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(54) Work-clamp pallet for machine tool

(57) The pallet is provided with a plurality of hydraulic clamping devices (6) and also with a special shut-off valve 54 for shutting down its oil path. It is so arranged that with its oil path (51) shut down after supplying its hydraulic clamping devices (6) with a set level of hydraulic pressure, this hydraulic pressure is maintained and the work-clamp pallet with works clamped thereon can be transferred onto the work table with hydraulic hoses etc. all disconnected to be subsequently clamped for machining of the works clamped thereon again with no supplementary feeding of hydraulic pressure.

As precaution for any eventual variation of the hydraulic pressure contained due to rare cases of hydraulic pressure leakage or variation of the oil temperature it is also provided with a hydraulic pressure fall preventing device (63, 64) and a hydraulic pressure abnormal fall detecting device (65).

FIG. 14

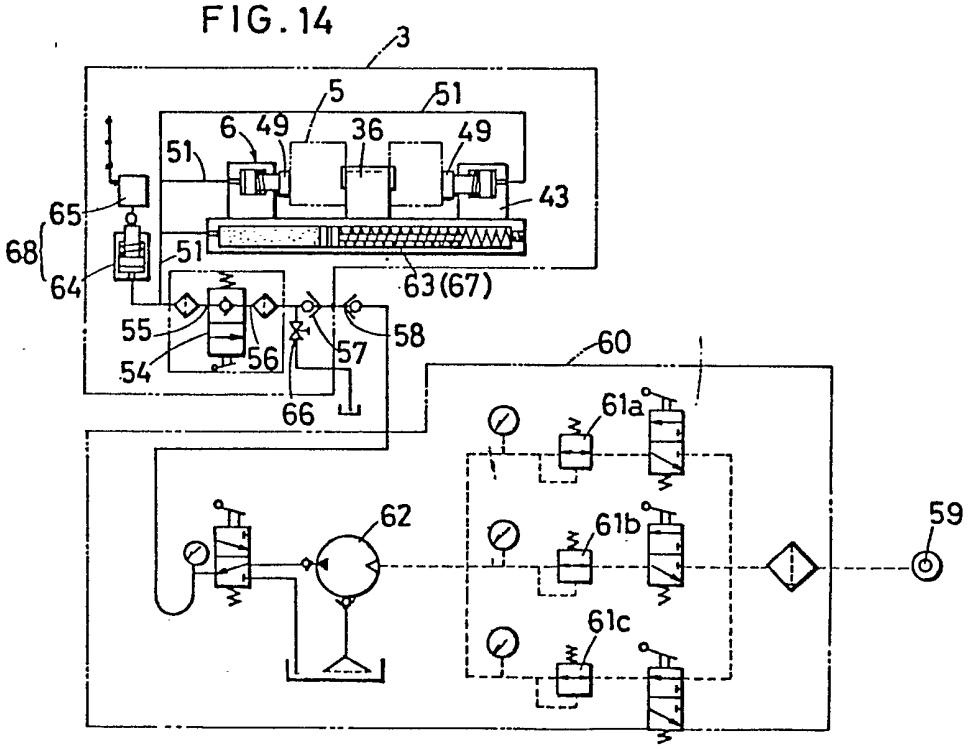

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FIG. 1

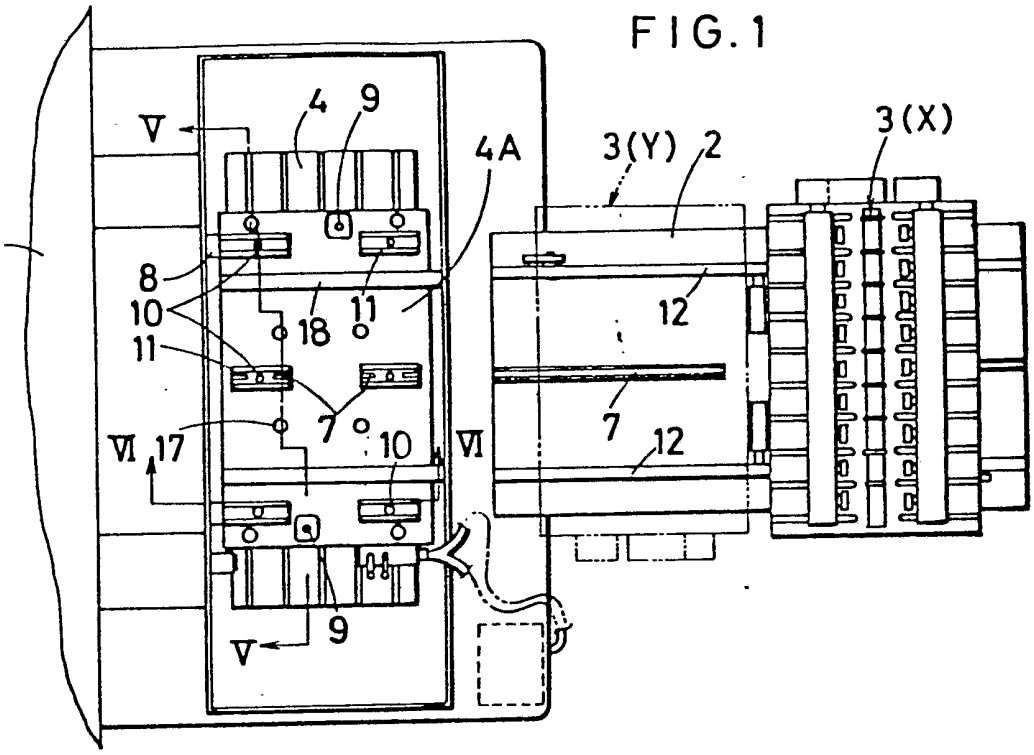


FIG. 2

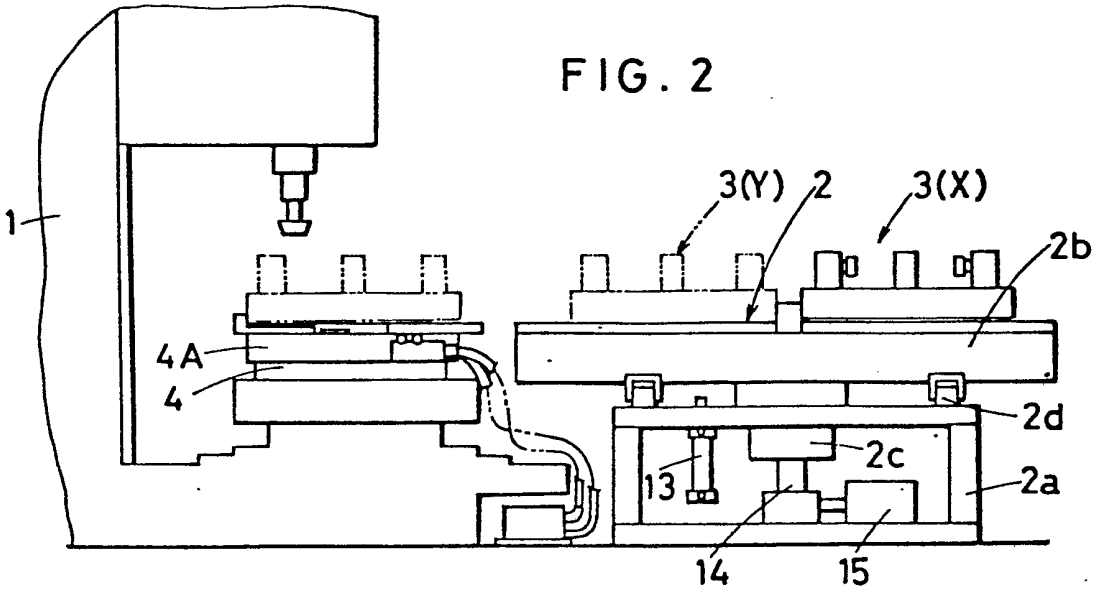


FIG. 3

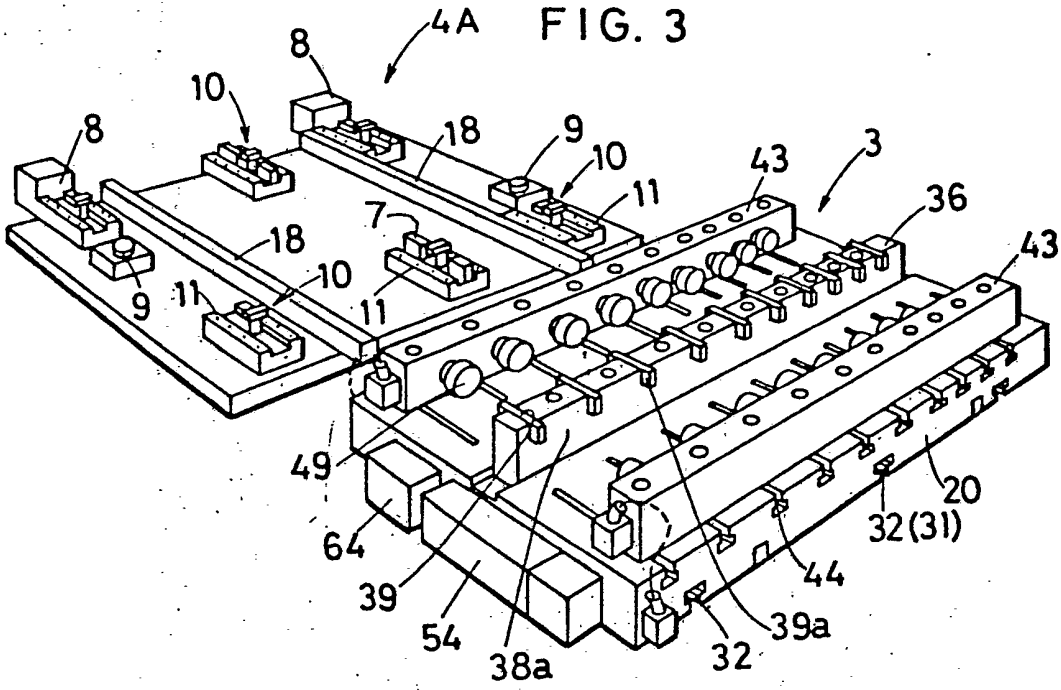


FIG. 4

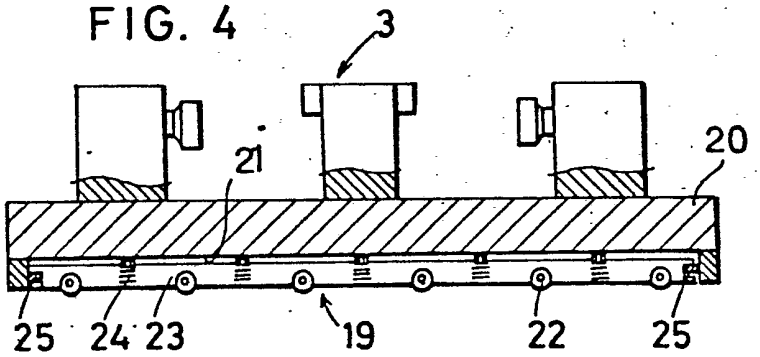


FIG. 5

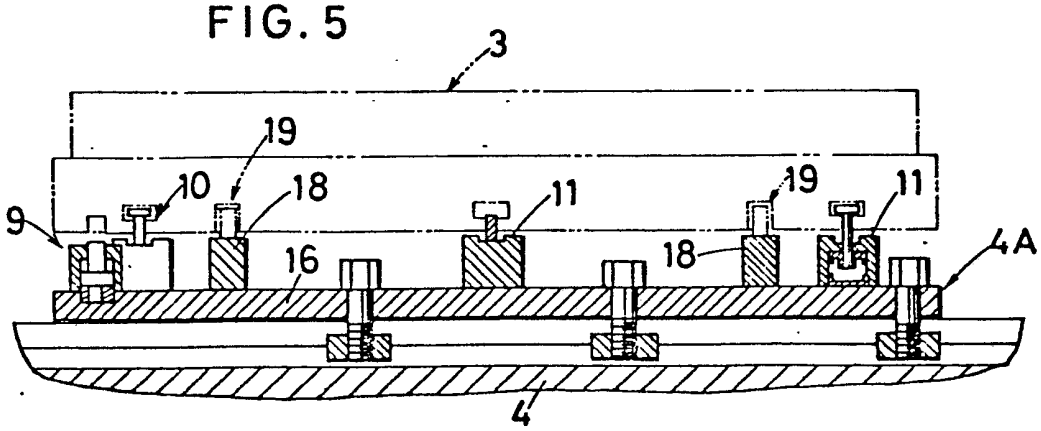


FIG. 6

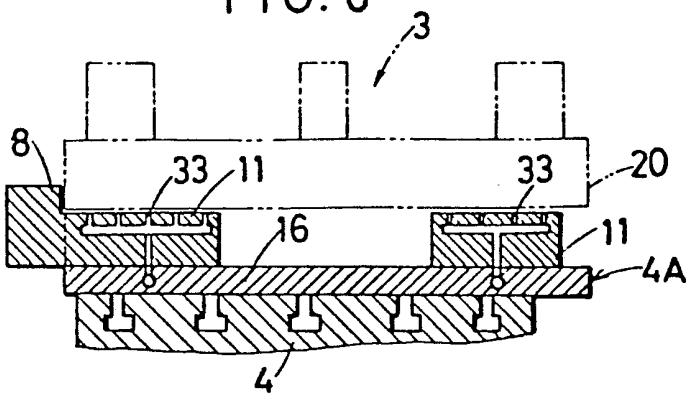


FIG. 7

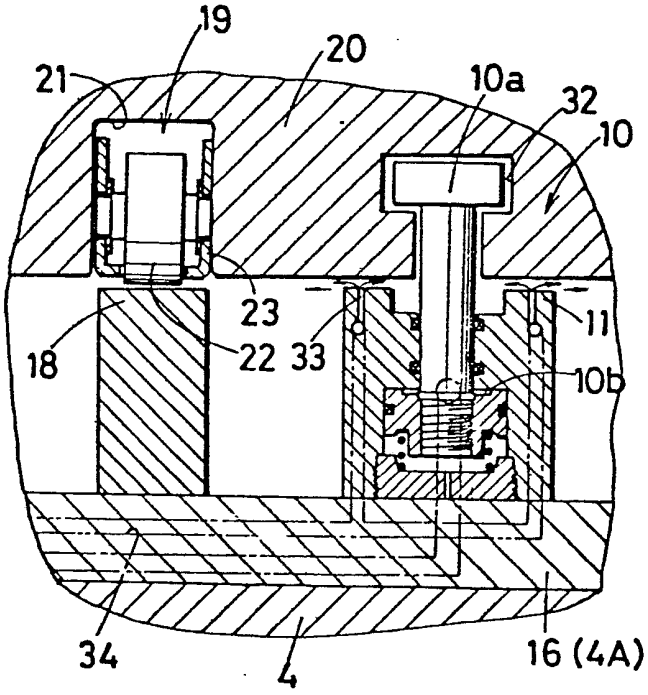
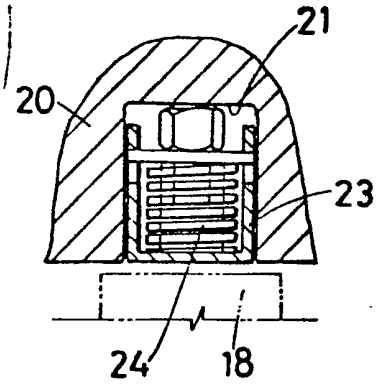


FIG. 8



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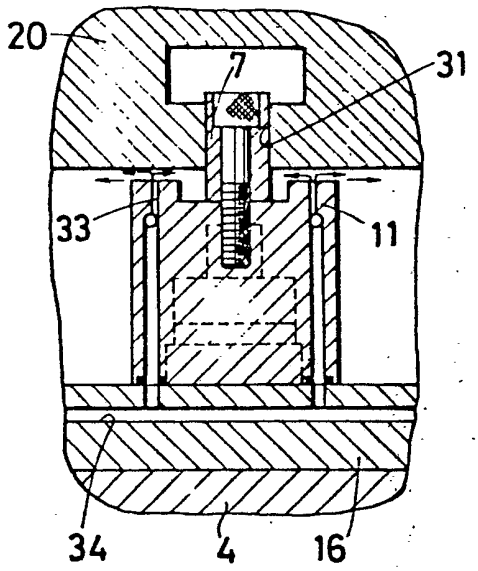

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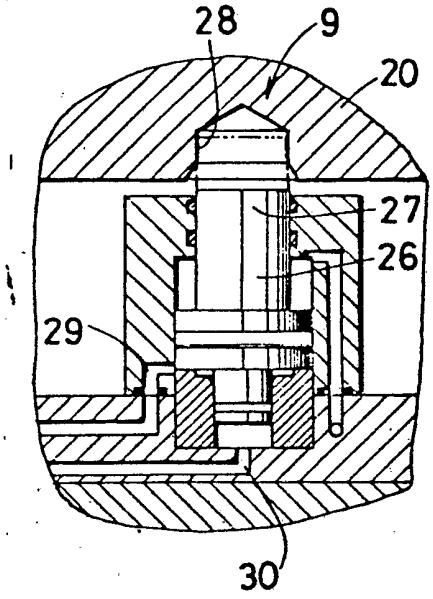

FIG. 11

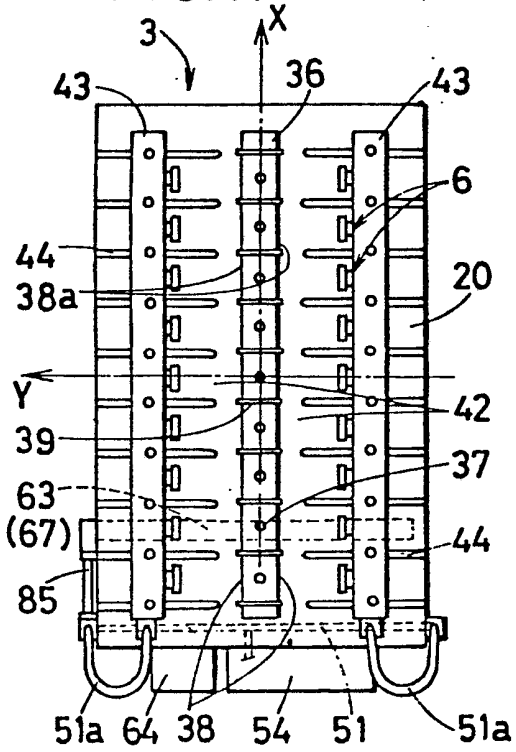

FIG. 12

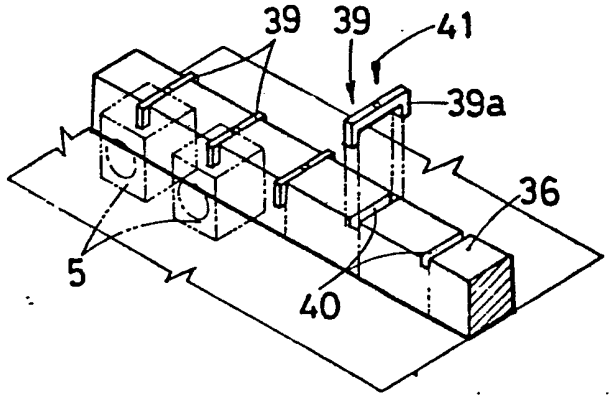

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FIG. 13

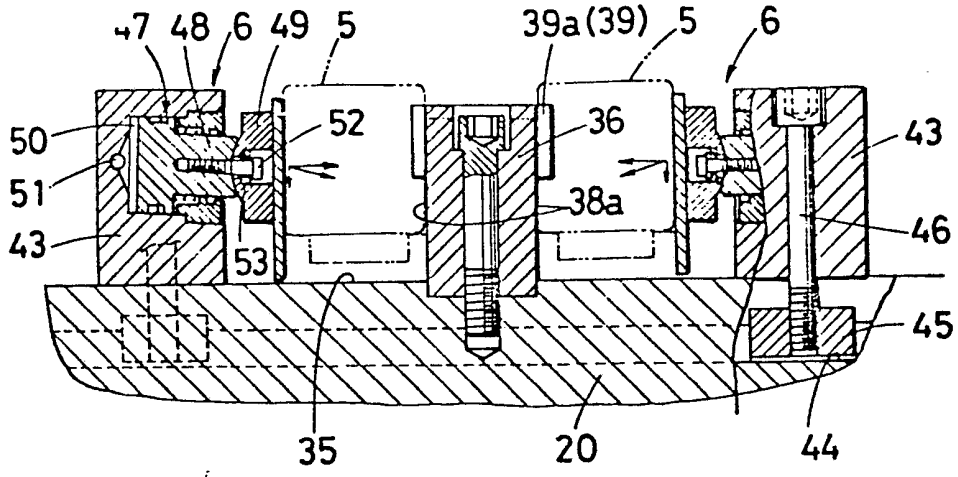
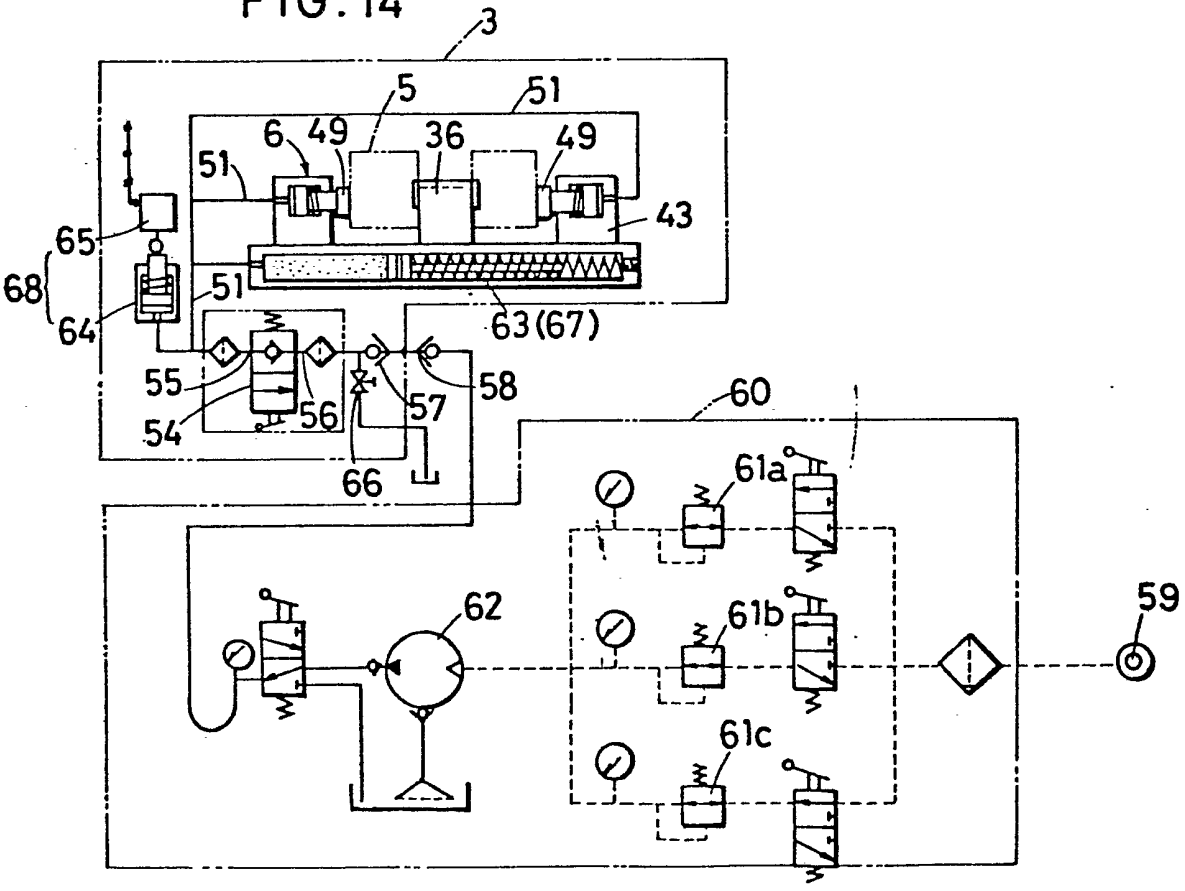


