

[54] FLUID-OPERATED MACHINE TOOL WITH MEANS FOR EFFECTING UNIFORM EXPANSION OF ITS FRAME IN RESPONSE TO HEATING BY OPERATING FLUID

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[56] References Cited UNITED STATES PATENTS

Table with 4 columns: Patent No., Date, Inventor, and Reference. Includes Baldenhofer (51/233), Zawistowski (82/DIG. 1), and DeYoung (51/233 X).

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[57] ABSTRACT

A machine tool wherein the lower portion of the frame defines a vessel for a supply of oil and the upper portion of the frame forms a bed with a pair of elongated ways for a reciprocable table. The table is movable by a double-acting cylinder and piston unit which receives oil from the vessel by way of a pump and a control valve system and discharges heated oil for return flow into the vessel. A portion of heated oil is diverted into elongated trough-shaped channels which are outwardly adjacent to the ways to heat the base and to thus prevent unequal expansion of various parts of the frame. The channels slope toward their ends and receive heated oil midway between such ends so that the oil flows toward the ends of the channels and thence into the ends of an elongated trough which is provided in the frame at a level between the channels and the vessel. The bottom surface of the trough slopes from its ends toward its median portion and the latter discharges oil into the vessel. The amount of oil which is diverted into the channels is determined by an adjustable distributor which is mounted in a return conduit connecting the vessel with the outlet of the control system.

