July 3, 1951 H. F. PHILLIPS 2,559,369

TRANSFER MECHANISM

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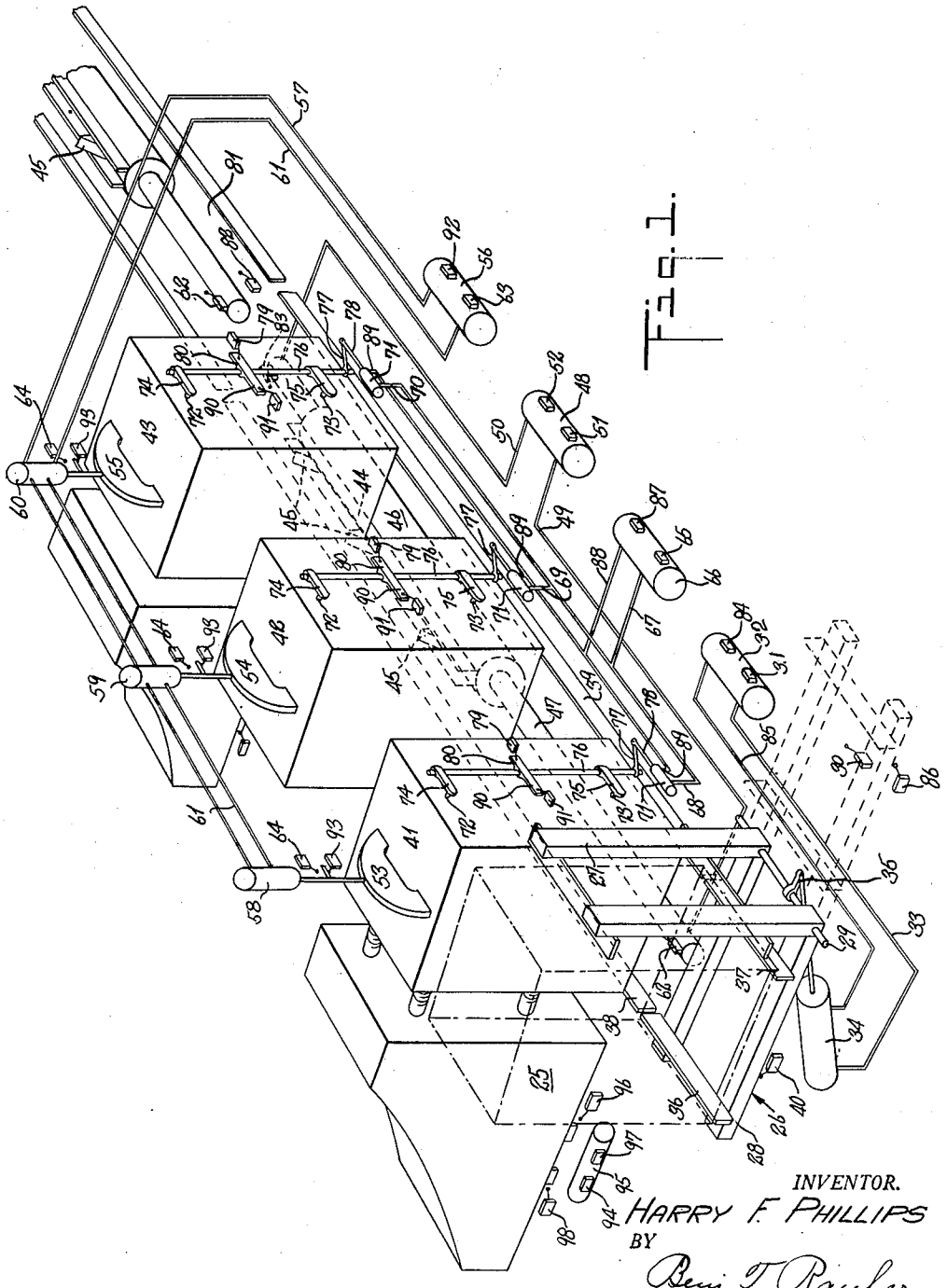


Fig. 1.