FIG. 14



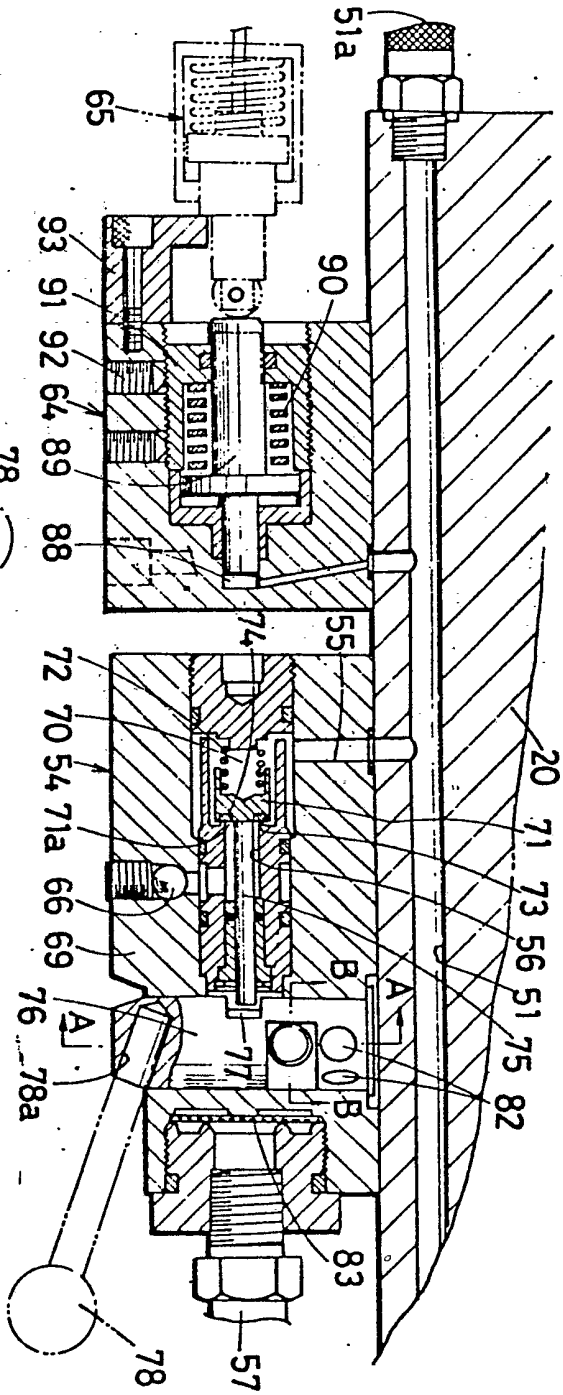


FIG. 15

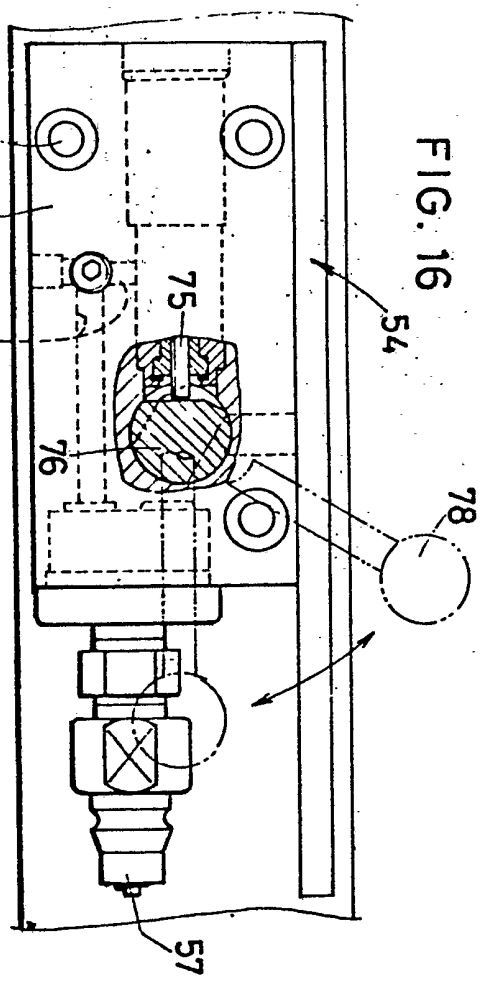


FIG. 16

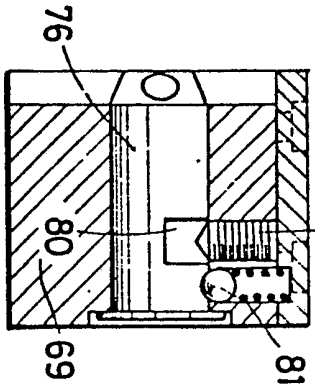


FIG. 17

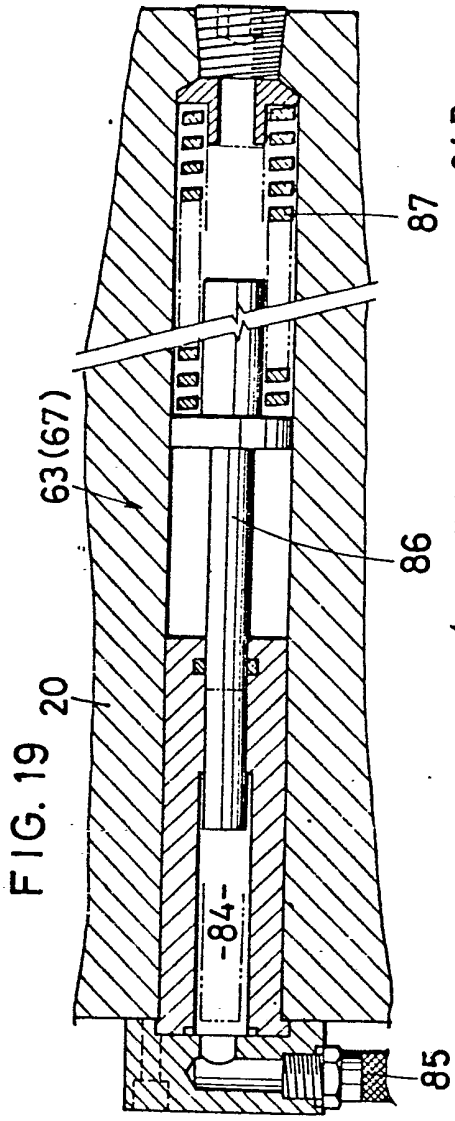


FIG. 19

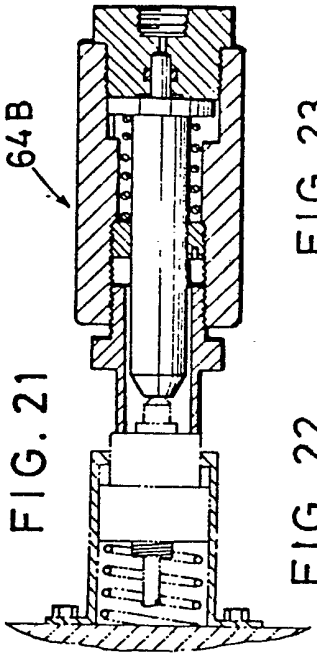


FIG. 21

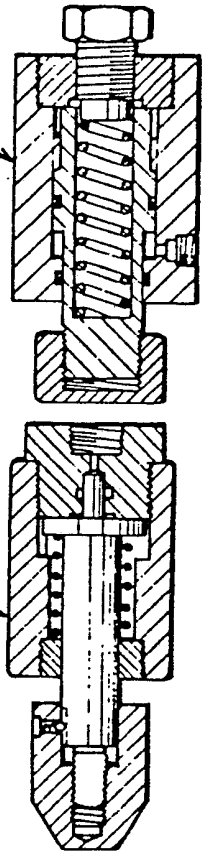
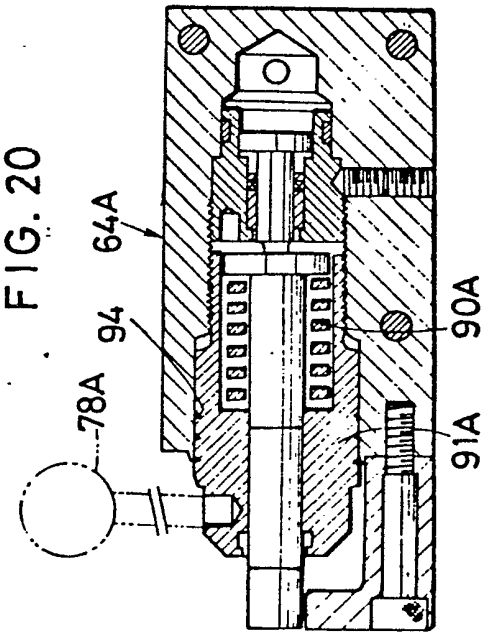


FIG. 22 FIG. 23



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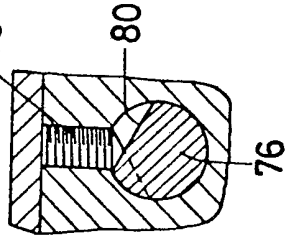


FIG. 18

FIG. 24

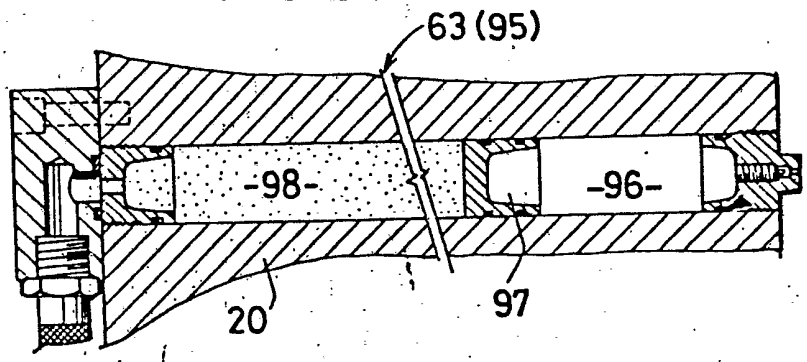
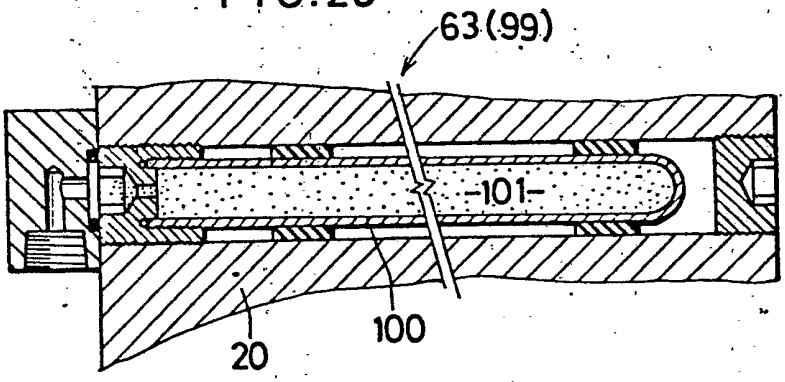