10 Claims, 2 Drawing Figures

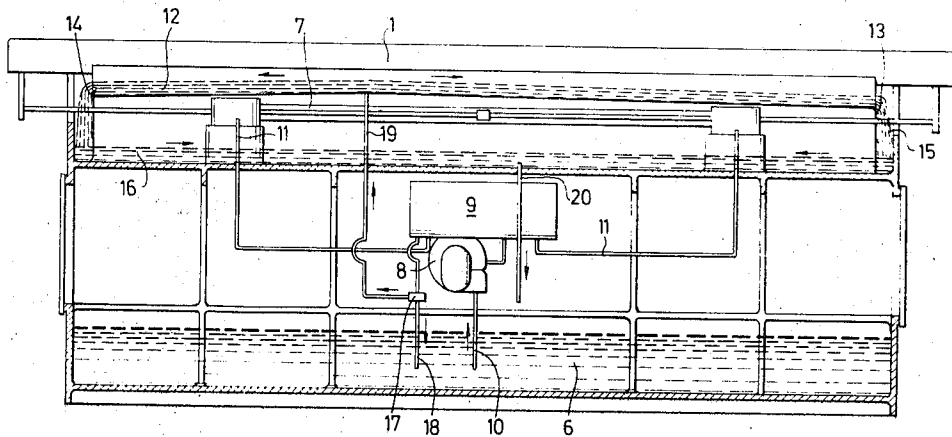


Fig. 1

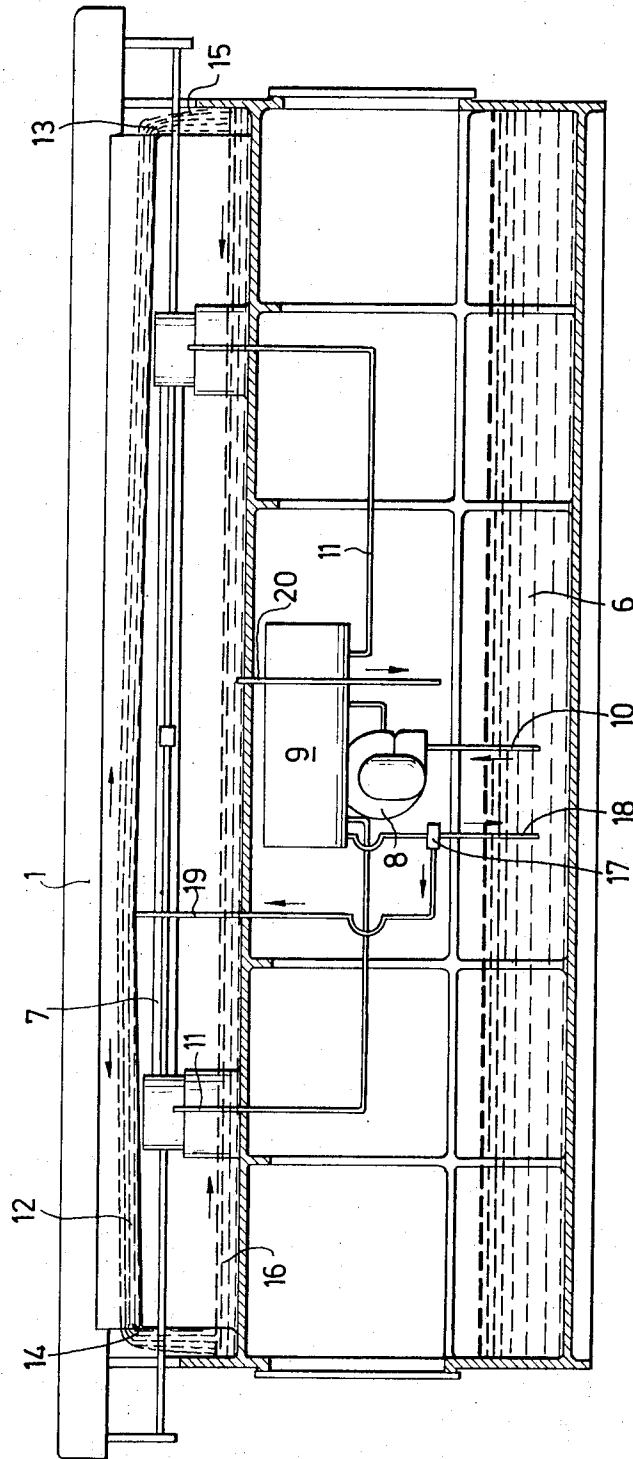
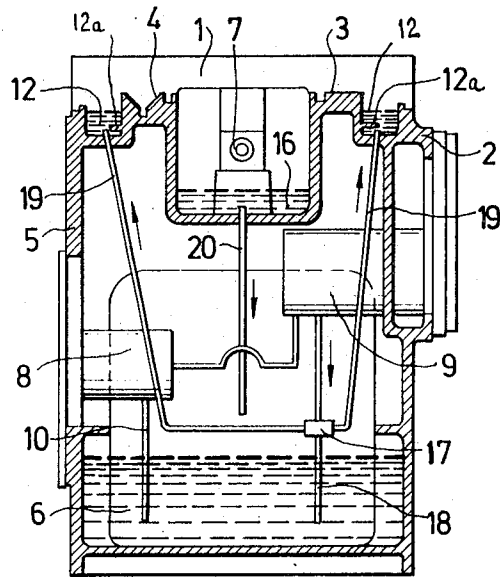


Fig. 2



**FLUID-OPERATED MACHINE TOOL WITH
MEANS FOR EFFECTING UNIFORM EXPANSION
OF ITS FRAME IN RESPONSE TO HEATING BY
OPERATING FLUID**

BACKGROUND OF THE INVENTION

The present invention relates to machines in general, and more particularly to improvements in fluid-operated machine tools. Still more particularly, the invention relates to improvements in machine tools of the type wherein one or more hydraulic fluid-operated prime movers actuate one or more movable parts with attendant heating of hydraulic fluid which is fed to such prime mover or prime movers by one or more pumps.

A drawback of machine tools which employ hydraulically operated prime movers is that the fluid is heated during passage to the hydraulic motor or motors whereby the heated fluid exchanges heat with the frame of the machine tool. Such heating is usually uneven so that certain parts of sections of the frame expand to a greater extent than the remaining section or sections with the result that the guide means for various movable parts of the machine tool are distorted or otherwise affected by unequal heating of the frame. In many machine tools, a vessel from which one or more pumps draw hydraulic fluid is located in the lowermost portion of the machine frame and the pump or pumps, together with one or more hydraulic motors, are mounted at a level above the vessel. The spent fluid is caused to flow from the motor or motors back into the vessel whereby the lower portion of the frame is heated to a much higher temperature than the upper portion which normally carries ways or analogous guide means for one or more tables, slides, carriages or the like. It is already known to provide such machine tools with specially designed heat exchangers which are utilized to reduce the temperature of fluid issuing from the hydraulic motor or motors. As a rule, such heat exchangers employ a blower which circulates atmospheric air through suitable passages provided in the frame to thereby cause an exchange of heat between the circulating air and the fluid flowing back into the vessel as well as the fluid which is confined in the vessel proper.