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TRANSFER MECHANISM

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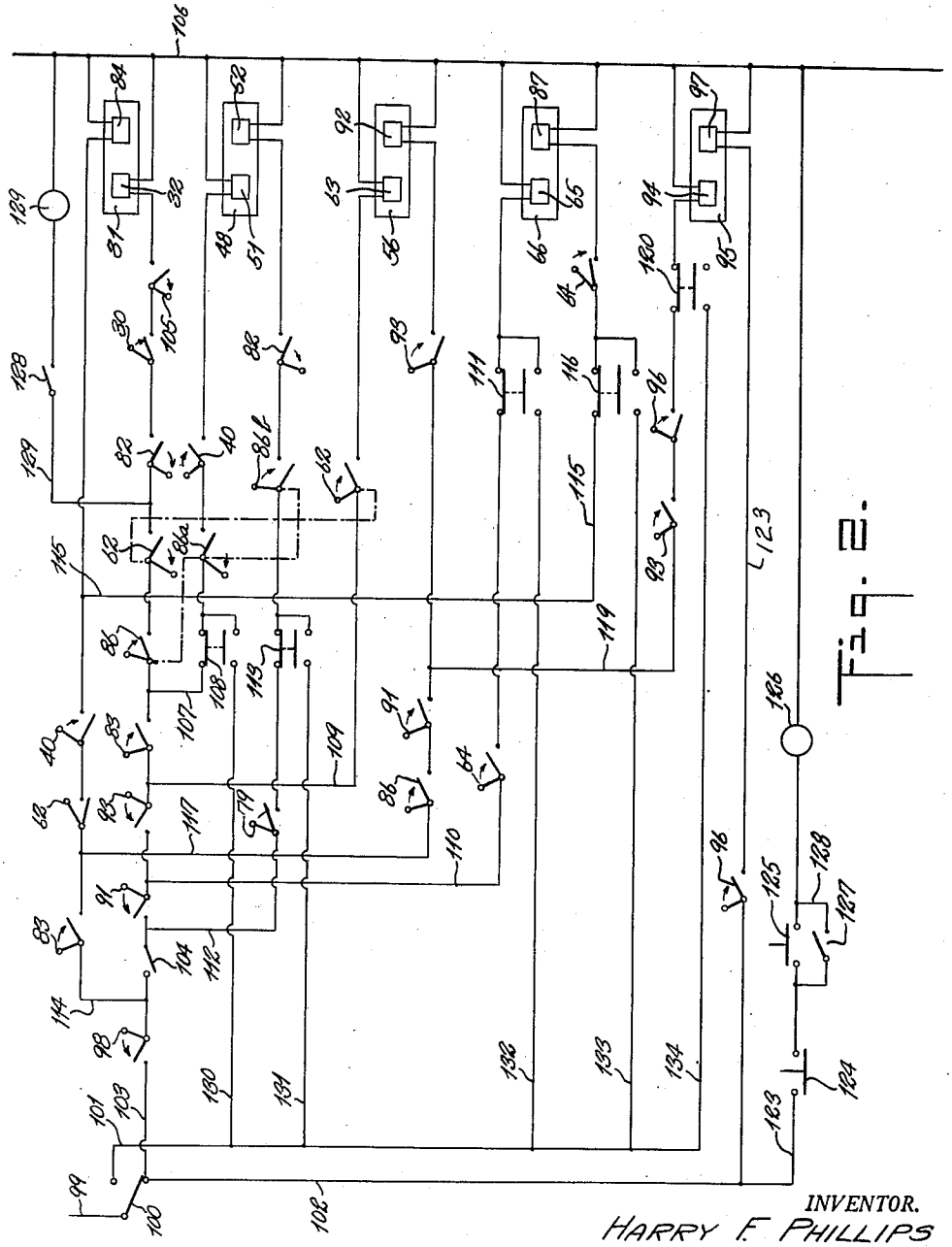


