# DESCRIPTION OF *the* HYDRAULIC SHAPER

Unit 1-T52(A) Part II Pages 33 to 46

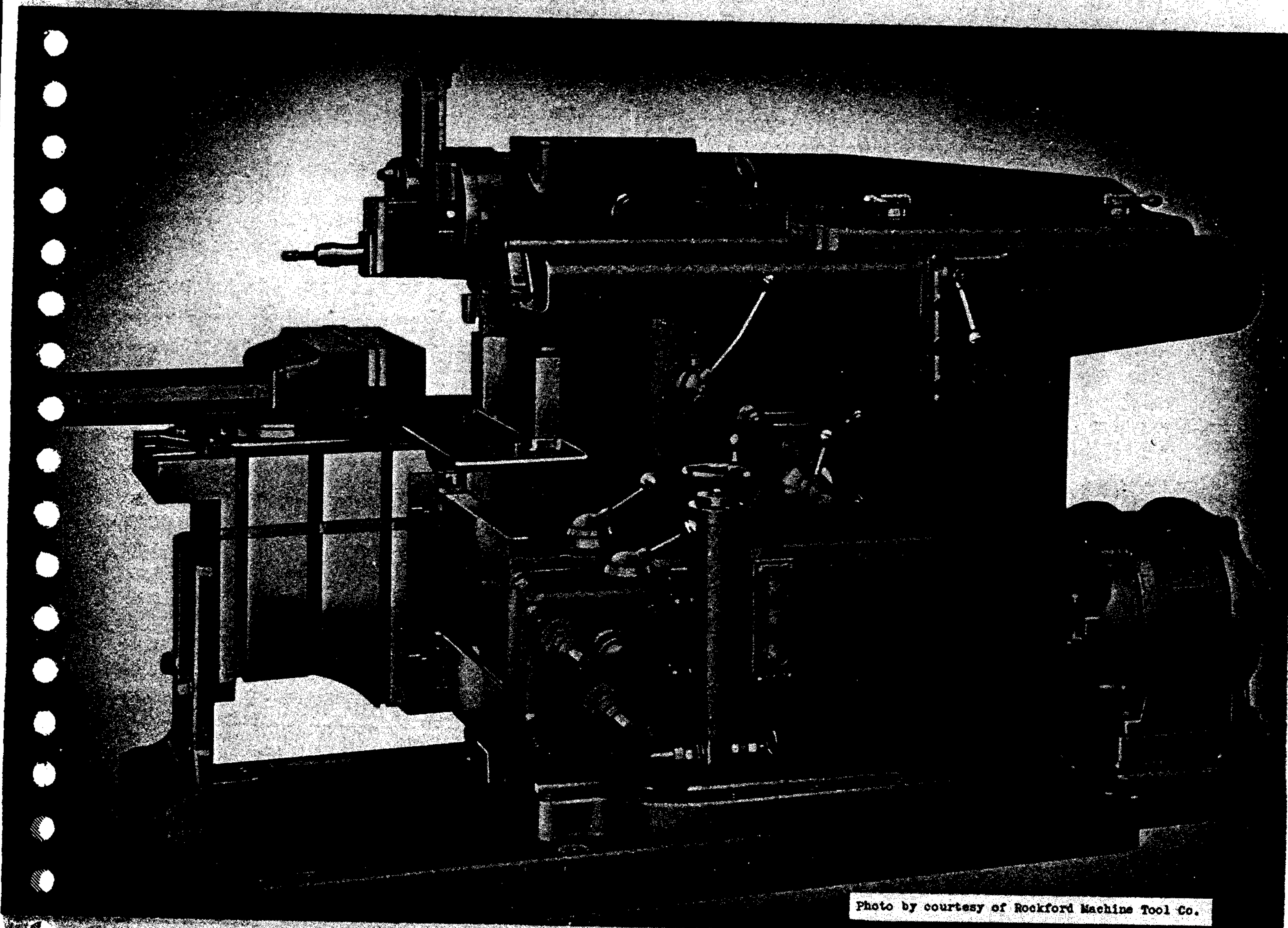


Photo by courtesy of Rockford Machine Tool Co.

UNIVERSITY OF THE STATE OF NEW YORK
STATE EDUCATION DEPARTMENT
BUREAU OF INDUSTRIAL AND TECHNICAL EDUCATION

# DESCRIPTION *of the* HYDRAULIC SHAPER

## OBJECTIVES OF UNIT

1. To point out wherein the hydraulic shaper differs from the crank shaper.

2. To describe parts and units which are common to the hydraulic shaper and its hydraulic system.

3. To indicate the function of such parts and units.

### INTRODUCTORY INFORMATION

Crank shapers and hydraulic shapers differ very little in their outward appearance and in their general construction. The main difference lies in the means used to move the ram backward and forward. The mechanism for actuating the ram on the crank shaper has been described in the previous section; that used on the hydraulic shaper, which operates on an entirely different principle, will be described in this section. Its operation is based on Pascal's law which, in brief, states that a fluid confined to a pipe or other enclosure will transmit applied pressure equally in all directions and to every surface to which it extends.

In the hydraulic shaper the ram receives its reciprocating motion from a piston which is moved backward and forward in a cylinder under the ram by a flow of oil from an electrically driven pump. The oil, under pressure, acts against opposite ends of the piston, alternately, and causes the ram to reciprocate, since it is connected with the piston.