FIG. 25



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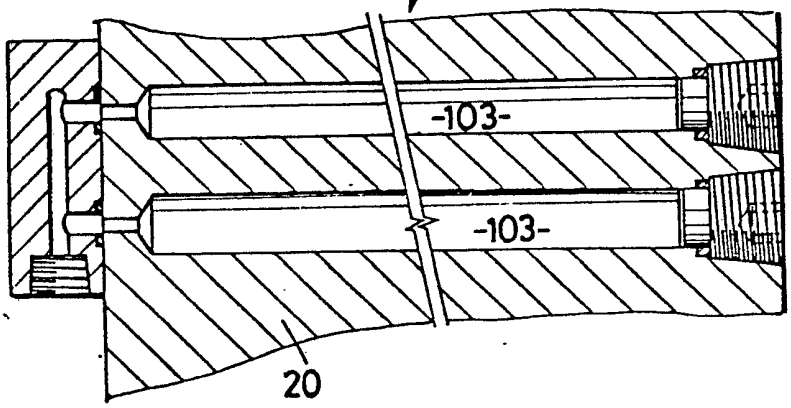

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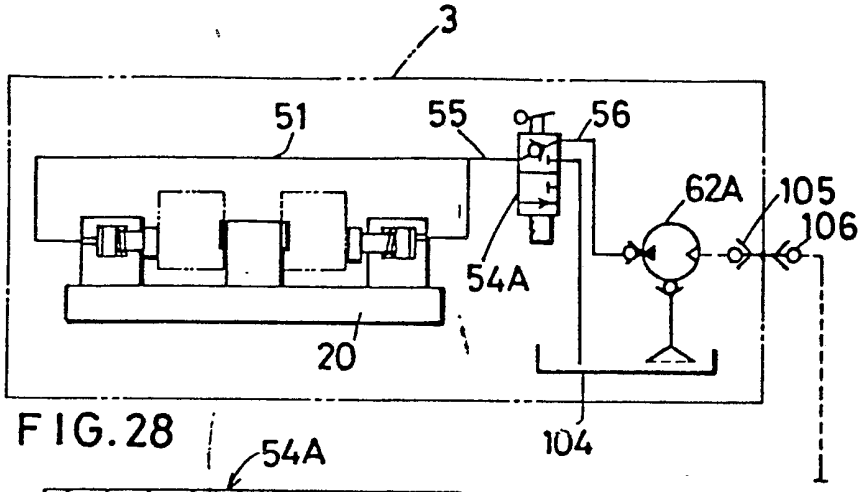

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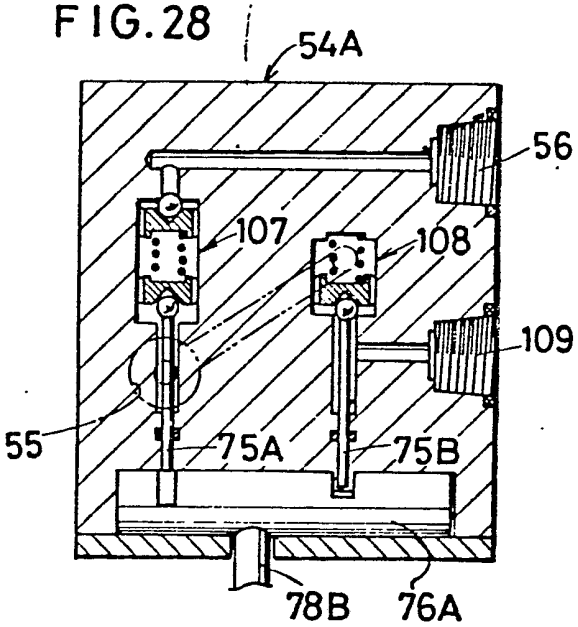

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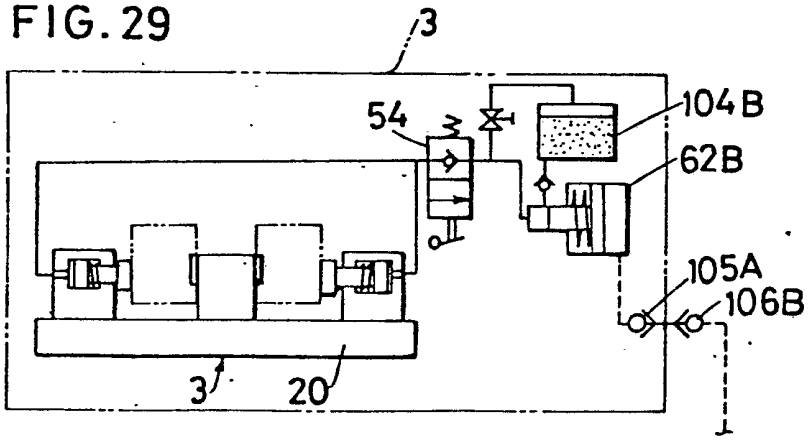