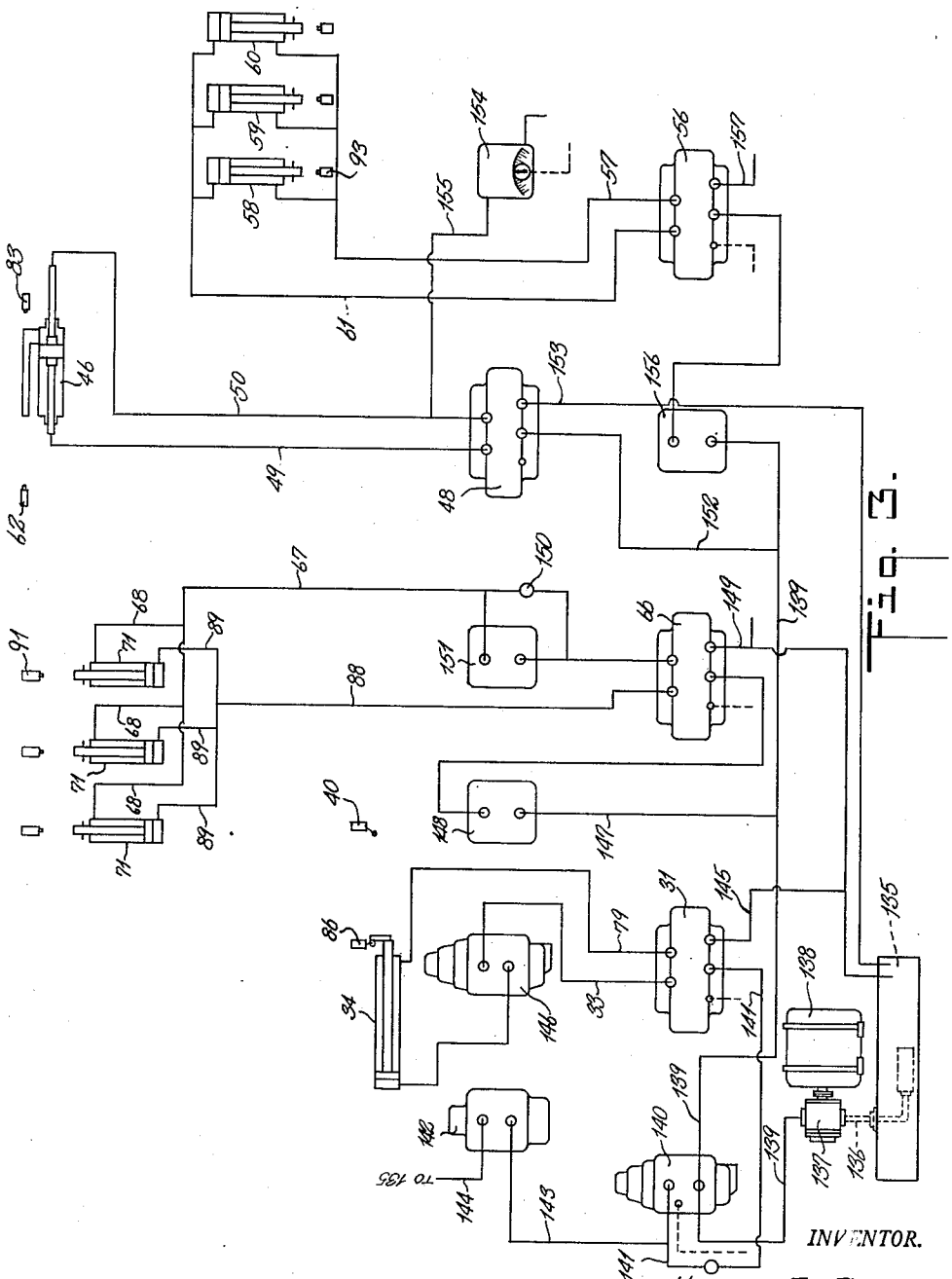
Fig. 2.

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July 3, 1951 H. F. PHILLIPS 2,559,369

TRANSFER MECHANISM

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TRANSFER MECHANISM

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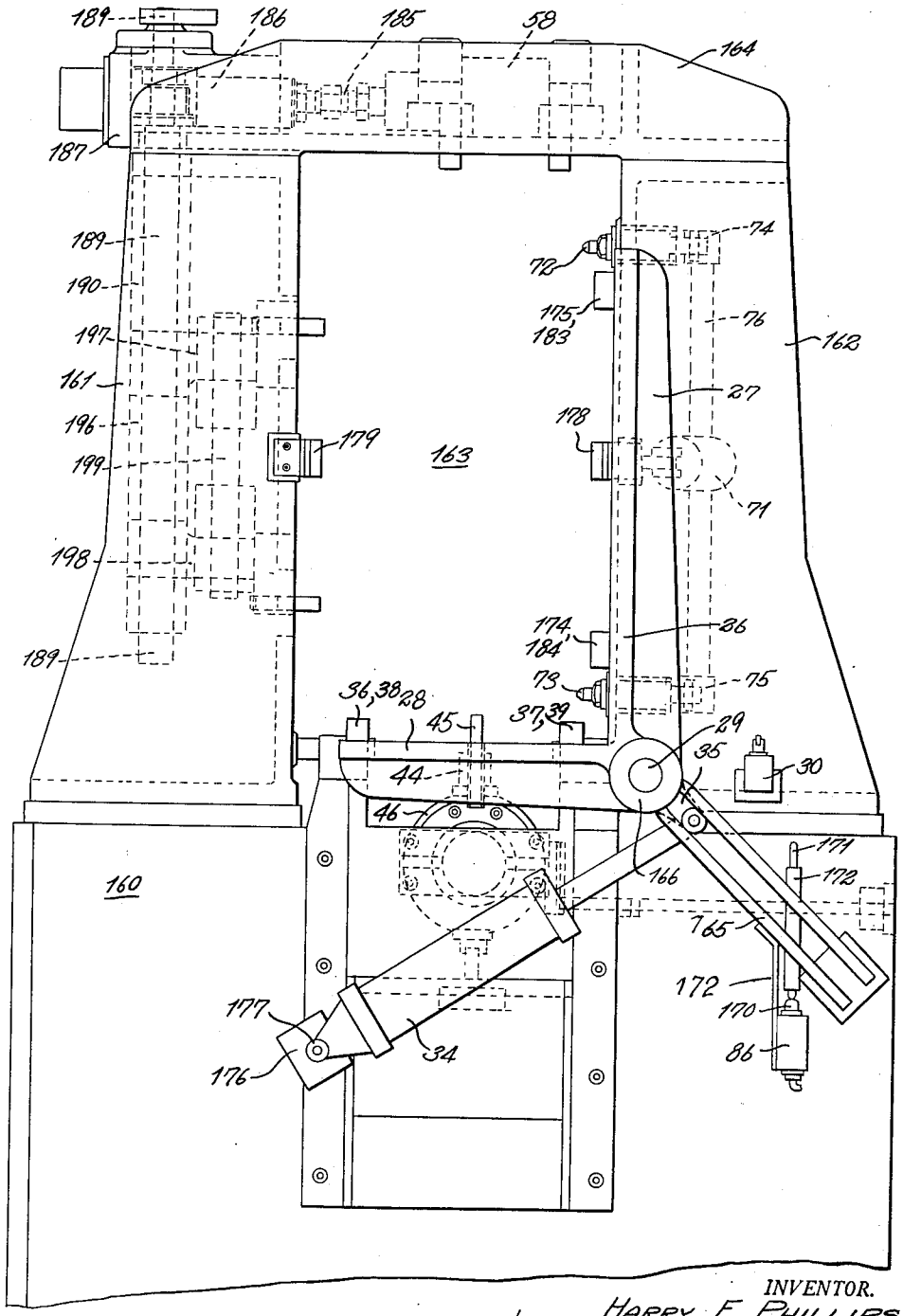