Several valves, each designed for a specific purpose, form a part of the hydraulic system used to operate and control the shaper. One valve, manually operated, starts and stops the shaper; another, mechanically operated, regulates the length of the ram stroke. A third one, whose operation is entirely automatic, controls the volume and regu-

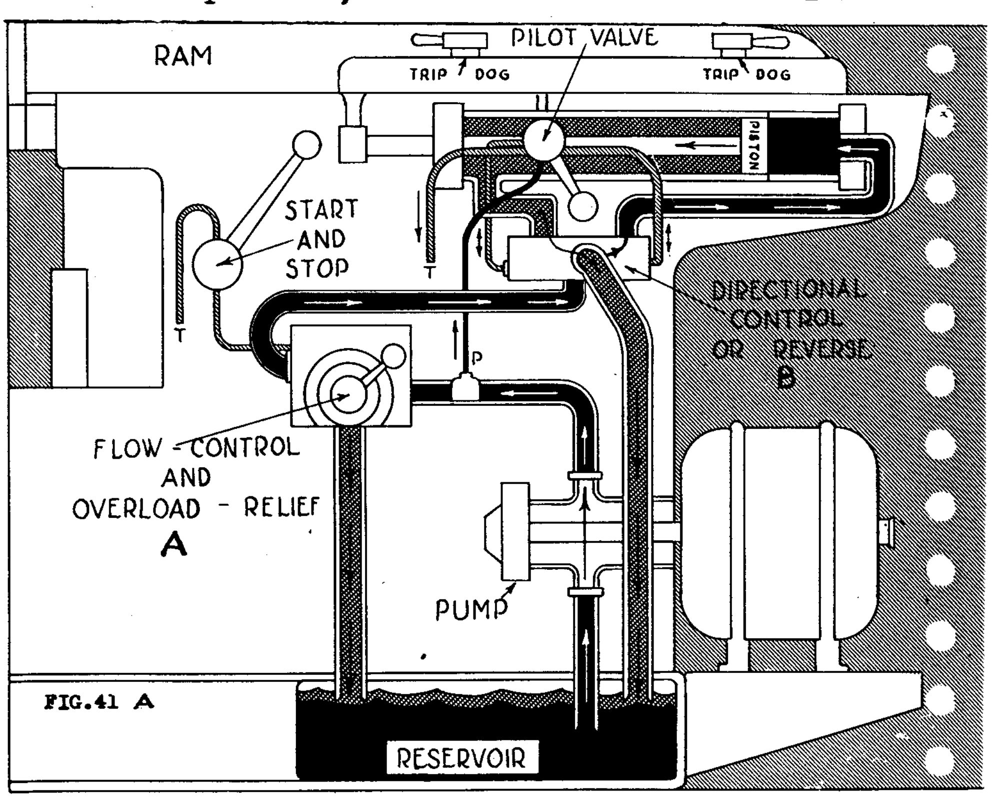



FIG.41 A

lates the pressure of the oil admitted to the hydraulic system. A fourth valve not only automatically directs the flow of oil to alternate ends of the ram cylinder, but also directs it back to the reservoir. Moreover, both the ram and the automatic feeding mechanisms operate hydraulically on shapers equipped with this type of driving unit.

## DESCRIPTION OF A HYDRAULIC UNIT

The hydraulic unit employed to drive a machine tool usually has been supplied by a manufacturer who specializes in this type of equipment and adapts it to the requirements of a particular machine, such as a metal shaper in this instance. The unit comprises a high-pressure pump, usually electrically driven, for circulating the fluid, and valves for controlling its pressure, its volume, and its direction of flow.

It also includes pipes and fittings which connect these parts and make of them a complete circuit wherein the fluid is drawn from the reservoir, directed to the cylinder under pressure, and then returned to its original source (in the reservoir) after the energy it conveys has been exerted on the piston for such time as is required for the ram to complete its forward or return stroke.

The illustrations in Fig. 41 show how a simple hydraulic circuit functions on a shaper. All pipes conveying fluid to the piston, that is, all pipes carrying fluid under high pressure, have been shown in black, whereas those which return the fluid to the reservoir have been shown in gray; the arrows indicate the direction of the flow.

Illustration A indicates the course of the fluid during the forward stroke of the ram. The fluid drawn from the tank by the pump, passes through the combination flow-control and relief valve A and on to the directional-control valve B. From here, it has been directed to the right-hand end of the cylinder, causing the piston and the ram connected thereto to move to the left. At the same time, that is, as the piston moves to the left, it expels fluid from the head-end of the cylinder and returns it to the supply tank by way of the directional-control valve.

