniform distribution of the oil over the bottom surface of the work. The lower die is fitted to the shape of the work piece. The bed carries a tower-like frame 18 which, in turn, supports a hydraulic pressure cylinder 19. Within the cylinder, a piston 20 may be reciprocated by oil pressure; at the lower end of the piston, the plate 21 holding the exchangeable upper die 3 is attached by means of a ball-shaped member. A second piston 22 having a smaller cross section, extends through the piston 20 the piston 22 forcing an expanding centering plate 12 into the bore of the work by the aid of a cone 23*a* (Figs. 2 and 3). The pressure exerted by the piston 22 is, however, smaller than that of the piston 20 to allow of a shrinking action in the bore; it is, however, large enough to prevent the bore from becoming untrue.

The pump set B consists of a double pump the pump unit 8 delivering a small oil volume under very high pressure, while the second pump unit 9 supplies a large oil volume under small pressure. The high-pressure pump unit serves for pressing the die against the work, while the low-pressure large volume pump unit is used for delivering the quenching oil. The cleaning station C and the cooling station D are of well-known design and so arranged that the cleaner is placed within the suction line, and the cooling station within the pressure line of the oil.

The pipe line system embodies an essential part of the invention, since it is solely the peculiar arrangement of the valves that enables the pressure circuit of the quenching oil to be opened at the proper time. The high-pressure line HD leads to a four-way valve 23 which controls the direction of oil flow either to the upper end 24 or to the lower end 25 of the cylinders. The low-pressure line ND has two branches joining at 26, so that the oil may take its way either over the check valve 27 to the valve 23 or through the release valve 28 to the quenching oil control valve 29 from which the channels 11 and 15 lead to the distributor. An additional line which is cut off from the high-pressure line by means of a release valve 30, leads also to the control valve 29. From the center part of the pressure cylinder of the hardening press, the pipe 31 leads back to the oil container.

Both pump units are driven from one motor so as to run always simultaneously; they act conjointly by drawing the oil from the container 14 through the suction line S*a* and the filtering-station C and forcing the oil through the cooling station D to the hardening press. When the valve 23 is in the lifting position, the two oil branches are fed in the direction of the arrows H and H′ so as to pass through the valve 23 and pipe 25 beneath the piston 20 and lift the same until it opens the mouth of the pipe 31 so that the excessive oil is by-passed into the container while flowing in the direction of the arrow R. When the valve 23 is set to the working position, so as to force the pressure piston 20 downwards, the pressure oil at first runs through the valve 23 in the direction of arrow P, and the quenching oil in the direction of the arrow S so that the two oil branches pass to the upper cylinder end 24 and conjointly press the piston downwards imparting to the same a small pressure, but high speed. As soon as the die 3 is in contact with the work piece, the pressure automatically rises. Hence, an excessive pressure will be exerted in the line 32 as compared with that in the line 33, this excessive pressure acting upon, and closing the check valve 27. The pressure in the high-pressure line is then capable of increasing as high as it has been adjusted by the release valve 30. When the pressure in line 32 exceeds that for which valve 30 is set, oil passes from line 32 through valve 30, and joins the stream of low pressure quenching oil flowing to the dies from line 33. The quenching oil circuit passes through the release valve 28 which has been set to a lower pressure and through the three-way valve 29. Depending on the position of this valve, the quenching oil circuit may be fed either through the channel 11 to the outer distributing chamber 6 (Fig. 2) or through the channel 15 to the inner distributing chamber (Fig. 3). After the work piece has cooled off, the valve 23 is shifted over to the lifting position. The pressure in the high-pressure line drops, the check valve 27 opens again, and the combined actions of the quenching and pressure oil raise the pistons 20 and 22. The oil which fills the space above the piston flows back to the container in the direction of the arrow R. The hardened work piece, which is now released, may be removed and replaced by another piece.

The described arrangement of the hardening press, the arrangement of the cooling and cleaning systems as well as that of the hydraulic controls and pumps is only one solution of the problem and one of many possible forms of carrying through the inventive idea. It will be understood that any other solution of the inventive design obvious to the expert shall be also considered to be covered by the patent. Of course, any other quenching medium might be also used in place of the oil flood, depending on the kind of the work to be hardened.

What I claim as my invention is:

1. An automatic hardening press comprising a frame containing a tank for liquid; a work-table formed as a die and mounted on said tank; an hydraulic cylinder mounted in said frame above said table; a first piston movable in said cylinder; a die carried by said piston; a second piston movable within said first piston; work centering means carried by said second piston; and a single source of liquid medium for actuat-

ing said pistons and quenching work held by said dies, said source being connected with said tank.

2. An automatic machine for quenching gears, comprising a frame containing a tank for liquid; a work table mounted on said tank; a hydraulic cylinder mounted in said frame above said table; a double piston movable in said cylinder; an upper die carried by said piston; a lower die on said table; a high pressure pump for moving said double piston; a low pressure pump for delivering the quenching liquid; a high pressure line between said high pressure pump and said cylinder; a low pressure line between the lower die and the low pressure pump; a check valve between the high pressure line and the low pressure line; a high pressure-timing valve between the high pressure line and the low pressure line; and a low pressure-timing valve in the low pressure line for causing the flow of quenching liquid through the dies to start when the necessary pressure between the dies and the v[illegible] reached.

3. An automatic machine for quenching gears, comprising a frame; a work table carried by said frame; an hydraulic cylinder mounted above said table; a piston in said cylinder for clamping work to said table; work centering means on said piston; a source of high pressure liquid; a high pressure line connecting said source to said cylinder; a source of low pressure quenching liquid; a low pressure line connecting said low pressure source to said work table and to said high pressure line; a check valve between the high and low pressure lines for permitting liquid from both lines to flow to said cylinder when work is to be clamped to said table; and automatic pressure controlled means for directing the flow of low pressure liquid to the work table when the pressure in the high pressure line rises sufficiently to close said check valve.

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