Fig. 4.

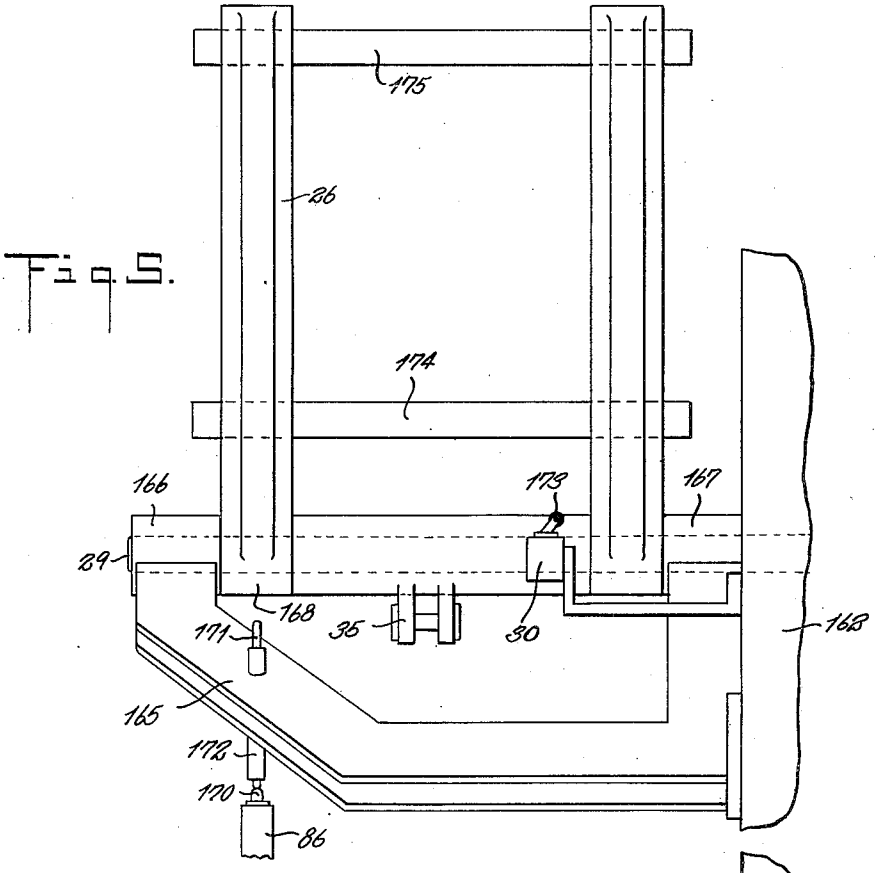
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July 3, 1951 H. F. PHILLIPS 2,559,369

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Fig. 5.