It was found that the just outlined heat exchangers cannot prevent unequal or localized overheating of the machine frame. Thus, it happens again and again that the lower portion of the machine frame is heated to a temperature which is much higher than the upper portion whereby the expansion of the lower portion exceeds that of the upper portion with the result that the ways on the upper portion of the machine frame are distorted. This is particularly undesirable in machine tools which are provided with very long ways, for example, in surface grinding machines wherein a large table is movable along parallel ways provided on the upper portion of the machine frame.

The just discussed unequal heating of frames in certain machine tools is compounded by the generation of heat resulting from engagement of one or more tools with one or more workpieces. As a rule, such additional heat is withdrawn from the machine by separate cooling means, for example, by a circulating liquid coolant.

SUMMARY OF THE INVENTION

An object of the invention is to provide a novel and

improved machine, particularly a machine tool, wherein unequal heating of various portions of the frame is prevented in a simple, space-saving and inexpensive way.

Another object of the invention is to provide a novel and improved conditioning system for the frames of machine tools, particularly such machine tools which employ one or more prime movers in the form of rotary hydraulic motors or hydraulic cylinder-and-piston units.

A further object of the invention is to provide a novel and improved recirculating system for heated hydraulic fluid which issues from one or more motors in a machine tool wherein one or more carriages or analogous bulky parts are movable along rails, ways or analogous guide means.

Still another object of the invention is to provide in a machine tool novel and improved means for preventing unequal heating and expansion of various portions of the frame without resorting to any cooling devices for the circulating hydraulic fluid.

A feature of the invention resides in the provision of a machine, particularly a machine tool, which comprises a frame including a first portion which is preferably located at a higher level and is provided with suitable guide means (such as one or more elongated guide members or ways) and a second portion which is preferably located at a lower level and is provided with a vessel for a supply of hydraulic fluid, a movable table, carriage or an analogous unit which is mounted for movement along the guide means, drive means for moving the unit and including hydraulic motor means mounted in the frame and arranged to receive fluid from the vessel and to discharge fluid at an elevated temperature, channel means provided in the first portion of the frame adjacent to the guide means, and fluid recirculating means for returning at least some of the fluid which is discharged from the motor means into the vessel by way of the channel means to thereby at least substantially equalize the temperatures of the first and second frame portions.

The channel means preferably includes one or more elongated channels which are preferably immediately or closely adjacent to and extend in parallelism with the respective guide members. Each channel preferably includes a median portion which is located at a higher level and two end portions which are located at a lower level so that fluid which is admitted into the median portion of a channel will flow by gravity toward its end portions. The recirculating means comprises means for admitting at least some of the fluid which is discharged from the motor means into the median portion of the channel and means for returning to the vessel fluid from the end portions of the channel. Such returning means may include an elongated trough which is preferably located at a level between the first and second portions of the frame and has two raised end portions and a median portion located at a lower level. The returning means may further include means for conveying fluid from the end portions of the channel or channels into the end portions of the trough whereby such fluid flows toward the median portion of the trough, and means for returning fluid from the median portion of the trough into the vessel. The fluid which reaches the end portions of the channel or channels may overflow directly into the end portions of the trough.

In accordance with another feature of the invention, the recirculating means includes a preferably adjustable distributor which receives fluid from the motor means by way of a control system including one or more regulating valves and is mounted in a return conduit which connects the outlet of the control means with the vessel. The distributor can divert a desired amount of heated fluid from the return conduit and into one or more risers which convey the fluid into the channel or channels.