FIG. 30

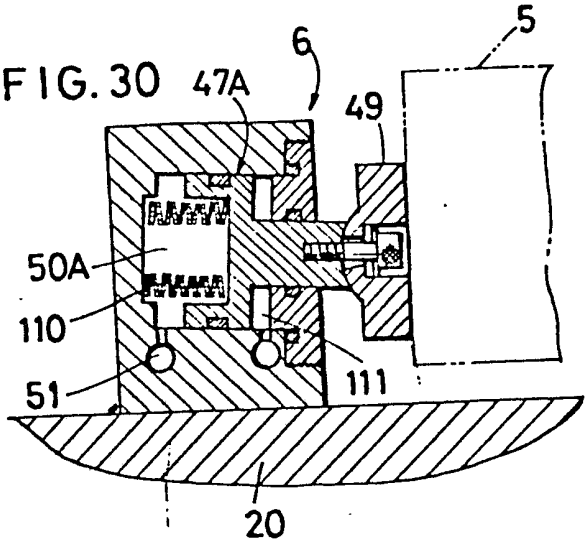


FIG. 34

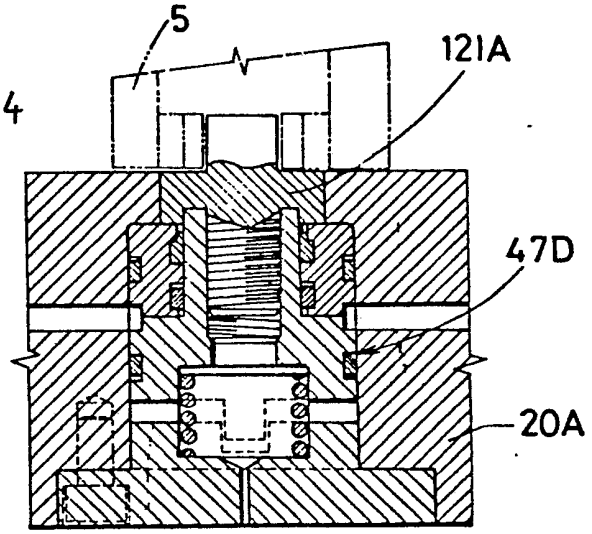


FIG. 35

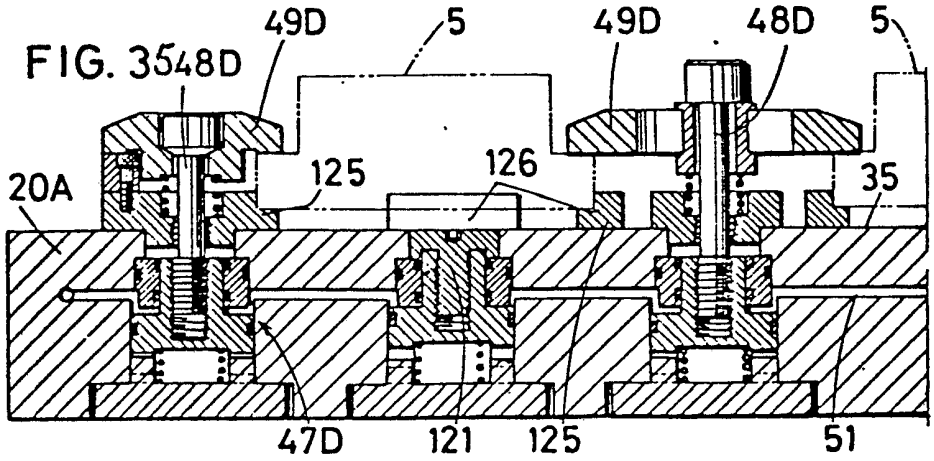


FIG. 31

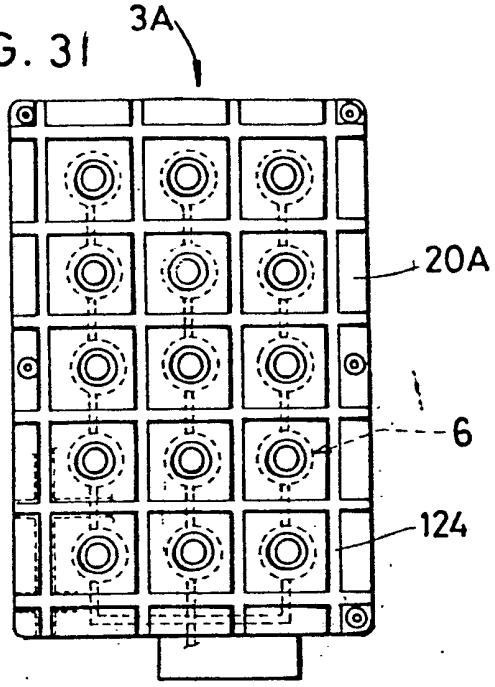


FIG. 32

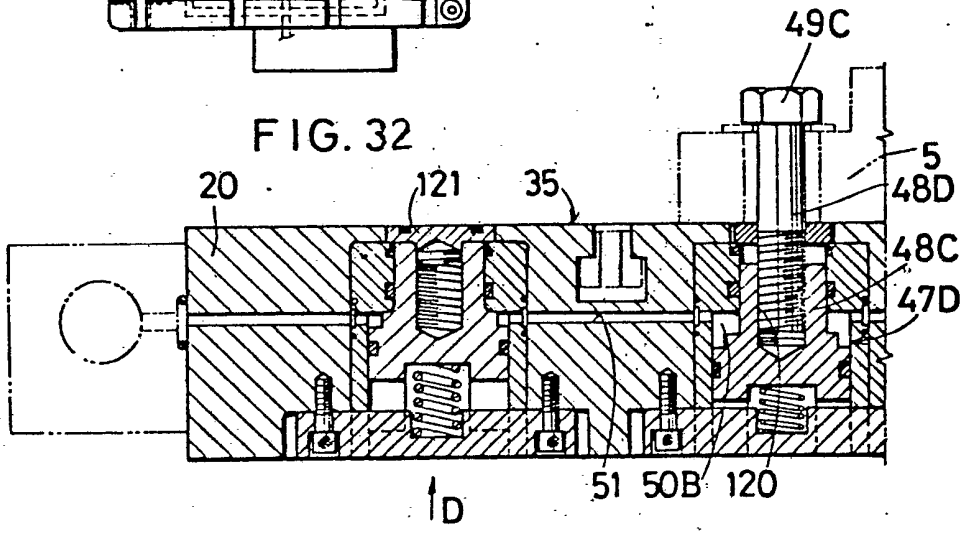


FIG. 33

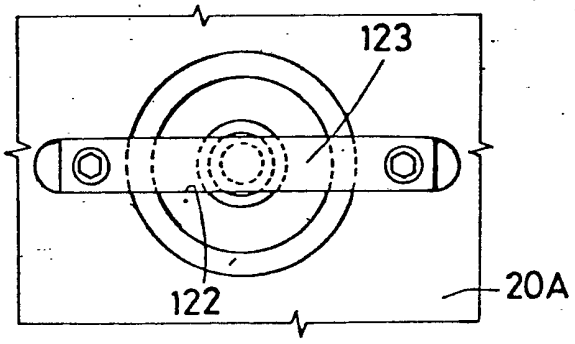


FIG. 36

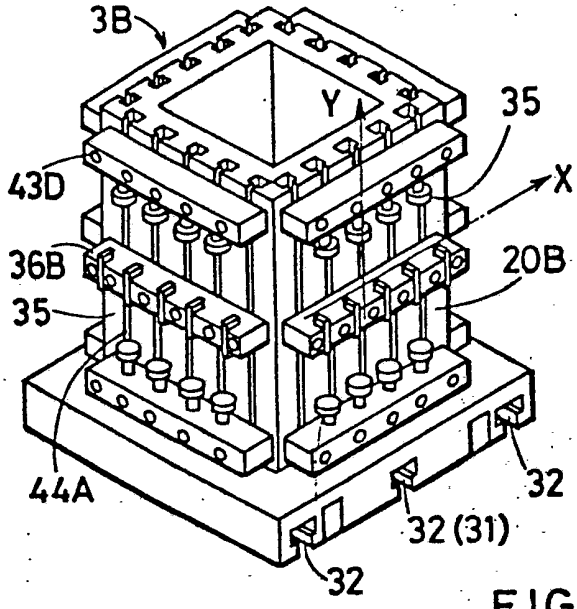


FIG. 37

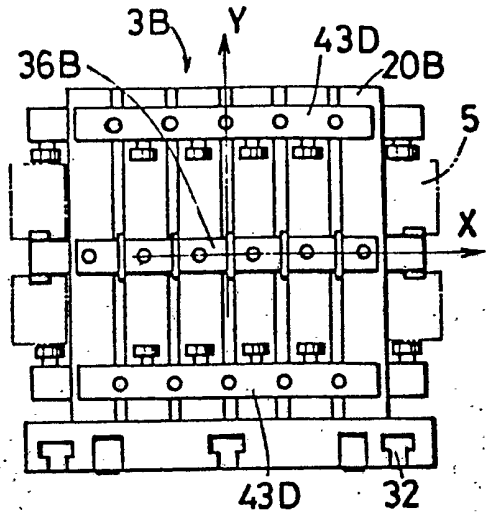
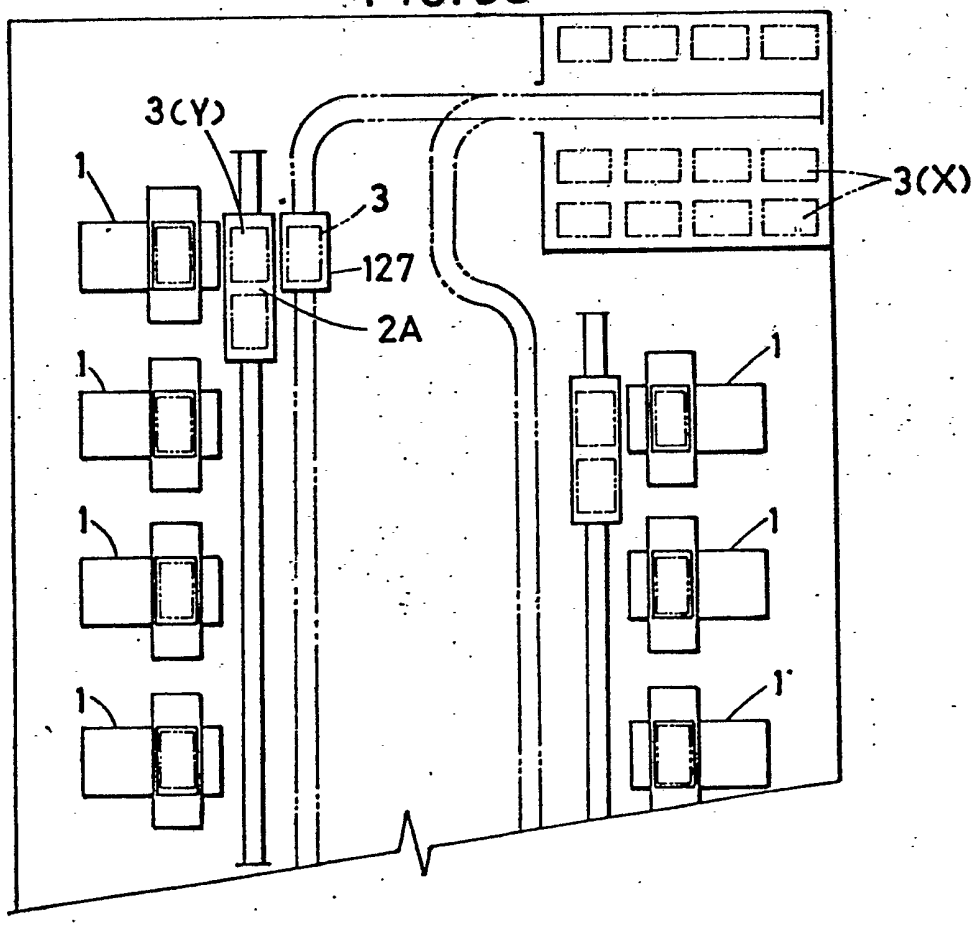


FIG. 38



SPECIFICATION

Work-clamp pallet for machine tool

Background of the Invention

Field of the Invention

The present invention relates to work-clamp pallets for various machine tools, for example, of the vertical and/or the horizontal type, especially those for latest NC machine tools of the vertical and/or the horizontal type.

Description of the Prior Art

For machining on a machine tool, works are required to be precisely positioned on its work table and subsequently clamped securely thereto.

Especially in the case of the NC machine tool, no truly precise machining of works can be accomplished unless the works are positioned precisely, however excellent may be the performance of the machine tool.

While in recent years quite remarkable has been the progress of NC machine tools in performance such as cutting speed, the variety and performance of cutting tools available and the possibility of automatic changing of cutting tools, these resulting in a marked improvement of their working efficiency, there has been still much to be desired about the improvement of the means for changing works as one of their peripheral techniques and this has been a major bottle-neck for the desired improvement of their working efficiency and productivity.

Hitherto, in a vertical machine tool it has been a usual practice to provide T-sectioned grooves in its work-clamping face and by the aid thereof position a plurality of works direct on its work table according to the design drawing and, after subsequent clamping of the positioned works by means of bolts or small clamping devices, check the position of each work by actual measurement and do necessary adjustment and re-clamp each work before proceeding with machining thereof.

According to this conventional practice, however, the machine tool has to be stopped and does not contribute to production while the finished works are removed and new works for the next cycle of machining are set on the work table. Hence, even with a modern NC machine tool, the net working rate is then 30 ~ 40% at the best, the remaining 60 ~ 70% of the working hours are lost in preparatory work such as changing works and cleaning the machine for removal of chips.

For improving the efficiency of the work-changing procedure, therefore, studies have been made of various clamping means and methods of placing them properly arranged on the work table.

For instance, an attempt was made to have fixedly secured to the topside of the work table a work-clamp base having arranged on it a plurality of hydraulic clamping devices, and connect the hydraulic cylinder of each of these clamping devices to a hydraulic pressure supply device using a hydraulic hose so that a plurality of works can be clamped quickly by those small yet powerful hydraulic clamping devices.

Since, however, the abovementioned work-clamp base is to be used fixedly secured to the work table of a machine tool, changing of works is to be made on the work table also in this case. So, while the method is effective indeed for improving the efficiency of the work-changing procedure, very slight is the improvement in machine's working efficiency attainable thereby.

For overcoming this problem, proposed was the idea of using a work-clamp pallet which allows changing of works outside the machine tool and it has since been gaining in popularity, being put to practical use progressively.

According to the idea, a pallet-changing table is provided in front of a machine tool so as to enable exchange of work-clamp pallets between it and the machine tool's work table, works are set on a plurality of work-clamp pallets, one at a time, at the work-changing station of the pallet-changing table, each work-clamp pallet so prepared is transferred onto the work table and positioned thereon and clamped thereto to be thus readied for machining of the works set thereon.

When the abovementioned work-clamp pallet is provided with hydraulic clamping devices, there arises the following problem.

It is that when each work-clamp pallet is transferred with the hydraulic hoses leading from the hydraulic pressure supply device connected thereto, those hoses are required to be pretty long and the multiplicity thereof pending or being entangled interferes with smooth transfer of the pallet.

Moreover, during machining, the work table with the work-clamp pallet clamped thereon moves longitudinally as well as laterally over substantial strokes, hence means have to be provided for reeling in and out the hydraulic hoses lest they should interfere with movement of the work table.

Worse, if any of the hydraulic hoses should be burnt by the red-hot chips resulting from machining, the resulting leakage of hydraulic oil is bound to spoil the clamping devices and, should it be the case, machining must be interrupted for replacing the work-clamp pallet. If the worse comes to the worst, the leaked hydraulic oil is ignited to cause a fire which might develop to be a catastrophe involving the entire plant.

In order to cope with the above problem, it is possible indeed to shut off the oil path by a directional changeover valve after feeding hydraulic pressure to the hydraulic clamping devices for clamping of the works thereby and thereafter transfer the work-clamp pallet with the hydraulic hoses disconnected.

With a spool valve hitherto used ordinarily as such directional changeover valve, however, perfectly leak-free shutting-off of the hydraulic oil is impossible, hence hydraulic pressure leakage from the hydraulic clamping devices is inevitable.

Should a hydraulic pressure leakage occur, the resultant decrease of the clamping force is likely to cause false machining of the works and even if this could be avoided, it is required to interrupt

machining for replacing the work-clamp pallet.

This risk can be precluded if the hydraulic hoses are not disconnected after clamping of the work-clamp pallet to the work table, but this is accompanied by the abovementioned problem.

Thus, the idea of providing the work-clamp pallet with hydraulic clamping devices has not yet been put to practical use as it is accompanied by a number of problems or difficulties, also being expensive.

Providing the work-clamp pallet with mechanical clamping devices using a screw mechanism or the like, on the other hand, is accompanied by the following drawbacks.

With a mechanical clamping device miniaturizing is difficult unlike with a hydraulic counterpart, and also difficult is generation of the required clamping force of say several tons. Another problem is that mechanical clamping devices have to be manipulated one after another for clamping as well as unclamping, hence no substantial improvement of the efficiency of work-setting procedure can be hoped for.

The work-clamp pallet is put to practical use wider for machine tools of the horizontal type than for the vertical type counterparts.

Today many of the latest, large horizontal machining centers are complete with a multi-pallet automatic pallet-changing device for automatic changing of works.

The work-clamp pallet used in this case is a box-shaped one with work-clamping faces provided on 4 or 2 sides thereof. The clamping device employed therefor has an improved universal feature for works to be machined in this case are relatively large, also varied in shape.

In each work-clamping face thereof, therefore, are provided a multiplicity of tapped holes and it is so designed that works are clamped to the work-clamping face by a plurality of bolts screwed into some thereof.

With this type of work-clamp pallet positioning of works on the work-clamping face is not easy, the work-clamping procedure being also troublesome, hence it is less suited for clamping small works.

If it should be possible to do positioning and clamping of a plurality of works on each work-clamping face of the box-shaped pallet efficiently, increased will be the variety of works that can be machined by a horizontal machining center for more effective utilization thereof.

Summary of the Invention

The present invention is aimed at solving the abovementioned problems.

In the work-clamp pallet according to the present invention, there is provided a special shut-off valve at the beginning end of the oil path for supplying hydraulic pressure to and discharging it from the hydraulic cylinder of each hydraulic clamping device.

A second object of the invention is to enable transfer of the work-clamp pallet onto the work table after clamping the works thereon by the above-mentioned hydraulic clamping devices with the hydraulic hoses leading from the hydraulic pressure supply device disconnected and also to enable machining of works clamped on the work-clamp pallet with no supplementary supply of hydraulic pressure to the work-clamp pallet clamped to the work table of the machine tool.