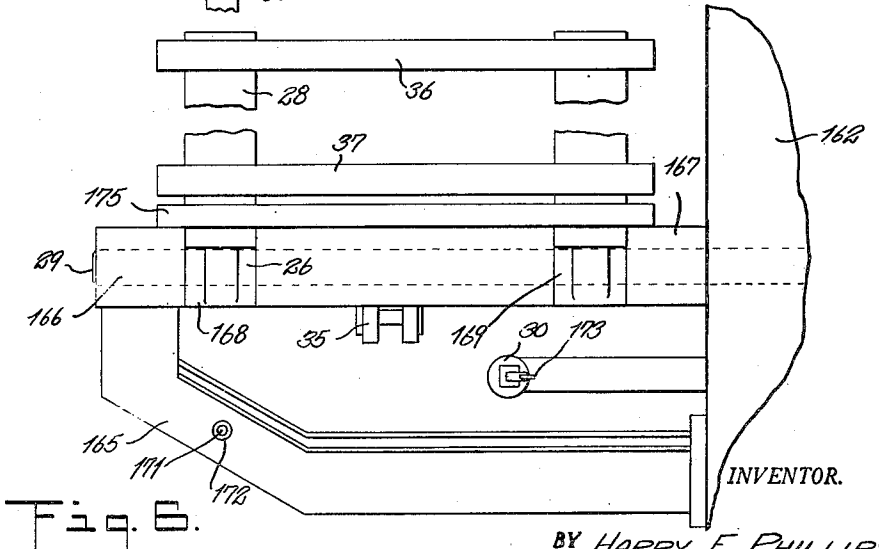


Fig. 6.

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TRANSFER MECHANISM

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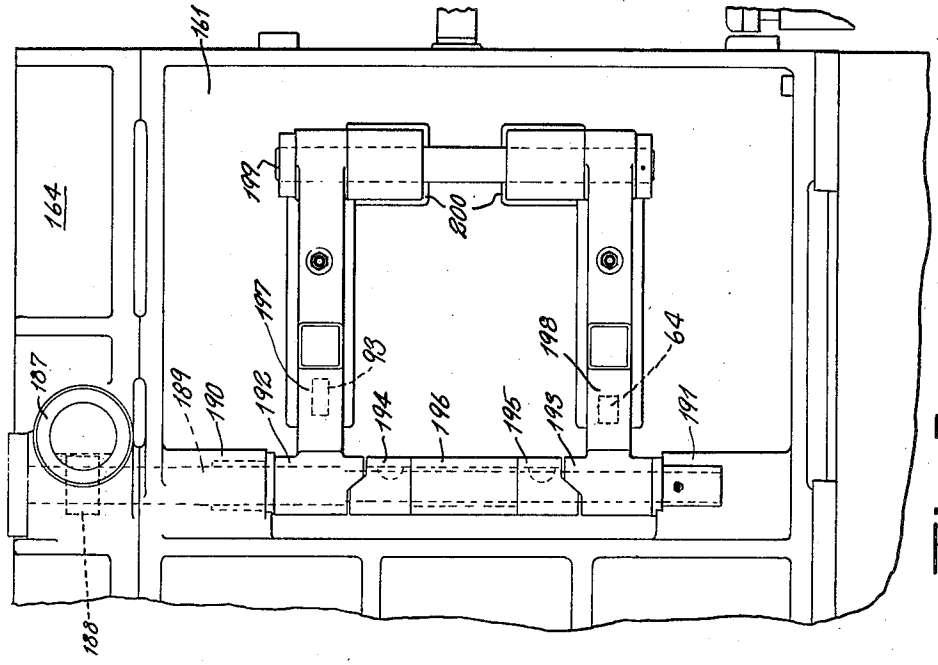


Fig. 8.