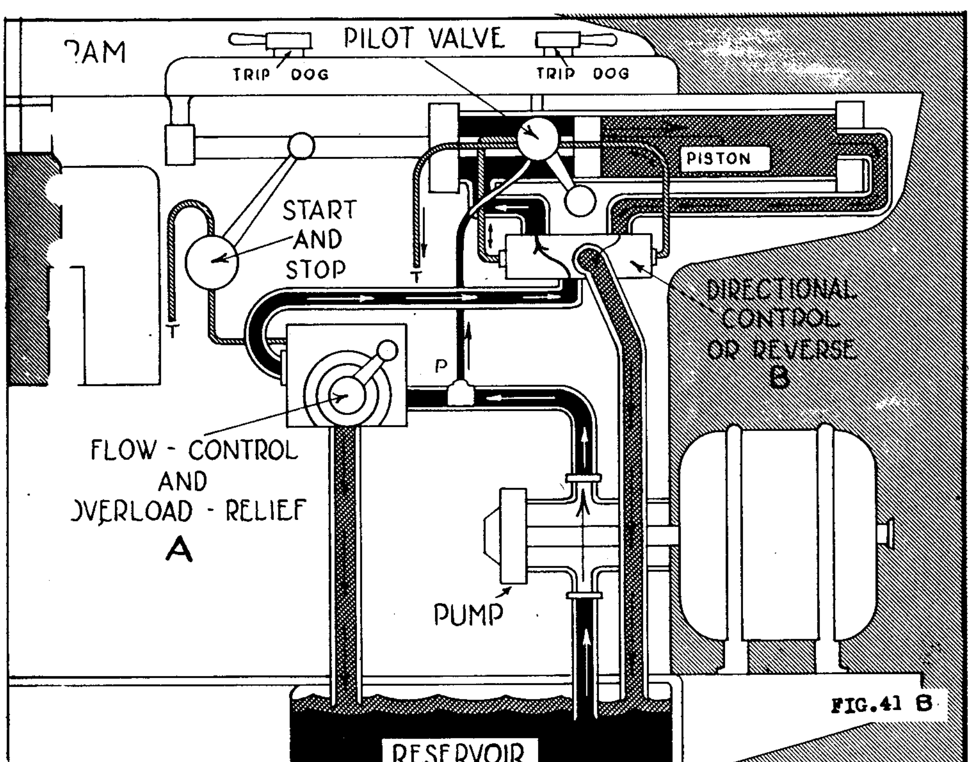


FIG.41 B

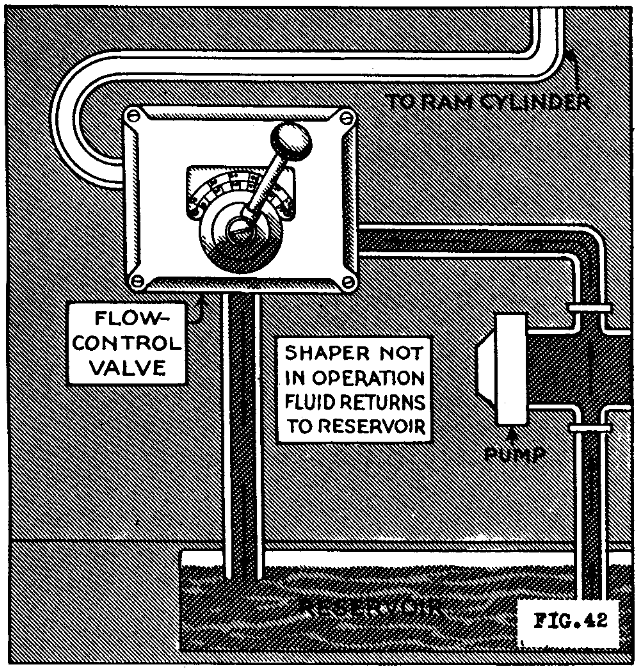


FIG. 42

Similarly, in Fig. 41 B, the pipes shown in black depict the course of the fluid during the return stroke of the ram. Now, by means of the directional-control valve, the fluid under high pressure has been directed, not to the right-hand end as before, but to the left-hand end of the cylinder, thereby reversing the direction of the piston travel and causing the ram to move to the right. As it is forced to the right, the piston ejects the fluid from this end of the cylinder, causing it to return to the tank.

When the shaper is stopped for one reason or another, the pump, which is usually of the constant-delivery type, continues to pump the usual volume of oil. Since the oil is not now being utilized to drive the shaper, it must be disposed of in another manner. This is a function of the flow-control valve (Fig. 42) which operates automatically in conjunction with the start-and-stop lever. This valve opens wide, and the oil returns directly to the reservoir instead of going to the ram cylinder as it does when the machine is in operation.

Briefly, this explains how the hydraulic unit functions. The manner in which the individual parts or units perform their functions will be explained in greater detail under their own headings.

## DESCRIPTION OF THE PUMPS

The pump, whether driven electrically or by means of a belt, is usually operated at a constant speed calculated to assure the delivery of fluid in sufficient volume and at sufficient pressure to exceed slightly the maximum demands which may be imposed upon it by the machine of which it has become a part.

Three types of pumps are used more or less commonly for this purpose. They are the gear pump, the vane pump, and the plunger pump, illustrated in Figs. 43 to 46. Each design has features and advantages which make its selection desirable, and each type is made in sizes to fit various working conditions.

The gear pump and the vane pump are known as constant-delivery pumps. As the name indicates, they will deliver a specified amount of fluid at a constant pressure as long as their speeds remain constant.

Since the output of these pumps, regulated by their speeds, has been calculated to equal or exceed slightly the maximum amount of fluid they will be called upon to deliver during heavy operations and at high machine speeds, it follows that for lighter operations and slower speeds these pumps will deliver considerably more fluid than is actually required. When this condition arises, a relief valve connected to the hydraulic system automatically diverts the excess fluid to the reservoir instead of to a pipe leading to the machine drive.

In contrast with the constant-delivery pumps, the plunger pump of the design shown in Fig. 46 permits the amount of fluid delivered to the hydraulic system to be varied. This is accomplished, not by changing its speed of rotation nor by diverting part of its output by means of a relief valve, but rather by regulating the amount of reciprocating movement imparted to its plungers.

A brief description of each type of pump follows. In design and construction they vary considerably, but each will perform creditably if used under conditions for which it has been designed.

## THE GEARED PUMP

This is a type of rotary pump which employs gears with intermeshing teeth for pumping the fluid. The construction of this pump is simple, its only moving parts being the gears. Although spur gears have been used successfully in these pumps, gears with helical teeth result in quieter operation, especially when rotating at the faster speeds required to maintain high pressure in the hydraulic system.

In operation, the gears revolving in the direction indicated by the arrows create a partical vacuum in the space marked V in the gear case. The suction thus created and the atmospheric pressure in the oil reservoir force the fluid into the pump chamber through the intake.

As the revolving gears pass the intake, the fluid fills the spaces between the teeth. The fluid, confined between the outer pump casting and the spaces between the gear teeth, is then carried to the opposite side of the pump chamber and ejected at the outlet. The volume of fluid pumped and the pressure

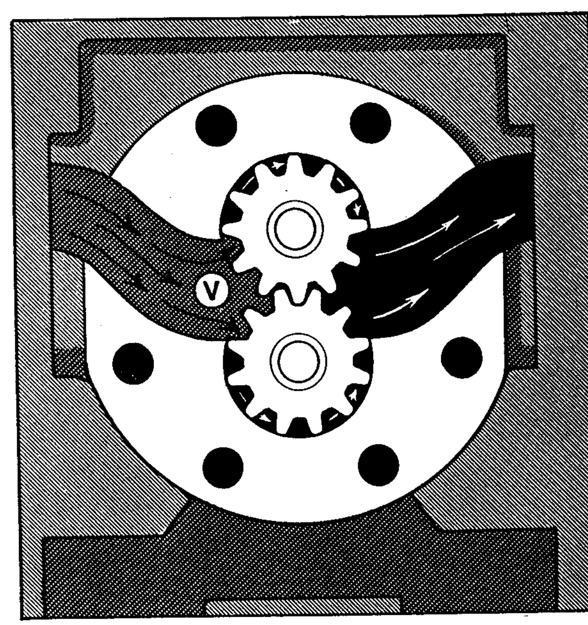
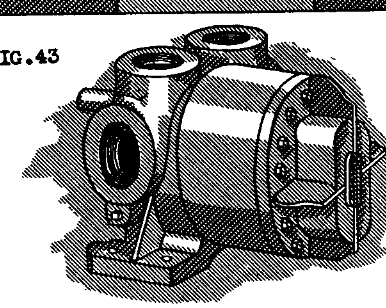



FIG.43



at which it enters the hydraulic system, depend largely on the speed of the gears.