The novel features which are considered as characteristic of the invention are set forth in particular in the appended claims. The improved machine itself, however, both as to its construction and the mode of equalizing the temperature of its frame, together with additional features and advantages thereof, will be best understood upon perusal of the following detailed description of certain specific embodiments with reference to the accompanying drawing.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a diagrammatic partly side elevational and partly longitudinal vertical sectional view of a machine tool which embodies the invention; and

FIG. 2 is a transverse vertical sectional view of the structure shown in FIG. 1.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to the drawing in detail, there is shown a machine tool which constitutes a surface grinding machine having an elongated horizontal table 1 which is movable along two spaced-apart elongated horizontal parallel guide members or ways 3 and 4 provided on an upper frame portion 2 which constitutes a base or bed for the table 1 and forms part of an elongated frame 5. The lower portion of the frame 5 defines an elongated vessel 6 which contains a large supply of hydraulic fluid, preferably oil. The machine tool further comprises various clamping devices, supports and tool holders for the workpiece or workpieces on the table 1. Such components are not shown in the drawing because their construction and/or mounting forms no part of the present invention.

The means for reciprocating the table 1 along the ways 3 and 4 of the bed 2 comprises a prime mover here shown as a hydraulic motor in the form of a double-acting cylinder and piston unit 7. This cylinder and piston unit 7 is mounted in the space between the ways 3 and 4 and at a level slightly below such ways. The chambers of the cylinder which forms part of the cylinder and piston unit 7 can receive fluid from a hydraulic pump 8 which is mounted in the frame 5 and delivers pressurized fluid to a control system 9 including suitable valves (not specifically shown). The control system 9 supplies pressurized fluid into and receives heated fluid from the chambers of the cylinder in the unit 7. The inlet of the pump 8 draws hydraulic fluid from the vessel 6 by way of a suction pipe or supply pipe 10. Heated fluid is returned from the control system 9 to the vessel 6 by way of a return conduit 18 which contains an adjustable distributor 17. The connection between the control system 9 and the chambers of the cylinder in the cylinder and piston unit 7 includes two conduits 11 one of which returns spent fluid from the respective chamber when the other delivers pressurized fluid to the other chamber, and vice versa.

In accordance with a feature of the invention, the bed 2 of the frame 5 is provided with or carries two elongated channels 12 each of which is outwardly adjacent to the respective ways 3, 4. The drawing shows trough-shaped channels which are immediately adjacent to the outer sides of the respective ways 3, 4 and which may be provided with one or more longitudinally extending ribs 12a or analogous projections. The bed 2 may constitute a one-piece casting and can be integrally formed with the channels 12. The median portion of each channel 12 is located at a level at least slightly above the end portions 13, 14 of the respective channel so that fluid which is admitted into the median portion automatically flows by gravity toward the two end portions to be discharged into an elongated trough 16 which is provided in the machine frame 5 between the ways 3, 4 and at a level slightly below the channels 12. The median portion of the trough 16 is located at a level at least slightly below the level of its two end portions so that the fluid streams 15 which are discharged at the end portions 12 and 13 of the channels 12 can flow into the respective end portions of the trough 16 and begin to flow by gravity toward the median portion of the trough. Such median portion communicates with the upper end of at least one conduit 20 which constitutes a conveyor for returning the fluid from the trough 16 into the vessel 6. The means for admitting heated fluid into the median portion of the channels 12 includes a pair of risers 19 which are mounted with the distributor 17. As mentioned before, the distributor 17 is adjustable and is mounted in the return conduit 18 which connects the control system 9 with the vessel 6. If desired, the upper end portion of the conduit 20 can extend slightly above the bottom surface in the median portion of the trough 16 so as to insure that the trough will invariably contain a predetermined minimum quantity of fluid extending to the level of the upper end of the conduit 20.