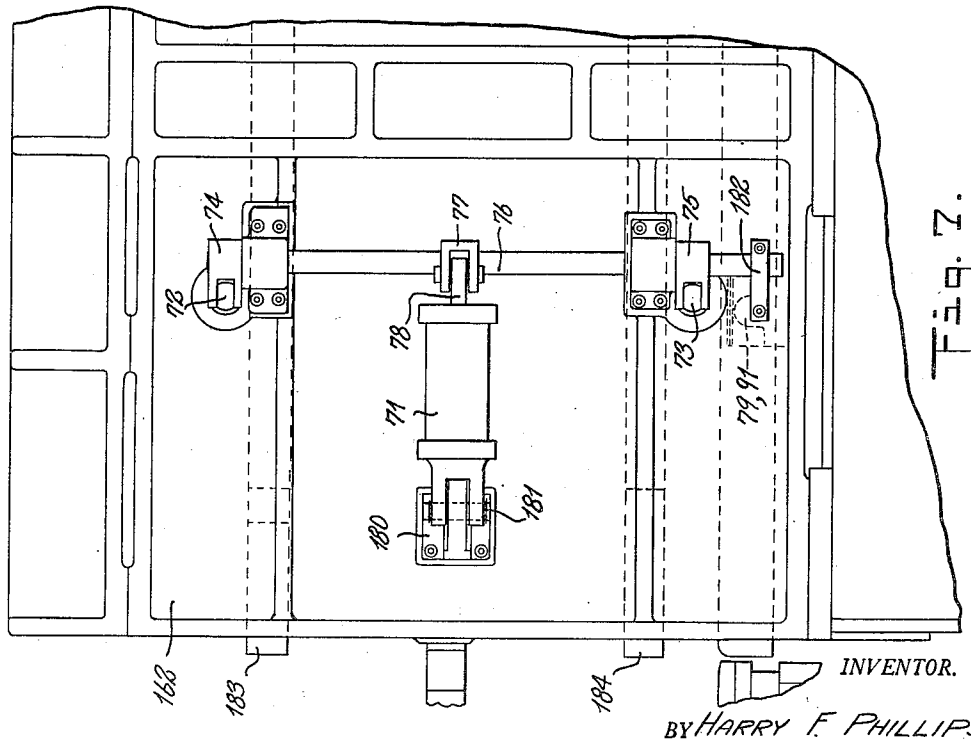


Fig. 7.

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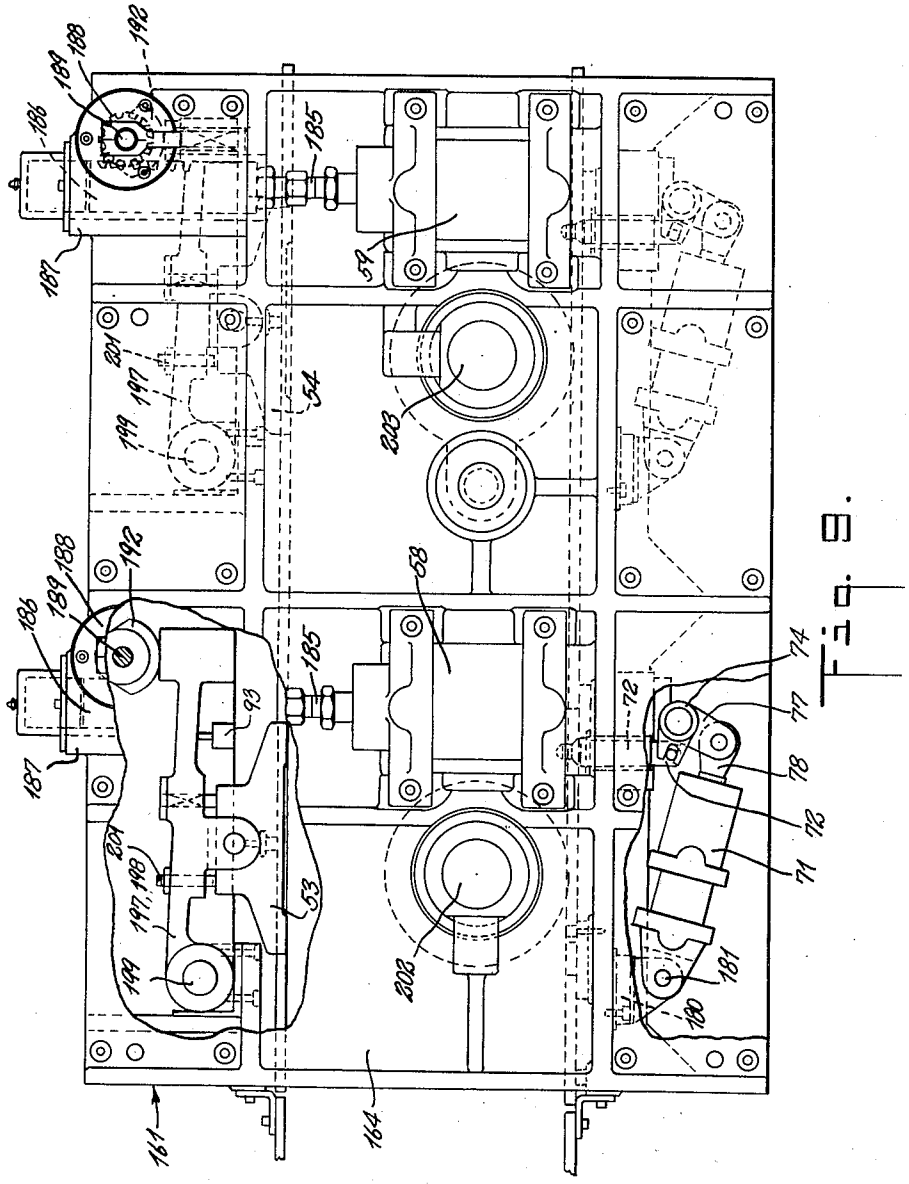