Pumps of this design perform very satisfactorily when connected directly to an electric motor. When the pump speed resulting from this type of drive is too fast, a speed-reduction unit may be used between the motor and the pump.

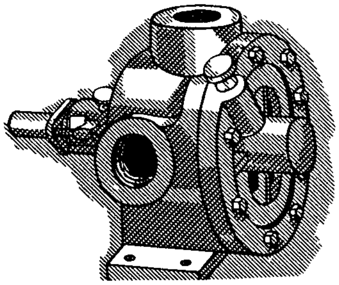
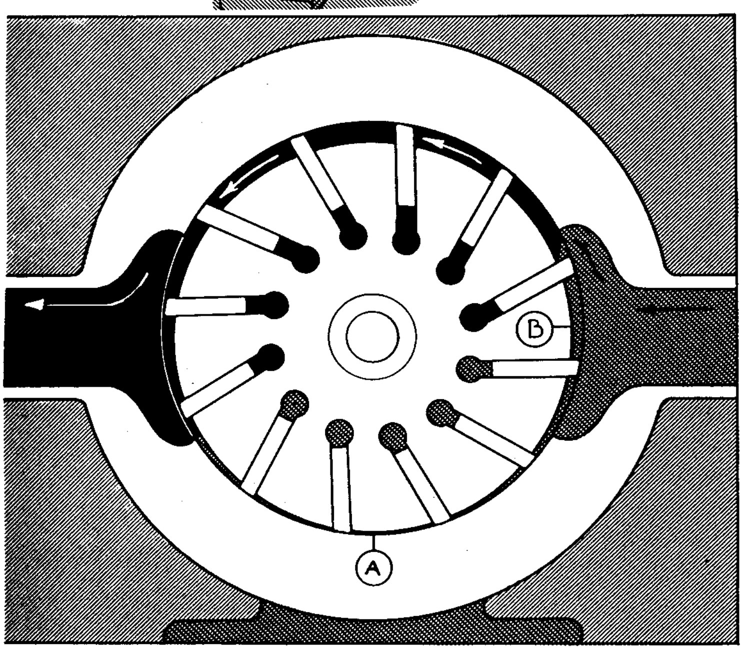


FIG.44




## THE VANE PUMP

The vane pump is also a rotary pump of the constant-delivery type, but instead of gears it employs a rotor equipped with vanes for pumping the fluid. Its principle of operation is quite similar to that of the geared pump, in that the vanes create a partial vacuum in the pump chamber, as do the gear teeth in the geared pump. Similarly, the spaces between the vanes, like those between the teeth in the geared pump, confine the fluid and cause it to be carried from the intake to the exhaust port for ejection into the hydraulic system.

In design and operation, however, the vane pump differs from the geared pump. The vane pump utilizes a rotor with slots in its periphery into which have been fitted vanes which move radially, that is, vanes which slide toward or away from the center of the rotor during its rotation.

The radial movement of the vanes which, combined with the rotary motion of the rotor, is responsible for the functioning of the pump, may be induced by various forms of pump construction. In Fig. 44, for example, the pump chamber is round and the shaft and rotor have been located off center for this purpose. The centrifugal force set up by the revolving rotor and the pressure of the fluid within the pump chamber cause the vanes to slide outward in their slots and hug the surface of the pump chamber. Since the rotor is off center and practically touches the pump body at point A, the vanes are forced into their slots when they are carried past this point. Then, continuing its rotation in a counterclockwise direction from A, each vane gradually emerges from its slot and in so doing enlarges the space B directly behind and thereby creates a suction in this part of the pump chamber.

For obvious reasons, the intake port has been located at this place in the pump chamber also, and the fluid, having been forced into the space between vanes by atmospheric pressure, is then carried around the pump chamber by the vanes and expelled through the exhaust port.

The exhaust port is located opposite the intake port and in that section of the pump chamber in which the action of the vane in its slot is the reverse of its action at the intake port; that is, instead of moving out in its slot, the vane now begins to recede in its slot. This movement, combined with its rotary movement toward point A, causes the space between the pump chamber and the rotor in which the fluid has been trapped, to become smaller gradually, leaving the fluid no alternative but to enter the exhaust port.

Fig. 45 illustrates a type of pump used with the shaper shown on page 33. This is another form of vane-pump construction wherein the rotor is located centrally in the pump chamber, instead of off center, and the radial movement of the vanes in their slots is controlled by the contour of the ring. Instead of being round, the ring opening has been elongated at points O to form two opposing pumping chambers.

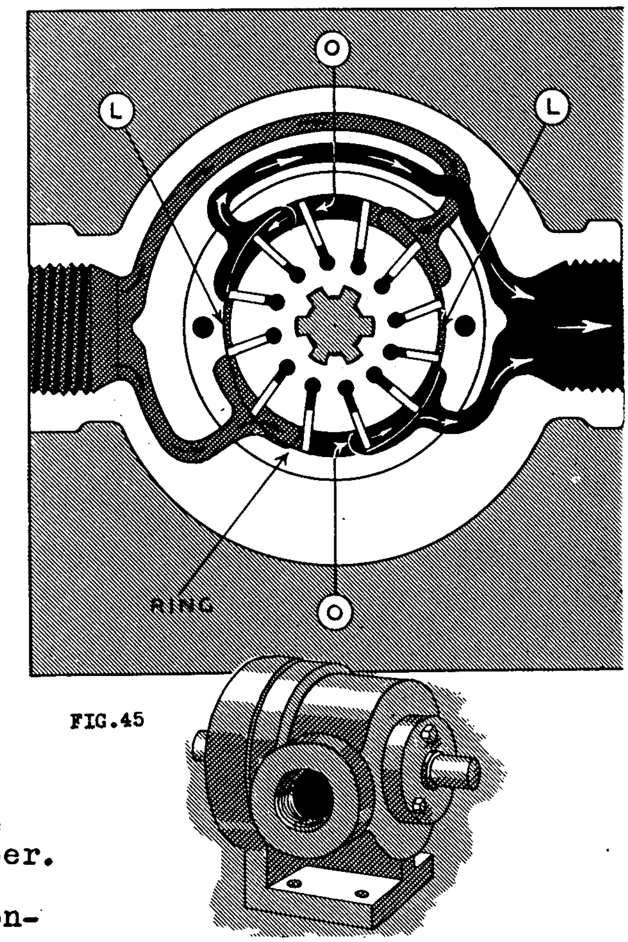


FIG.45

The shape of the ring opening causes the vanes to function twice for each turn of the rotor. The vanes are forced into the slots at L and centrifugal force and pressure back of the vanes immediately move them out again and keep them in contact with the ring after they pass these points.