The heated fluid which is caused to enter the channels 12 by way of the risers 19 flows from the median portions toward the end portions 13 and 14 of such channels to thereby insure uniform heating of the upper portion or bed 2 of the frame 5. The lower portion of the frame 5 is uniformly heated by fluid which is confined in the vessel 6. This insures that all or nearly all parts or sections of the frame 5 are maintained at the same temperature so that the distortion of such frame is reduced to a minimum in spite of the fact that the cylinder and piston unit 7 normally effects a substantial heating of the fluid. As shown in FIG. 2, the cylinder and piston unit 7 can be mounted directly in the trough 16.

Uniform heating of the entire frame 5 is further enhanced by the provision of the trough 16 wherein the flow of heated fluid is countercurrent to the fluid flow in the channels 12. By properly selecting the cross-sectional areas of the channels 12 and the cross-sectional area of the trough 16, the designer of the frame 5 can further enhance the uniformity of heating action upon various portions of the frame 5. Other factors to be considered in connection with uniform heating of all portions of the frame 5 are the cross section of the bed 2 as well as the amount of heat which is radiated during the flow of heated fluid in the trough-shaped channels 12. The uniform or substantially uniform heating of all portions of the frame 5 is achieved without resorting to any special cooling or heat ex-

changing means. Another possibility of regulating the heating action upon various portions of the frame 5 involves an adjustment of the distributor 17 which determines the amount of fluid which is recirculated by way of the channels 12 and trough 16 and the amount of fluid which is allowed to return directly into the vessel 6 by way of the return conduit 18.

The parts 9, 18, 17, 19, 16, 20 constitute a recirculating system for heated fluid which renders it possible to recirculate some or all of the heated fluid issuing from the chambers of the cylinder in the cylinder and piston unit 7 by way of the channels 12 and to thus insure uniform heating of the bed 2 as well as an equalization between the heating action of fluid upon the bed 2 and upon the lower frame portion which is provided with the vessel 6. It is clear that the improved system for effecting uniform heating of the frame can be incorporated with equal advantage in other types of frames for machine tools or the like.

The fact that the upper portion or bed 2 of the frame 5 is heated is of no consequence as long as the heating of this portion at least approximates or equals the heating of the lower portion of the frame 5. This insures that the deformation or expansion of all portions of the frame in response to heating by oil or another hydraulic fluid is uniform and thus prevents distortion or changes in the orientation or inclination of ways for the table 1 and/or other movable units or components which receive motion from one or more hydraulic motors. The placing of channels 12 immediately adjacent to the outer sides of the respective ways 3 and 4 is desirable because such positioning of the channels reduces the likelihood of deformation of the bed 2. The rib or ribs 12a further enhance the exchange of heat between the fluid in the channels 12 and the adjacent portions of the ways 3 and 4. It is clear that the cylinder and piston unit 7 constitutes but one of several types of hydraulic motors which can be used in the frame 5 to furnish heated oil or another hydraulic fluid for recirculation into the vessel 6 by way of the channels 12. It is also clear that the frame can be provided with more than two channels or with a single channel which is then preferably located between the ways 3 and 4.

Without further analysis, the foregoing will so fully reveal the gist of the present invention that others can, by applying current knowledge, readily adapt it for various applications without omitting features which fairly constitute essential characteristics of the generic and the specific aspects of my contribution to the art and, therefore, such adaptations should and are intended to be comprehended within the meaning and range of equivalence of the claims.

What is claimed as new and desired to be protected by Letters Patent is set forth in the appended claims:

1. In a machine, particularly in a machine tool, a combination comprising a frame including a first portion provided with elongated guide means extending substantially over the whole length of the frame and a second portion provided with a vessel for supply of hydraulic fluid; a movable unit mounted for movement along said guide means; drive means for moving said unit including hydraulic motor means provided on said frame and arranged to receive fluid from said vessel and to discharge such fluid, said discharged fluid being at an elevated temperature; elongated channel means provided in said first portion adjacent to said guide means and extending also substantially over the whole

length of said frame; and fluid recirculating means for returning fluid which is discharged from said motor means into said vessel by way of said elongated channel means to thereby at least substantially equalize the temperature of said frame portions.

2. A combination as defined in claim 1, wherein said first portion is located at a level above said second portion and said guide means includes at least one elongated guide member, said channel means including at least one elongated channel closely adjacent to and extending in parallelism with said guide members.