FIG. 7

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TRANSFER MECHANISM

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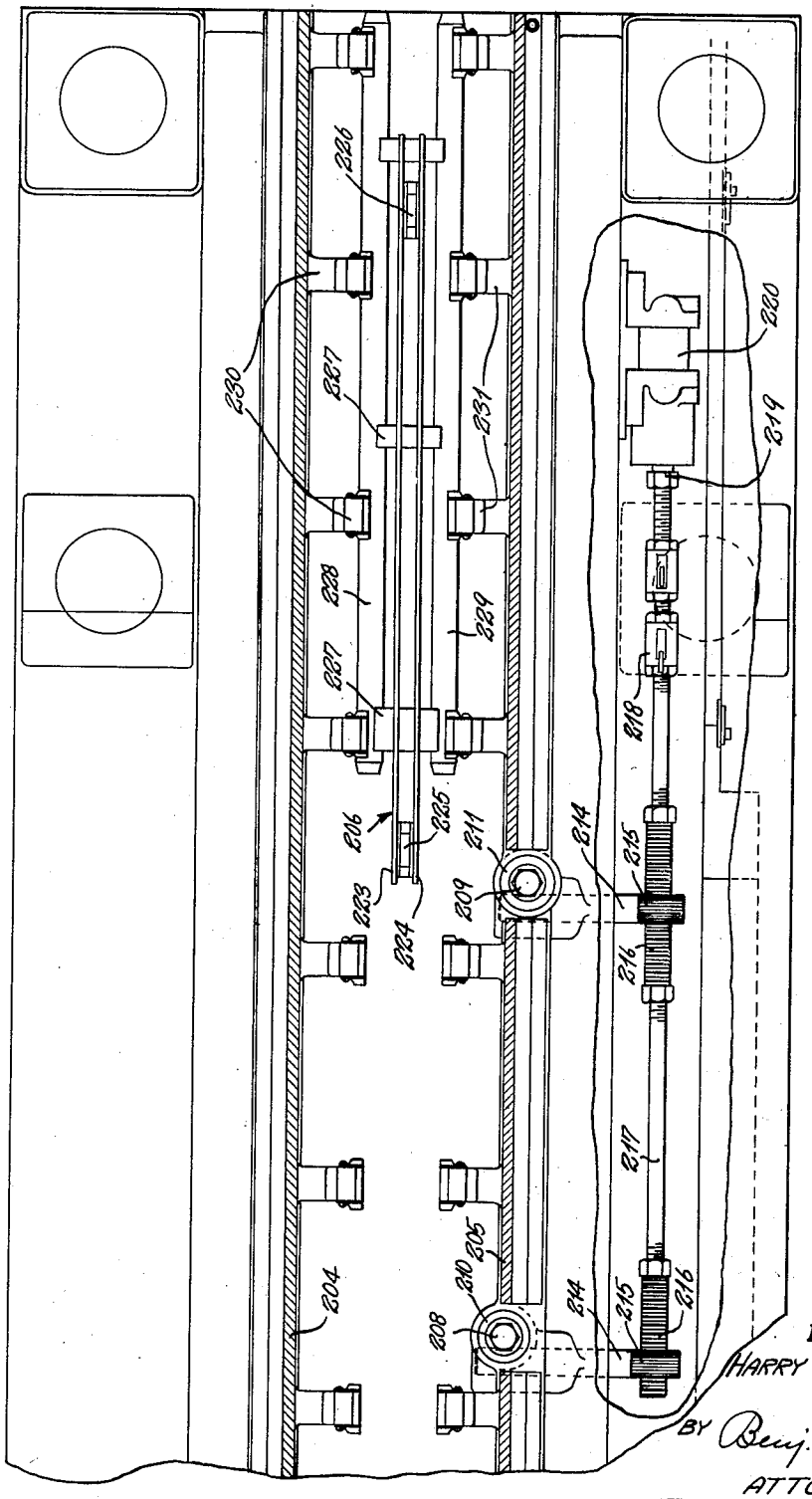


Fig. 10.