The intake and discharge of fluid occur through ports in side-valve plate bushings located on each side of the pump chamber. The valve openings connect with two intake and two exhaust ports, one of each being required for each pump chamber.

These pumps function well when directly connected to an electric motor. They rely on valves to control the volume of the fluid which is delivered to the ram cylinder when the entire output of the pump, calculated to meet the maximum demand, is not required. The alternate method, that of changing the speed of the pump as more or less fluid is required, is usually impracticable.

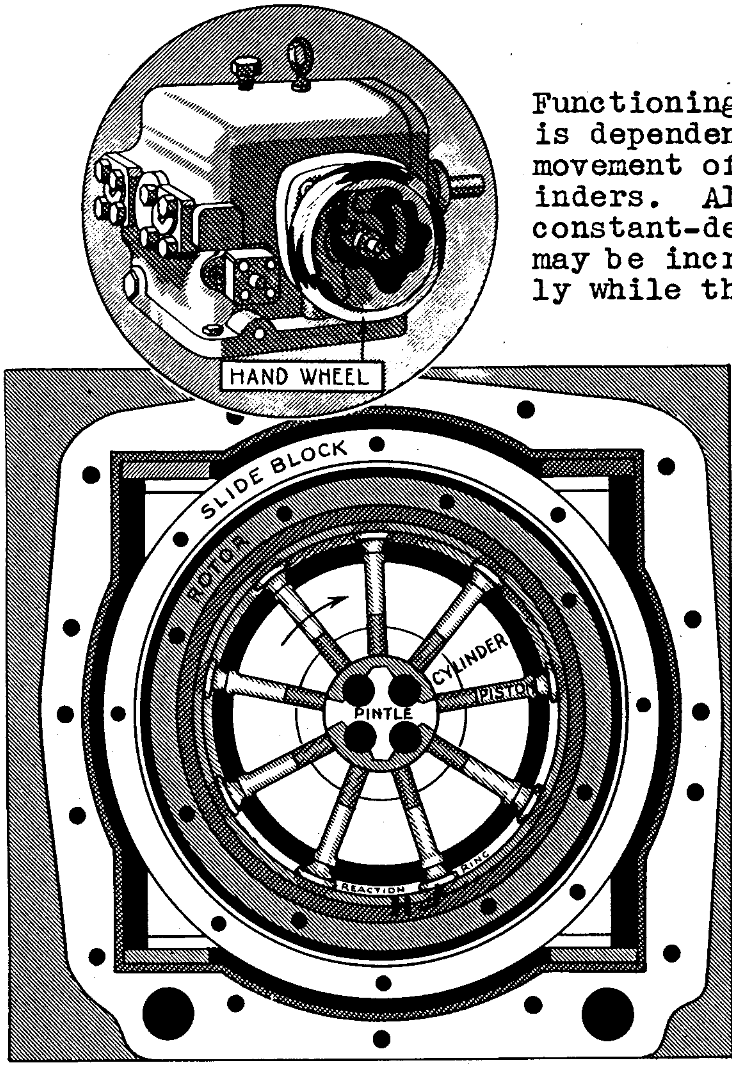



FIG.46

## THE PLUNGER PUMP

Functioning of the plunger pump shown in Fig. 46 is dependent upon the reciprocating (in-and-out) movement of the plungers or pistons in their cylinders. Although pumps of this type are made in constant-delivery models also, one whose output may be increased or decreased, or stopped entirely while the pump is in motion, will be described. Pumps of this kind are known as variable-displacement pumps.

Fig. 46 shows the interior of such a pump and indicates the relationship one part bears to another when the pump is in neutral, that is, when the pump, even though it is in motion, delivers no fluid. In this position all parts are centrally located around the shaft or pintle.

From the center shaft on out, the parts are these: the cylinder, which revolves on the stationary pintle; the pistons, which revolve with the cylinder; the reaction ring, which forms an integral part of the rotor and revolves as a unit; and the slide block, which may be moved to the left or to the right within the pump casing.

With the pump in motion, and the parts in the position shown in Fig. 46, the cylinder revolves about the stationary pintle, and obviously carries the pistons around with it.

As a result of the centrifugal force set up by the rapidly revolving cylinder, the pistons move out radially and are forced into continuous contact with the reaction ring. At the same time, of course, the reaction ring and the rotor are caused to revolve also.

Inasmuch as the reaction ring comes in contact with the piston on one side of its conical head only H, each piston is given a slow partial rotation in its bore, in one direction during one half of the revolution of the cylinder and a partial turn in the opposite direction during the other half revolution.

In addition to the movements already imparted to the pistons, rotary by the cylinder and oscillating by the reaction ring, the pistons must be given a reciprocating (in-and-out) movement in their cylinders if the pump is to deliver fluid.

In the pump illustrated, this is accomplished by moving the unit comprised of the slide block, the rotor and the reaction ring from its position on center, shown in Fig. 46, to its position to the left of center, shown in Fig. 47, or to any intermediate position between these settings. The handwheel in Fig. 46 controls the movement of the slide block sideways.

Since the shaft or pintle is immovably located in the center of the pump casing, shifting the slide block to the left or to the right brings the reaction ring closer to the cylinder on one side and creates a proportionately larger opening on the opposite side. Then, as the cylinder revolves, the pistons move out during one part of a revolution and are forced into their cylinders during the other part.

During their rotation in the lower half of the revolution, the pistons (1-4 in Fig. 47) move out of their cylinders progressively farther, create a suction and draw fluid into their cylinders as they pass over the openings in the underside of the pintle. This fluid, coming from the intake, has been shown in gray. Arrows indicate the direction of its flow.

During their rotation in the upper half of the revolution, the pistons (5-9 in Fig. 47) are forced into their cylinders gradually by the reaction ring and discharge the fluid as they pass over openings in the upper surface of the pintle. The fluid being discharged (shown in black) is under high pressure.