Preferably, the pallet enables positioning of many works on the work-clamping face of the work-clamp pallet and small yet powerful hydraulic clamping devices are used, thus reducing the frequency of changing work-clamp pallets for consequent improvement of the working rate of the machine tool.

The work-clamping pallet is provided with a hydraulic pressure fall preventing device with its hydraulic pressure accumulating room connected with the abovementioned oil path and also with an actuator which comes into play in the event of an abnormal fall of hydraulic pressure to trigger a limit switch on the work table side.

Thus the machine can be used with the hydraulic pressure held at the set level free from any abnormal fall and/or rise thereof even in the event of leakage of the hydraulic oil in the hydraulic oil system of the work-clamp pallet sealed by the above-mentioned shut-off valve and of variation of the temperature of the hydraulic oil.

In accordance with the present invention there is provided a work-clamp pallet comprising a base block, a plurality of hydraulic clamping devices, oil path and shut-off valves, wherein

the base block whose topside constitutes a work-clamping face on which works are set is provided with a positioning means for positioning thereof on the work table of a machine tool longitudinally as well as laterally and a clamping means for clamping thereof to the work table,

each hydraulic clamping device is composed of a hydraulic cylinder secured to the work-clamping face and a clamping block connected to the tip of the piston rod thereof,

the clamping block is arranged shiftable between the clamping position where the work is clamped by the hydraulic cylinder and the unclamping position where clamping is released,

the oil path is provided to communicate the working oil rooms of the individual hydraulic cylinders,

the shut-off valve has its valve box secured to the base block with its secondary port connected to the beginning end of the oil path and the hydraulic pressure inlet on the primary port side disconnectably connected to the hydraulic pressure outlet of the hydraulic pressure supply device so that when after supplying hydraulic pressure from the hydraulic pressure supply device to the hydraulic oil room of the hydraulic cylinder with the hydraulic pressure outlet connected to the hydraulic pressure inlet the former is disconnected from the latter, the oil path is shut down by the shut-off valve so that fall of the hydraulic pressure in the hydraulic oil room is precluded.

If necessary, a hydraulic pressure fall

preventing device is attached to the base block with its hydraulic pressure accumulating room connected to communicate with the oil path.

Brief Description of the Drawings

Of the appended drawings showing embodiments of the present invention, Figs. 1 ~ 26 relate to a principal embodiment and Figs. 27 ~ 38 alternative embodiments.

FIG. 1 is the plan view of the work table of a machine tool and a pallet-changing table;

FIG. 2 is the side view of what is shown in Fig. 1;

FIG. 3 is a perspective view of an auxiliary table and a work-clamp pallet;

FIG. 4 is a partial vertical sectional side view of the work-clamp pallet showing its castor means;

FIG. 5 is a sectional view taken along the line V—V in Fig. 1 showing a cross-section of the auxiliary table.

FIG. 6 is a sectional view taken along the line VI—VI in Fig. 1 showing another cross-section of the auxiliary table.

FIG. 7 is a vertical sectional front view of the castor means and a clamping device;

FIG. 8 is a vertical sectional front view showing the spring section of the castor means;

FIG. 9 is a vertical sectional front view of a guide rail;

FIG. 10 is a vertical sectional front view of a positioning device;

FIG. 11 is the plan view of the work-clamp pallet;

FIG. 12 is a partial perspective view of a standard frame;

FIG. 13 is an enlarged vertical sectional side view showing essential parts of the clamping device;

FIG. 14 is a hydraulic pressure system chart of the work-clamp pallet and hydraulic pressure supply device;

FIG. 15 is a horizontal sectional plan view of a shut-off valve and a hydraulic pressure abnormal fall detection device;

FIG. 16 is the side view of the shut-off valve;

FIG. 17 is a sectional view taken along the line A—A in Fig. 15;

FIG. 18 is a sectional view taken along the line B—B in Fig. 15;

FIG. 19 is a horizontal sectional plan view of a spring-type accumulator;

FIGS. 20 ~ 23 are vertical sectional side views showing each one of modified actuators;

FIG. 24 is a horizontal sectional plan view of a piston type accumulator;

FIG. 25 is a horizontal sectional plan view of an elastic tube type accumulator;

FIG. 26 is a horizontal sectional plan view of a hydraulic oil dwelling type accumulator;

FIG. 27 is a hydraulic pressure system chart for the work-clamp pallet in a first alternative embodiment;

FIG. 28 is a vertical sectional side view of the shut-off valve of Fig. 27;

FIG. 29 is a hydraulic pressure system chart for the work-clamp pallet in a second alternative embodiment;

FIG. 30 is a vertical sectional side view of the hydraulic clamping device in a third alternative embodiment;

FIGS. 31 ~ 35 show a fourth alternative embodiment, of which

FIG. 31 is the plan view of the work-clamp pallet;

FIG. 32 is a partial vertical sectional front view of the work-clamp pallet;

FIG. 33 is a view taken from the direction indicated by the arrow D in Fig. 32;

FIG. 34 is a vertical sectional front view showing essential parts of a modified hydraulic clamping device;

FIG. 35 is a partial vertical sectional side view of the work-clamp pallets provided with a modified hydraulic clamping device;

FIG. 36 is a perspective view of the work-clamp pallet in a fifth alternative embodiment;

FIG. 37 is the front view corresponding to Fig. 36; and

FIG. 38 is a layout of a shop having in it modified pallet-changing tables and a work-changing station in a sixth alternative embodiment.

Detailed Description of the Preferred Embodiments

Referring to Figs. 1 ~ 26, described below in detail is the principal embodiment of the present invention.

As shown in Figs. 1 ~ 3, a rotary pallet-changing table 2 is placed in front of an NC (numerically controlled) vertical machine tool 1 with spaces thereon for two work-clamp pallets.

On a movable work table 4 of the machine tool 1 is fixedly secured thereto an auxiliary table 4A on which the work-clamp pallet 3 is positioned and clamped and it is so arranged that the work-clamp pallets 3 can be exchanged between the pallet-changing table 2 and this auxiliary table 4A.

At a work-changing station X on the pallet-changing table 2 a multiplicity of works 5 are positioned on the work-clamp pallet 3 with a high precision and each thereof is subsequently clamped by a hydraulic clamping device, and then the pallet-changing table 2 is rotated horizontally by half a turn before the work-clamp pallet 3 is transferred to a work-clamp pallet changing station Y.

Next, the work-clamp pallet 3 is transferred from the work-clamp pallet changing station Y onto the auxiliary table 4A being guided by a guide means 7, and after being stopped by a stopper 8, the work-clamp pallet 3 is positioned by a pair of positioning devices 9 to be subsequently powerfully clamped to supports 11 arranged on the auxiliary table 4A by means of 6 pairs of hydraulic clamping devices 10.

By thus positioning the individual works 5 on the work-clamp pallet 3 and then the work-clamp pallet 3 with respect to the table 4 with a high precision, each work 5 can be positioned with

respect to the table 4 with an equally high precision, as will be described later in greater details.

After completion of clamping of the work-clamp pallet 3 to the auxiliary table 4A the machine tool 1 is started for machining the works.

While machining is under way, works 5 are set on another work-clamp pallet 3 at the work-changing station X.

After completion of a cycle of machining, the work-clamp pallet 3 is shifted to the work-clamp pallet changing station Y and the pallet-changing table 2 is again rotated by half a turn for the work-clamp pallet 3 with the finished works 5 on to be shifted to the work-changing station X and the work-clamp pallet 3 with new works 5 to be machined on to be shifted to the work-clamp pallet changing station Y, and the above procedure is repeated for successive changing of the work-clamp pallets.

Now explained briefly are the constructions of the pallet-changing table 2 and the auxiliary table 4A.

The pallet-changing table 2 is composed of a rotary frame 2b carried on castors 2d to be horizontally rotatable about a shaft 2c on a base frame 2a, and on the topside of a top plate secured to the rotary frame 2b there are set two parallel transfer rails 12 and a single line of guide rail 7. Reference numeral 13 denotes a rotary locking device, 14 a pivot and 15 an electric motor which is provided as necessary.

The auxiliary table 4A is designed as a unit composed of a rectangular base plate 16 and a number of devices arranged thereon, and is secured to the table 4 by means of bolts 17.

On the base plate 16 are arranged the two, left and right, transfer rails 18, a pair of positioning devices 9 located as far away from the center to the left and right, a total of 6 pairs of clamping devices 10 two pairs each on the left and right and at the center, the supports 11 arranged on both, left and right, sides of each clamping device 10, two pieces of guide rail 7 each extending longitudinally with a center pair of clamping devices at its center, and a lateral (left and right) pair of stoppers 8 and so on.

As shown in Figs. 4 ~ 10, as a traveling gear 19 of the work-clamp pallet 3 there is set in a square-sectioned groove 21 provided in the underside of the base block 20 U-sectioned members 23 carrying one castor 22 each with their vertical positions freely adjustable. This U-sectioned member 23 is urged downwardly by a compression spring 24 for the tread part of the castor 22 alone to be projected and both end parts of the U-sectioned member 23 are supported by the support members 25. (Figs. 4, 7 and 8.)

As seen from Fig. 10, the positioning device 9 consists of a pneumatic cylinder with a plug 27 connected to its piston rod 26 and the base block 20 is positioned with a high precision as this plug 27 is engaged in a mating hole 28 in the underside thereof. A pneumatic pressure is supplied to a working-side port 29 to cause engagement of the plug 27 in the mating hole 28, the working side port 29 communicates with a detection side port 30 for the pneumatic pressure to be supplied to the detection side port 30 so that the engagement of the plug 27 is displayed on a control panel (not shown) etc. Description of any further detail of this phase of the construction is, however, omitted.

As mentioned above, the guide rail 7 is fitted in the guide groove 31 in the underside of the base block 20 to slide therein relatively as the work-clamp pallet 3 is transferred from the work-clamp pallet changing station Y onto the auxiliary table 4A and the base block 20 is guided thereby safe from lateral shifting. Further, each clamp arm 10a undergoes relative movement in a clamping means 32 formed of the T-sectioned grooves in the underside of the base block 20, and after positioning of the base block 20 by the positioning device 9, hydraulic pressure is supplied to the hydraulic oil room 10b of the clamping device 10 for the clamp arm 10a to be pulled down so that the compression spring 24 of the traveling gear 19 is compressed for the tread of the castor 22 to be retracted to be flush with the underside of the base block 20 and the base block 20 is thus clamped to the supports 11.

Compressed air is then caused to blow out of air outlets 33 in the topside of each support 11 and the foreign objects deposited on each support 11 are blown off thereby so that the risk of engagement thereof is precluded with simultaneous possibility of confirming close contact of the underside of the base block 20 with the topside of the support 11 through detection of rise of the pneumatic pressure in a compressed air supply channel 34.

The pneumatic pressure from a compressed air source is supplied to a pneumatically-driven hydraulic pump for a hydraulic pressure to be generated and supplied to the clamping device 10 as well as to the positioning device 9 and the air outlets 33 of each support 11.

Upon engagement of the plug 27 of the positioning device 9 in the mating hole 28 pneumatic pressure is supplied to the detection side port 30 and the condition is displayed by lighting of a pneumatic pressure indicator lamp.

As the underside of the base block 20 comes into close contact with the topside of the support 11, the pneumatic pressure in a gushing air supply channel is caused to rise, and this is detected by means of a pressure switch whose output signal is led to a contact confirmation lamp (not shown) for the contact condition to be indicated thereby.

The auxiliary table 4A may as well be formed to be fixedly combined with the table 4 but, when, as mentioned above, it is made as an independent or separate unit to be secured to the table 4, it is readily applicable to any existing machine tool.

Referring to Figs. 11 ~ 14, now described are the base block 20 and the hydraulic clamping device 6 of the work-clamp pallet 3.

This work-clamp pallet 3 is intended for use with a vertical machine tool 1, and its base block

20 is made of a thick, rectangular steel plate, with its topside constituting the work-clamping face 35 for the works to be set thereon.