3. A combination as defined in claim 2, wherein said guide means comprises a plurality of elongated guide members and said channel means comprises a plurality of elongated trough-shaped channels each closely adjacent to and parallel with a different one of said guide members, said guide members being disposed between said channels.

4. In a machine, particularly in a machine tool, a combination comprising a frame including a first portion provided with guide means including at least one elongated guide member, and a second portion located at a level below said first portion and provided with a vessel for supply of hydraulic fluid; a movable unit mounted for movement along said guide means; drive means for moving said unit including hydraulic motor means provided in said frame and arranged to receive fluid from said vessel and to discharge such fluid, said discharged fluid being at an elevated temperature; channel means provided in said first portion adjacent said guide means, said channel means including at least one elongated channel closely adjacent to and extending in parallelism with said guide member, said channel including a medium portion and two end portions at a level below said medium portion; and fluid recirculating means for returning at least some of the fluid which is discharged from said motor means into said vessel by way of said channel means to thereby at least substantially equalize the temperatures of said frame portions, said recirculating means comprising means for admitting at least some of the fluid which is discharged from said motor means into said median portion of said channel whereby the thus admitted fluid flows toward said end portions by gravity and means for returning to said vessel fluid from the end portions of said channel.

5. A combination as defined in claim 4, wherein said returning means includes an elongated trough provided in said frame at a level intermediate said first and second frame portions, said trough having a first portion located at a lower first level and at least one second portion located at a higher second level and arranged to receive fluid from the end portions of said channel, said returning means further including means for conveying fluid from said first portion of said trough into said vessel.

6. In a machine, particularly in a machine tool, a combination comprising a frame including a first portion provided with guide means comprising a pair of elongated guide members, and a second portion located at a level below said first portion and provided with a vessel for supply of hydraulic fluid; a movable unit mounted for movement along said guide means; drive means for moving said unit including hydraulic motor means provided in said frame and arranged to receive fluid from said vessel and to discharge such fluid, said discharged fluid being at an elevated temper-

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ature; channel means provided in said first portion and including a pair of elongated channels each adjacent to and parallel with one of said guide members, each of said channels having a raised median portion and a pair of end portions located at a level below said median portion; and fluid recirculating means for returning at least some of the fluid which is discharged from said motor means into said vessel by way of said channel means to thereby at least substantially equalize the temperatures of said frame portions, said recirculating means comprising means for admitting at least some of the fluid which is discharged from said motor means into the median portions of said channels whereby the thus admitted fluid flows toward both end portions of said channels, an elongated trough provided in said frame at a level between said first and second frame portions and having a pair of raised end portions arranged to receive fluid from the end portions of said channels, and a median portion located at a level below the end portions thereof, said trough being located in the space between but below said channels, and means for conveying fluid from said median portions of said trough into said vessel.

7. In a machine, particularly a machine tool, a combination comprising a frame including a first portion provided with guide means and a second portion provided with a vessel for supply of hydraulic fluid; a movable unit mounted for movement along said guide means; drive means for moving said unit along said guide

means including hydraulic motor means provided in said frame and arranged to receive fluid from said vessel and to discharge such fluid, said discharged fluid being at an elevated temperature; channel means provided in said first portion adjacent to said guide means; said channel means including at least one longitudinal extending rib; and fluid recirculating means for returning at least some of the fluid which is discharged from said motor means into said vessel by way of said channel means to thereby at least substantially equalize the temperatures of said frame portions.

8. A combination as defined in claim 1, further comprising control means arranged to regulate the entry of fluid into and the discharge of fluid from said motor means, said recirculating means including return conduit means connecting said control means with said vessel, distributor means for diverting at least some fluid from said return conduit means, and means for conveying the thus diverted fluid into said channel means.

9. A combination as defined in claim 8, wherein said means for conveying diverted fluid includes at least one riser.

10. A combination as defined in claim 1, wherein said guide means is located in a substantially horizontal plane and said movable unit is a table, said motor means including at least one cylinder and piston unit.

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