Obviously then, the amount of fluid which a pump of this type delivers, is governed by the distance the reaction ring has been moved off center, for this determines the distance each piston moves in its cylinder and thus controls the amount of fluid which is admitted to each cylinder.

If the slide block and rotor unit are moved to the right in the pump case, the function of the pistons during each half revolution of the cylinder is reversed, and the pistons (5-9) passing over the opening in the upper surface of the pintle, draw in fluid; those (1-4) passing over the openings in the lower surface of the pintle, discharge fluid.

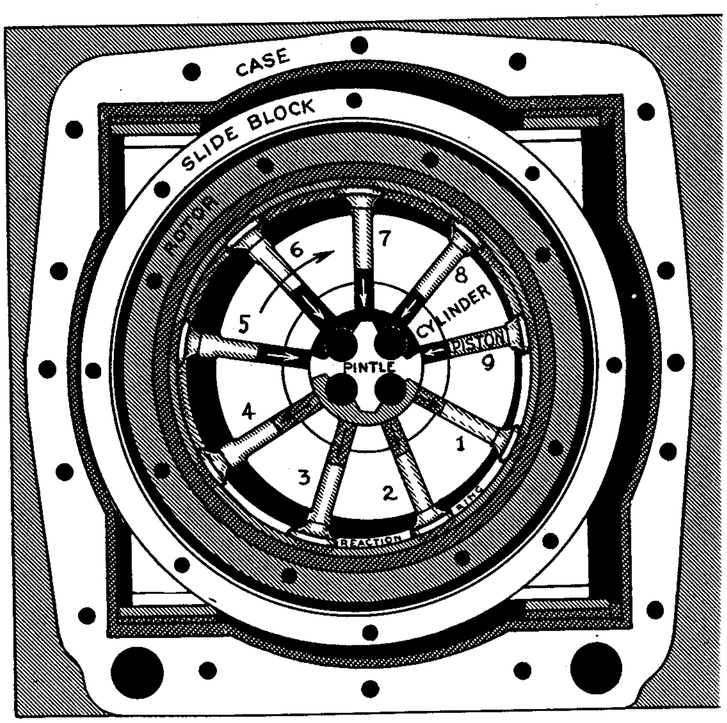



FIG. 47

## DESCRIPTION OF THE VALVES

Several valves employed to control the direction of the oil and to regulate its pressure and volume after it leaves the pump, have been described below. The valves have been named and their approximate positions in a hydraulic system for a shaper have been indicated in Figs. 41. These valves are of the plunger or piston type.

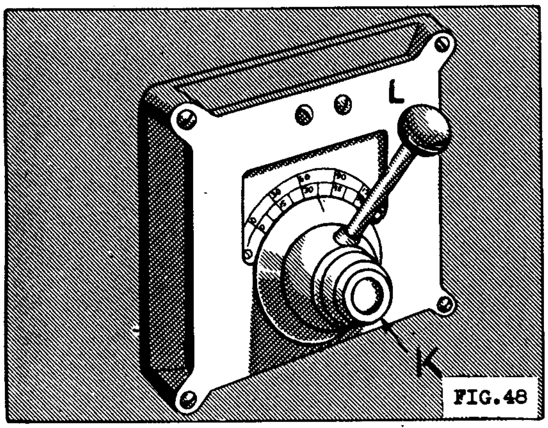


FIG.48

### THE FLOW-CONTROL AND OVERLOAD-RELIEF VALVE

This is the first valve through which the fluid passes after it leaves the pump. It performs a dual function. First, as a relief valve, it protects the hydraulic system from overloads by limiting the maximum system pressure. For the machine shown, a working pressure of eight hundred pounds per square inch has been recommended, and the valve has been adjusted to open when the pressure developed in the system reaches this figure.

Second, as an automatic flow-control valve, it automatically selects from the fluid coming from the pump that portion which will be allowed to enter the hydraulic system, and that unneeded portion which will be by-passed and returned to the reservoir directly.

In this shaper the speed-control dial (Fig. 48 ) has been made a part of the volume-control valve, inasmuch as the speed of the machine depends upon the volume of fluid permitted to act on the piston under the ram.

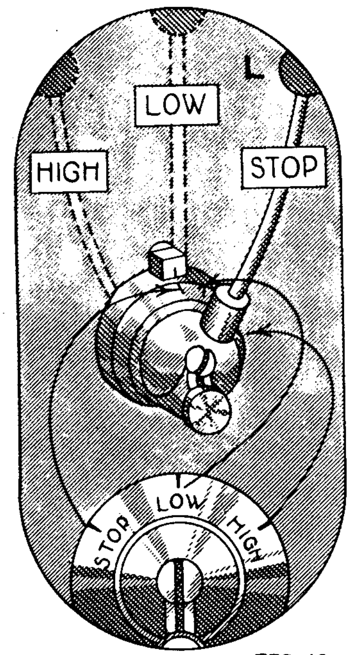


FIG.49

Lever L controls the volume adjustment of this valve, and its position in relation to the speed-control chart determines and indicates the cutting speed in feet per minute of the ram. Movement of the lever to the left reduces the volume of oil permitted to pass to the ram cylinder and results in a corresponding decrease in ram speed. Conversely, movement of the lever to the right increases the speed of the ram by increasing the flow of oil to its cylinder.

This valve operates to control the pressure and also regulates the volume by by-passing excess fluid, that is, by diverting fluid from the port it would normally enter if needed, to another port which returns it to the reservoir.

### THE START-AND-STOP VALVE

The start-and-stop valve (Fig. 49) is operated by lever L which controls both starting and stopping of the shaper. The location of the valve on the shaper and the position it occupies in the hydraulic system have been indicated on the illustration in Figs. 41. This valve, manipulated by lever L, exercises control over the shaper by actuating and working in conjunction with the flow-control and overload-relief valve to which it is connected with pipes.

With lever L in its "Stop" position, pressure on one side of the otherwise balanced control piston within the flow-control valve, is dropped to atmospheric pressure by allowing fluid to flow back through the start-and-stop valve and on to the tank. This causes the overload-relief valve to open wide and allows the entire pump delivery to discharge back to the reservoir at low pressure until shifting of lever L to an operating position stops the escape of fluid through the valve to which it is connected.