With the center of the work-clamping face 35 as the point of origin, X-axis is set laterally, Y-axis longitudinally and Z-axis vertically.

A standard frame 36 is the standard for high-precision positioning of works 5 on the work-clamping face 35, and is fixedly secured to the work-clamping face 35 along its X-axis by means of 9 fixing bolts 37.

The longitudinally front and rear sides of this standard frame 36 constitute each one work-positioning face 38, which is equally divided along its length into individual unit work-positioning faces 38a with one end of each defined by a stopper 39.

The positioning stopper 39 is gate-shaped, is removably fitted in a mating groove 40 in the top-side of the standard frame 36, fixed with a screw 41 as necessary, and its work-checking face 39a is projected beyond each work-positioning face 38a.

It is so arranged that each of a plurality of like works 5 can be precisely positioned along both X- and Y-axis when it is brought into contact with each unit work-positioning face 38a as well as the work-checking face 39a of the corresponding positioning stopper 39.

When the work 5 to be set is long and narrow, the corresponding number of positioning stoppers, which are not required, are to be removed.

On both, front and rear, sides of the standard frame 35 are arranged across each work-accommodating space 42 clamping frames 43, each of which can be secured to the work-clamping face 35 with its position freely adjustable along Y-axis by means of fixing bolts 46 screwed into T-nuts fitted in 9 lines of T-sectioned grooves 44 provided in the work-clamping face 35.

Each clamping frame 43 has housed therein hydraulic clamping devices 6 each thereof located correspondingly to each unit work-positioning face 38a and so arranged that a clamping block 49 connected to the tip of a piston rod 48 of its hydraulic cylinder 47 can be driven thereby fore and back between the clamping position nearest to the unit work-positioning face 38a and the unclamping position remotest therefrom.

That is, the hydraulic cylinders 47 are formed in the clamping frame 43, with their hydraulic oil rooms 50 communicatingly connected by an oil path 51 by which hydraulic pressure is supplied and discharged.

The clamping block 49 is connected to the tip of the piston rod 48 using a bolt 52. Its partly spherical contact face is brought into contact with a spherical seat of the piston rod and the clamping block 49 is urged by an elastic body 53 toward the piston rod 48 for compensation of oscillation thereof.

The hydraulic clamping device 6 may as well be provided as each independent clamping unit proper but in this case the pattern of the oil path 51 is bound to be complicated.

As seen from Fig. 14, the work-clamp pallet 3 is provided with a shut-off valve 54 with its secondary port 55 connected to the beginning end of the oil path 51, while a hydraulic pressure inlet 57 is locate on its primary port 56 side.

The hydraulic pressure supply device 60 is installed on the pallet-changing table 2 independent of the work-clamp pallet 3 and serves to alternatively reduce the pneumatic pressure supplied from a pneumatic pressure source 59 with one of its reducing valves 61a, 61b and 61c of different set pressure levels and supply the reduced pneumatic pressure to a hydraulic pump 62 for generation of a hydraulic pressure thereby.

A hydraulic pressure outlet 58 of the hydraulic pressure supply device 60 is connected to the hydraulic pressure inlet 57 of the work-clamp pallet 3 placed at the work-changing station X on the pallet-changing table 2 for the predetermined hydraulic pressure to be supplied to the hydraulic clamping device 6 for each work 5 to be clamped thereby and then, after switching of the shut-off valve 54 to the closing position, the hydraulic pressure outlet 58 is disconnected from the hydraulic pressure inlet 57 of the work-clamp pallet 3 and the latter (3) is then transferred onto the auxiliary table 4A for machining of the works thereon.

In order to facilitate connection of the hydraulic pressure outlet 58 of the hydraulic pressure supply device 60 to the hydraulic pressure inlet 57 of the work-clamp pallet 3 as well as disconnection therefrom it is advisable to design the hydraulic pressure inlet 57 as a joint of self-seal coupling.

In Fig. 14 reference numeral 67 denotes a spring-type accumulator of a hydraulic pressure fall preventing device 63, 64 and 65 an actuator of a hydraulic pressure abnormal fall detection device 68 and a limit switch on the machine tool side respectively and 66 a stop valve for releasing pressure.

Referring now to Figs. 14 ~ 26, explained in detail below are the shut-off valve 54, hydraulic pressure fall preventing device 63 and hydraulic pressure abnormal fall detection device 68.

The shut-off valve 54 is a seat valve of 2-port, 2-position changeover type and its valve box 69 is fixedly secured to one end face of the base block 20 by the use of bolts 70A. On the primary port 56 side of this shut-off valve 54 is provided the hydraulic pressure inlet 57 facing on the outside of the valve box 69. This hydraulic pressure inlet 57 is designed as a joint of self-seal coupling, to which the hydraulic pressure outlet 58 of the hydraulic pressure supply device 60 is disconnectably connected.

The secondary port 55 of the shut-off valve 54 is connected to the beginning end of the oil path 51 in the base plate 20. This oil path 51 opens in both, front and rear, end faces of the base block 20 and is connected with an oil path 51 in each clamping frame 54 via hydraulic hose 51a. (See Fig. 11.)

A valve core 71 in a valve chamber 70 of the shut-off valve 54 is urged by a compression spring 72 toward a valve seat 73, and the back flow of hydraulic oil from the secondary port 55 side to the primary port 56 side is prevented thereby.

A seating face 71a of the valve core 71 is formed as an annular member 74 of a synthetic resin of excellent abrasion resistance and mechanical strength, while the valve seat 73 is formed as an annular raised portion projecting toward the valve chamber 70 side, hence the seating face 71a of the valve core 71 contacts with the valve seat 73 perfectly gap-free for secure shutting-off of a hydraulic pressure as high as approx. 250 kg/cm^2 G for a long time.

When hydraulic pressure is supplied to the clamping device 6, this valve is opened against the force of the spring 72. The valve is, however, also required to be opened for discharge of hydraulic pressure therethrough when clamping is to be relieved for changing works 5, hence there is provided the following valve-opening means.

The tip of a valve opening rod 75 disposed in the primary port 56 is in contact with or close to the valve core 71, while the other end of the valve opening rod 75 is disposed on an inclined cam face 77 of a cam shaft 76. When the cam shaft 76 is turned by approx. 60° counterclockwise by means of a control lever 78 (Fig. 16), the valve opening rod 75 is pushed by the inclined cam face 77 toward the valve chamber 70 for the valve to be opened thereby, and the valve is closed by reversal of the above procedure (Fig. 15).

The extent of rotation of the cam shaft 76 is limited by means of a rotation limiter 79 which comes into contact with a rotation limiting face 80 of the cam shaft 76 to arrest it thereby.

Also, when the valve is open, a locking means 81 which is formed as a steel ball is fitted in a recess 82 on one side of the cam shaft 76, while it is fitted in the recess 82 on the other side of the cam shaft 76 when the valve is closed, so that the cam shaft 76 is locked in either of both valve positions.

Reference numeral 83 denotes a wire mesh filter, 66 a stop valve for releasing pressure and 78a is a hole provided for setting the control lever 78 therein.

As valve opening means one of the electromagnetic type or of the hydraulic type may as well be used besides what is described above.

As shut-off valve 54 can be used one of those of various constructions other than described above, but it is always required to be highly durable and extremely small in the amount of leakage of hydraulic pressure.

The work-clamp pallet 3 of the present invention is unique in that it can have works 5 positioned and clamped thereon at the work-changing station X which may possibly be provided in a part of the shop away from the machine tool 1 and can be transferred to where the works 5 clamped thereon are machined with the oil path 51 therein perfectly shut down by means of the abovementioned shut-off valve 54 to hold the clamped condition without the necessity of supplementing the hydraulic pressure thereafter.

Hence the hydraulic pressure in the hydraulic clamping device 6 is required to be kept above the set level for a long time, i.e. from setting of works 5 on the pallet 3 to completion of machining thereof.

In order to prevent hydraulic pressure leakage from the hydraulic cylinder 27 of the clamping device 6 as well as fall and/or rise of hydraulic pressure due to variation of the oil temperature, the base block 20 is provided with the following hydraulic pressure fall preventing device 63 and hydraulic pressure abnormal fall detection device 68.

The spring-type accumulator 67 as the hydraulic pressure fall preventing device 63 is provided in the base block 20 and its pressure accumulating oil room 84 is connected with the oil path 51 by means of hydraulic hose etc. (Figs. 11 and 19.)

This spring-type accumulator 67 is so designed that with a piston 86 urged by a compression coil spring 87 the spring force is balanced with the hydraulic force when the hydraulic pressure is at the set level.

When the hydraulic pressure starts falling, the piston 86 is urged by the spring 87 into the pressure accumulating oil room 84 and the resulting compression of the hydraulic oil prevents the fall of hydraulic pressure.

Conversely, when the hydraulic pressure starts rising due to expansion of the hydraulic oil caused by rise of the oil temperature, the piston 86 retracts against the force of the spring 87 and abnormal rise of the hydraulic pressure is thus prevented.

The hydraulic pressure abnormal fall detection device 68 is composed of the actuator 64 provided in/on the base block 20 and the limit switch installed on the table 4 side of the machine tool 1.

It is so arranged that the actuator 64 uses the hydraulic pressure in the hydraulic oil chamber 88 communicating with the oil path 51 in the base block 20 to push the piston 89 outwardly while the same piston 89 is urged inwardly by a compression spring 90 for setting the hydraulic pressure, so that, when the hydraulic pressure is at the set level, the hydraulic pressure is roughly balanced with the spring force with the piston 89 kept at the position corresponding to the normal hydraulic pressure as illustrated.

When the hydraulic pressure in the hydraulic oil chamber 88 has fallen below the set level, the piston 89 is displaced inwardly by the spring force to the position for detection of abnormal hydraulic pressure.

The displacement of the piston 89 is detected by the limit switch 65 and the signal output thereof is input to the control device (not shown) of the machine tool 1 and the latter is emergency-stopped in the event of any abnormal fall of the hydraulic pressure.

Reference numeral 91 denotes a spring holder which is locked by a fastener 92 after proper setting of the length of the spring 90.

Reference numeral 93 is a means provided for keeping constant the positional relation between the actuator 64 and the limit switch 65.

When it is necessary to adjust the clamping force the clamping device 6 according to the material, shape and size of the work 5, an actuator 64A as illustrated in Fig. 20 is used for adjusting the hydraulic pressure set level.

The length of the spring 90A can be adjusted by turning the spring holder 91A by means of the control lever 78A, and the length of spring corresponding to each hydraulic pressure set level is readable from a dial 94.

A number of modifications of the actuator are shown in Figs. 21 ~ 23, and 3 modifications of the hydraulic pressure fall preventing device in Figs. 24 ~ 26.

The piston-type accumulator 95 (Fig. 24) is made to push a piston 97 by the pressure of the compressed nitrogen gas in a compression room 96 so as to prevent fall of the hydraulic pressure in a pressure accumulating oil room 98.

The elastic tube-type accumulator 99 (Fig. 25) is made to use the resiliency of an elastic tube made of steel or a compound rubber material for compressing the hydraulic oil in a pressure accumulating oil room 101 so as to ensure against fall of the hydraulic pressure.

The accumulator of the hydraulic oil dwelling type 102 (Fig. 26) is made to utilize the elastic volume strain of the large amount of hydraulic oil in a hydraulic oil dwelling room 103 for preventing fall of the hydraulic pressure.

The oil pressure fall preventing device 63 as exemplified above can be built in the base block 20 with no space requirement on the surface thereof, hence it is even possible to provide a plurality of accumulators in a single base block 20.

When the oil temperature is subject to marked changes due to variation of the atmospheric temperature in the shop etc., it is advisable to use the spring-type accumulator 67.

Referring now to Figs. 27 ~ 38, described below are a number of alternative embodiments with partial modifications of the principal embodiment of the present invention already described.