With lever L in one of its operating positions — either "Low" or "High" —, the flow-control valve, instead of diverting fluid, directs it to the ram cylinder in amounts automatically controlled by the position of the speed-control lever on its adjacent speed-control dial, as explained in the section above.

THE DIRECTIONAL-CONTROL OR REVERSE VALVE

The directional-control valve has been placed between the flow-control valve and the ram cylinder (Refer to Figs. 41 for its location in the hydraulic system.) for the purpose of changing the direction of the flow of oil from one end to the other of the ram cylinder in order to induce the ram to reciprocate. This valve receives fluid from the flow-control valve where its volume, as determined by the position of the speed-control lever, and its pressure as well, have been regulated automatically.

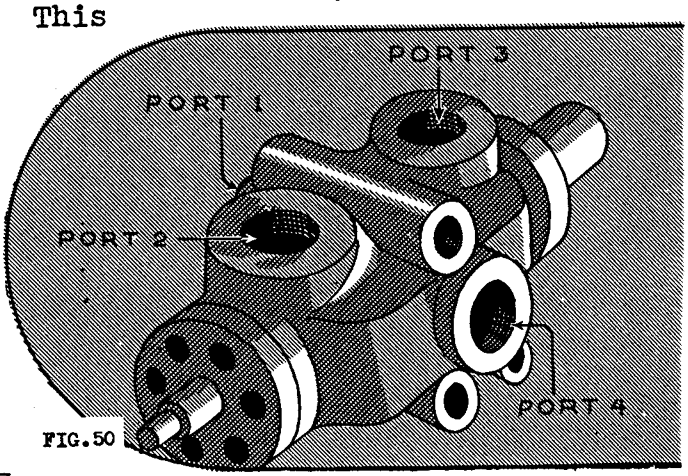


FIG. 50

This valve (Fig. 50), known as a four-way valve, has four threaded openings or ports which connect with various members of the hydraulic system by means of pipes. Port 1 at the rear, used as an intake port only, admits oil from the pump; port 4, used as an exhaust only, emits oil and returns it to the reservoir; ports 2 and 3, connected to the left- and right-hand ends of the ram cylinder, respectively, serve in both capacities. For example, when port 2 serves as an intake port and port 3 serves as an exhaust (Fig. 51) then the ram moves to the left, and when the functions of these ports become reversed, then the ram moves to the right.

In Fig. 52, the piston within the valve has been moved to the left. In this position the space between its lands forms a connection between the intake (port 1) and port 2 which now becomes an exhaust port. Oil entering the valve chamber under high pressure through port 1 now leaves the valve through port 2, enters the ram cylinder from the left and causes the ram to move to the right.

Furthermore, No. 3 now becomes an intake port, receiving oil forced from the right-hand end of the ram cylinder and directing it through channels C and D to exhaust port 4 to be returned to the reservoir. This indicates the course of the oil through the valve during the return stroke of the ram.

This valve, like most valves used in a hydraulic system, is of the piston or plunger type, and although different makes of valves vary somewhat in construction, all of them function in much the same manner as the one described here. In the valve shown in Fig. 51 a sliding piston of circular cross section controls the passage of oil from the intake to a selected exhaust port by routing it through interconnected channels or grooves within the valve chamber.

The piston, instead of being of one diameter throughout its entire length, has been reduced somewhat in its center section to permit a connection between adjacent ports and channels, lands $L_1$ and $L_2$ serving to block channels to which fluid should not be admitted. For example, in Fig. 51, the piston has been moved to the right within the valve chamber. With the piston in this position, oil under pressure enters the valve chamber through channels connected with port 1 in the rear, passes through the space between the lands of the piston, goes on to the opening leading to port 3, and then passes through pipes to the right-hand end of the ram cylinder, causing the ram to move to the left.

Meanwhile, oil draining from the left-hand end of the ram cylinder enters the valve at port 2, and, because of land $L_1$ on the piston, must pass through channels A and B, and then to port 4 which is connected with the reservoir. The oil follows this course during the cutting stroke of the ram.

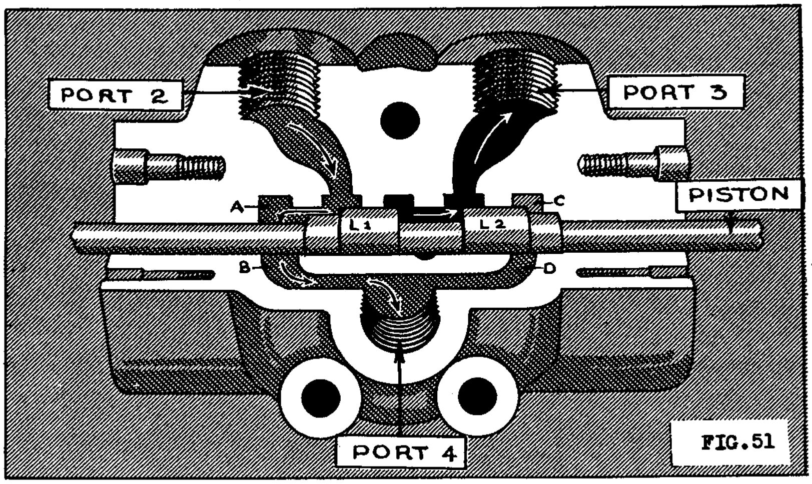



FIG.51

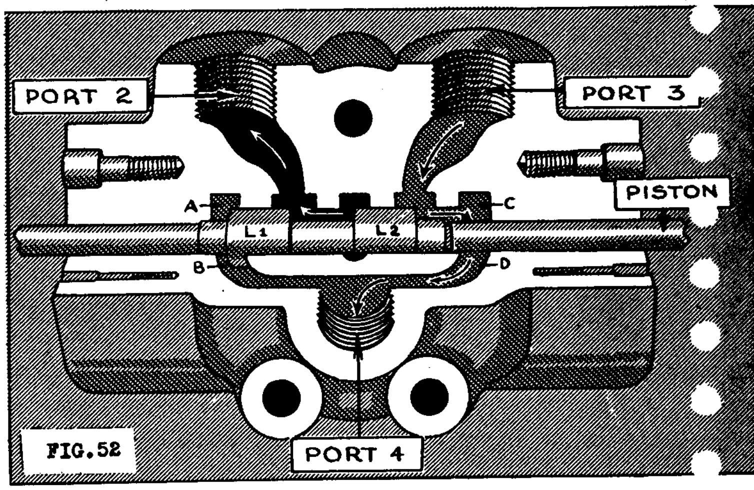



FIG.52

THE PILOT VALVE

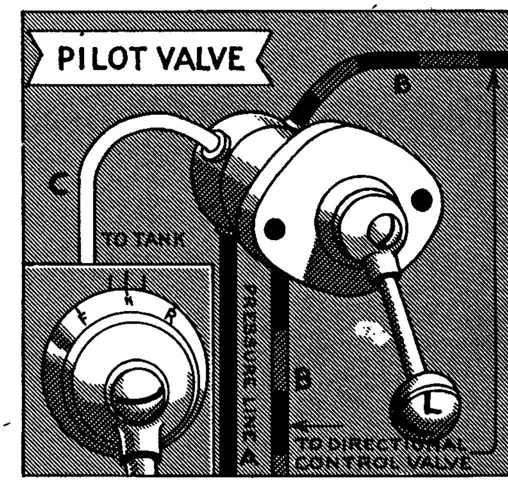


FIG.53

The pilot valve, located under the ram, is actually a small valve used to actuate the larger reverse valve which controls the movement of the ram. Although it may be operated manually by shifting lever L whenever the ram travel must be reversed quickly, it is usually operated mechanically by the two trip dogs on the ram. These govern both the length of the stroke and its position relative to the work.

As they move back and forth with the ram, the trip dogs give a partial rotation to a projection on the pilot valve at alternate ends of the ram stroke. This action releases a comparatively small amount of oil from one side or the other of the piston in the reverse-valve chamber, causing the pressure to drop automatically. As a result of the unequal pressure on one side, the piston is forced to change its position relative to the valve ports which connect with the ram cylinder as previously explained and illustrated.

The pilot valve exercises its control over the reverse valve by means of four small pipes which connect it with the hydraulic system: one to the high-pressure line A; one each B to the right and left ends of the reverse valve to permit dropping the pressure on one side or the other of its piston; and, finally, one C to the reservoir to carry off the small amount of oil released from the reverse valve. (Refer to Fig. 53.)

When the shaper is in operation, fluid whose pressure has been regulated by the setting of the relief valve and whose volume has been determined by the position of the speed-control lever, passes from the pump to the directional-control valve.

Oil under high pressure leaves the directional-control valve, enters one end of the ram cylinder and exerts its pressure on the ram piston until the pilot valve, actuated by one of the trip dogs, causes a reversal of the flow of oil through the directional-control valve and a corresponding reversal in ram movement. Oil which has spent its energy is in the meantime discharged from the ram cylinder under low pressure and returned to the reservoir for recirculation.

DESCRIPTION OF THE POWER CROSS FEED

The power cross feed moves the table intermittently in a horizontal direction at the beginning of each ram stroke. In the hydraulic shaper a piston-type valve, operated by hydraulic pressure, actuates the feed mechanism which in turn causes the cross-feed screw to make a partial revolution for each stroke of the ram.

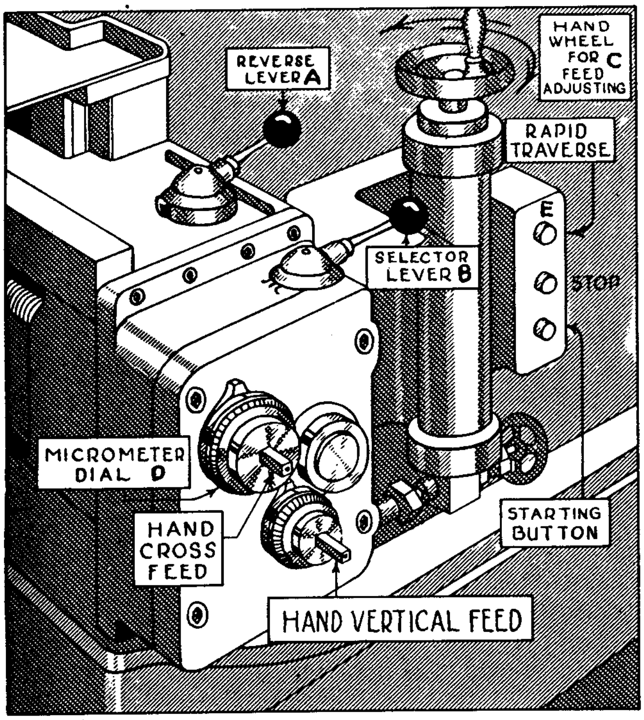



FIG. 54

Levers A and B, Fig. 54, control both the automatic cross and vertical feeds. The beveled edge on lever B, called the selector, bears the words "Cross" and "Vertical." They refer to the feed which may be selected by moving lever B in one direction or the other from its "Off" position.

The beveled edge of lever A, known as the directional-control lever, bears the words "Forward" and "Reverse," alluding to the direction of the cross feed for the table. Lever A also bears the words "Up" and "Down," referring to the vertical power traverse of the cross rail on the column.

The handwheel C is turned to obtain the amount of feed desired for each stroke of the ram. The amount of cross feed obtained may be read on the micrometer dial D on the cross-feed screw.

## DESCRIPTION OF POWER RAPID TRAVERSE

An electric motor mounted on the back of the cross rail on the operator's side of the shaper, furnishes the power for rapid traverse of the table.

The operation of rapid traversing is much the same as the operation of the regular feed, but there is one important exception. In addition to the cross power traverse, vertical power traverse is also available. In other words, the reverse lever A, Fig. 54, determines the direction (toward or away from the operator) of the horizontal traverse; likewise, it determines the direction (up or down) of the vertical traverse. The position of selector lever B determines whether the movement of the table is to be horizontal or vertical, depending on whether the word "Cross" or "Vertical" on the hub of the lever is moved to the reference mark.

Push button E controls the motor for power rapid traverse. The table will continue to traverse in the direction previously set while the push button is depressed. Traverse will stop immediately when pressure on the button is released.

When a change in the direction of the rapid traverse is desired, the traverse motor must be stopped before the reverse lever is shifted to the direction desired. This latter precaution must be carefully observed. If it is not observed, the reverse clutch may be damaged.