I. A first alternative embodiment is shown in Figs. 27 and 28.

In this alternative embodiment the base block 20 is provided with a hydraulic pressure supply device composed of a small pneumatically-driven hydraulic pump 62A which operates on the supplied pneumatic pressure to generate a hydraulic pressure and an oil tank 104, and its air inlet 105 is adapted to be disconnectably connected with an air outlet 106 of a separate compressed air supply device (not shown). In this embodiment the hydraulic pressure inlet is connected permanently with the hydraulic pressure outlet of the hydraulic pressure source.

As shut-off valve it is as well possible to use a seat valve at 3-port, 2-position changeover type 54A shown in Fig. 28.

This shut-off valve 54A is made up of an oil supply valve 107 disposed between the primary port 56 and the secondary port 55 and an oil drain valve 108 disposed between the secondary port 55 and the oil drain port 109, and is shown in the figure open for supplying hydraulic oil. For draining hydraulic oil a cam shaft 76A is to be turned by means of a control lever 78B for a valve opening rod 75A to be pushed down to close the oil supply valve 107 with simultaneous pushing up of the other valve opening rod 75B for opening the oil drain valve 108 for the hydraulic oil to be drained through the secondary port 55 and the oil drain port 109.

II. A second alternative embodiment is shown in Fig. 29.

In this alternative embodiment the base block 20 is provided with a hydraulic pressure supply device composed of a small, continuously operable booster 62B which operates on the supplied pneumatic pressure to generate a hydraulic pressure and an oil tank 104B, and the air inlet 105A of the booster 62B is adapted to be disconnectably connected with an air outlet 106B of a separate compressed air supply device (not shown).

III. A third alternative embodiment is shown in Fig. 30.

In this alternative embodiment a coned disc spring 110 is set in a hydraulic oil room 50A of a hydraulic cylinder 47A of the hydraulic clamping device 6 so that the work 5 can be clamped tentatively by spring force.

When the work 5 is to be set, first the coned disc spring 110 is compressed by the hydraulic pressure in a back-stroke oil room 111 and after setting the work 5 the hydraulic pressure is released for the work 5 to be tentatively clamped lightly by the spring force of the coned disc spring 110. Then, after final, precise positioning of the work 5, hydraulic pressure is supplied to a hydraulic oil room 50A for clamping up the work 5.

IV. A fourth alternative embodiment is shown in Figs. 31 ~ 35.

In this alternative embodiment a work-clamp pallet 3A is inteneded for use with a vertical machine tool. Its base block 20A is made of a thick steel plate and there are built in it a large number of vertical hydraulic cylinders 47D arranged longitudinally as well as laterally at an approximately equal pitch for clamping works 5 on the work-clamping face 35 of the base block 20A.

A piston rod 48C of each hydraulic cylinder 47D is vertically movable under the work-clamping face 35, and has a tapped hole 120 in its top end face.

One end of an auxiliary (extension) piston rod 48D is screwed into this tapped hole 120, a clamping block 49C formed at the head of the auxiliary piston rod 48D is applied to the work 5 and then hydraulic pressure is supplied from the oil path 51 to a hydraulic oil room 50B for

clamping the work 5 with the clamping block 49C.

With the clamping devices 6 away from or right under the works 5, a plug is to be screwed in the abovementioned tapped hole and the piston rod 48C is to be kept locked at the upper end of its stroke.

The piston rod 48C of the hydraulic cylinder 47D is checked against rotation by means of a rotation inhibitor 123 fitted in a mating groove 122 in the lower part thereof. (Fig. 33.)

The beginning end of the oil path 51 communicating the hydraulic oil rooms 50B of the hydraulic cylinders 47D is connected with the secondary port of the shut-off valve.

In the work-clamping face 35 there are provided T-sectioned or square-sectioned grooves 124 along X- as well as Y-axis, which in combination with square-sectioned members or the like fitted therein facilitate positioning of the works 5.

As an alternative embodiment of the abovementioned hydraulic cylinder 47D a simplified hydraulic cylinder is shown in Fig. 34. In the figure reference numeral 121A denotes a fixed plug used for positioning of a work 5 with a round hole in it.

As shown in Fig. 35, another alternative is possible, wherein each work 5 is held lifted by the use of a supporting block 125 as it is positioned by means of a positioning means 126 and the positioned work 5 is clamped by a clamping block 49D connected to the upper end of the auxiliary piston rod 48D of the hydraulic cylinder 47D.

V. A fifth alternative embodiment is shown in Figs. 36 and 37.

A work-clamp pallet 3B in this alternative embodiment is intended for use with a horizontal machine tool.

Its base block 20B is formed as a box-like steel frame whose 4 sides constitute each one work-clamping face 35, on which are provided 8 sets of hydraulic clamping device 6.

With the center of each work-clamping face 35 X and Y axes are set as illustrated.

Each standard frame 36B as well as each clamping frame 43D is removably secured in place with each 5 fixing bolts screwed into T-nuts disposed in T-sectioned groove.

When a large-sized work 5 is to be clamped on the work-clamping face 35, it is possible to remove all the abovementioned standard frames 36B and clamping frames 43D and clamp the work 5 with bolts and T-nuts set in T-sectioned grooves 44A as in the case of a conventional work-clamp pallet.

Fairly large-sized works 5 can be clamped when the standard frame 36B is shifted toward either clamping frame 43D.

The standard frame 36B and the clamping device 6 in this alternative embodiment are essentially the same as described above in connection with the principal embodiment but as the clamping device 6 it is also possible to use any of those shown in the above alternative embodiments.

The base block 20B is further provided on or in its underside with the clamping means 32 consisting of T-sectioned grooves, positioning means consisting of a pair of engaging holes, castor means set in the square-sectioned groove provided therein.

As the clamping means 32, however, a number of alternatives are usable, besides the one described above. It is, for instance, also possible to clamp the base block 20B on the work table 4 or auxiliary table 4A of a machine tool.

It is also possible to use as the positioning means a number of alternatives, besides the one described above.

The shut-off valves, hydraulic hoses etc. in this alternative embodiment are not shown in the figures.

VI. A sixth alternative embodiment is shown in Fig. 38.

In this alternative embodiment a plurality of machine tools 1 are installed in parallel and in front of each thereof is placed a pallet-changing table transferable linearly or sideways.

At a work-changing station X located somewhere in the shop the work-clamp pallets 3 are readied one after another by changing works 5 thereon, each work-clamp pallet 3 ready (with new works 5 on) is transferred on a mobile trailer 127 to before one of the pallet-changing tables 2A to be subsequently shifted onto it, and then on the pallet-changing table 2A the "new" and "old" work-clamp pallets 3 are exchanged.

A shop layout as shown in the figure is possible for with the work-clamp pallet 3, 3A or 3B of the present invention it is possible to shut down the oil path 51 of the hydraulic clamping devices 6 by means of the shut-off valve 54 or 54A to transfer it with the hydraulic pressure therein maintained as well as to have the works 5 clamped thereon machined.

CLAIMS

1. A work-clamp pallet for a machine tool composed of a base block, a plurality of hydraulic clamping devices, an oil path and a shut-off valve, wherein

said base block is provided with a positioning means for positioning said base block longitudinally and laterally with respect to a work table of a machine tool, a clamping means for clamping said base block to said work table and a work-clamping face for setting works thereon,

said each hydraulic clamping device is composed of a hydraulic cylinder secured to said work-clamping face and a clamping block connected to the front end of a piston rod of said hydraulic cylinder,

said clamping block is driven by said hydraulic cylinder so as to shift between a clamping position where it acts to clamp said work and an unclamping position where it relieves clamping,

said oil path communicates with each of hydraulic oil rooms of said hydraulic cylinders,

said shut-off valve has its valve box secured to said base block, its secondary port is connected

with the beginning end of said oil path, its hydraulic pressure inlet on its primary port side is adapted to be disconnectably connectable with a hydraulic pressure outlet of a hydraulic pressure supply device, and

with said hydraulic pressure inlet connected with said hydraulic pressure outlet for hydraulic pressure to be supplied to said hydraulic rooms of said hydraulic cylinders and after subsequent disconnection of said hydraulic pressure outlet from said hydraulic pressure inlet, said oil path is shut down by means of said shut-off valve so as to preclude any fall of hydraulic pressure in said hydraulic oil rooms.

2. A work-clamp pallet as claimed in claim 1, wherein said base block is that of said work-clamp pallet for a vertical machine tool, is made of a thick, rectangular steel plate and the topside of said thick plate constitutes said work-clamping face.

3. A work-clamp pallet as recited in claim 1, wherein said base block is that of said work-clamp pallet for a horizontal machine tool, is formed as a box-like frame and on at least one of the sides of said box-like frame constitutes said work-clamping face.

4. A work-clamp pallet as recited in any of claims 1 to 3 wherein said clamping means of said base block includes T-sectioned grooves provided in the underside of said base block.

5. A work-clamp pallet as claimed in any of claims 1 to 4, wherein said positioning means consists of a pair of engaging holes for positioning provided in the underside of said base block.

6. A work-clamp pallet as claimed in any of claims 1 to 5, wherein said hydraulic cylinder of said hydraulic clamping device is provided within said base block perpendicular to said work-clamping face, the inner end of an auxiliary piston rod is disconnectably connected to the outer end of its piston rod and said auxiliary piston rod is arranged to extend beyond said work-clamping face.

7. A work-clamp pallet as claimed in any of claims 1 to 5, wherein a clamping unit proper with said hydraulic cylinder of said hydraulic clamping devices built therein is fixed securely on said work-clamping face and said unit work positioning faces are provided extending beyond and perpendicular to said work-clamping face, and said piston rods of said hydraulic cylinders are arranged to be driven forward and back with respect to said unit work-positioning face substantially parallel to said work-clamping face.

8. A work-clamp pallet as claimed in any preceding claim, wherein said hydraulic cylinder of said hydraulic clamping device is a single-acting hydraulic cylinder of spring restitution type.

9. A work-clamp pallet as claimed in any preceding claim, wherein said hydraulic cylinder of said hydraulic clamping device is a double-acting hydraulic cylinder.

10. A work-clamp pallet as claimed in any preceding claim, wherein said shut-off valve is a seat valve with its valve core urged against a valve seat by a valve-closing spring so as to inhibit back-flow of hydraulic oil from its secondary port towards its primary port, and a valve-opening means is provided for opening said valve.

11. A work-clamp pallet as claimed in claim 10, wherein a seating face of said valve core is made of a synthetic resin material.

12. A work-clamp pallet as claimed in claim 11, wherein said valve seat is formed as an annular protrusion.

13. A work-clamp pallet as claimed in any preceding claim, wherein said hydraulic pressure inlet in said shut-off valve is formed as a joint of self-seal coupling.

14. A work-clamp pallet as claimed in any preceding claim, wherein said base block is provided with a hydraulic pressure fall preventing device and its pressure accumulating oil room communicates with said oil path.

15. A work-clamp pallet as claimed in claim 14, wherein said hydraulic pressure fall preventing device is a spring-type accumulator.

16. A work-clamp pallet as claimed in claim 14 or 15, wherein said base block is provided with a hydraulic pressure abnormal fall detecting actuator and its hydraulic oil room for detection communicates with said oil path.

17. A work-clamp pallet as claimed in any preceding claim wherein said hydraulic pressure supply device is an external hydraulic pressure supply device independent of said work-clamp pallet.

18. A work-clamp pallet as claimed in any preceding claim, wherein said hydraulic pressure supply device is a pneumatically-driven type hydraulic pressure supply device which operates on the supplied pneumatic pressure to generate a hydraulic pressure and said base block is provided with this hydraulic pressure supply device with its pneumatic pressures inlet adapted to be disconnectably connectable with a pneumatic pressure outlet of an external pneumatic pressure supply device.

19. A work-clamp pallet substantially as hereinbefore described with reference to and as illustrated in the accompanying drawings.

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