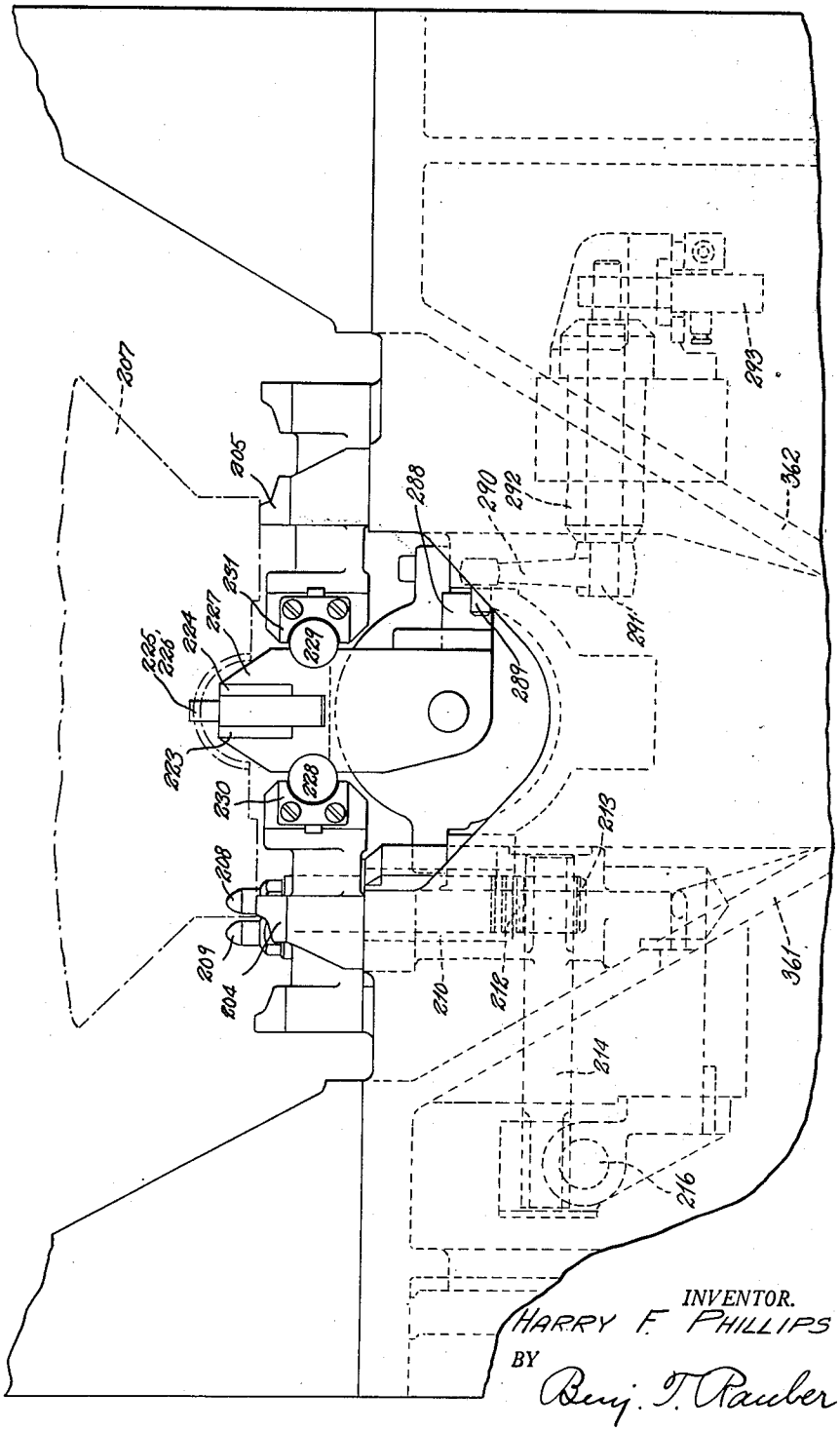
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TRANSFER MECHANISM

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Fig. 11.



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TRANSFER MECHANISM

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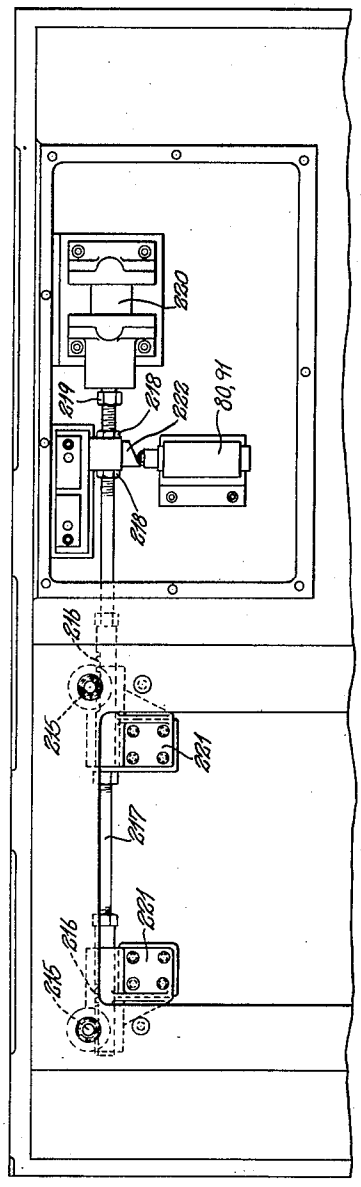


Fig. 12.

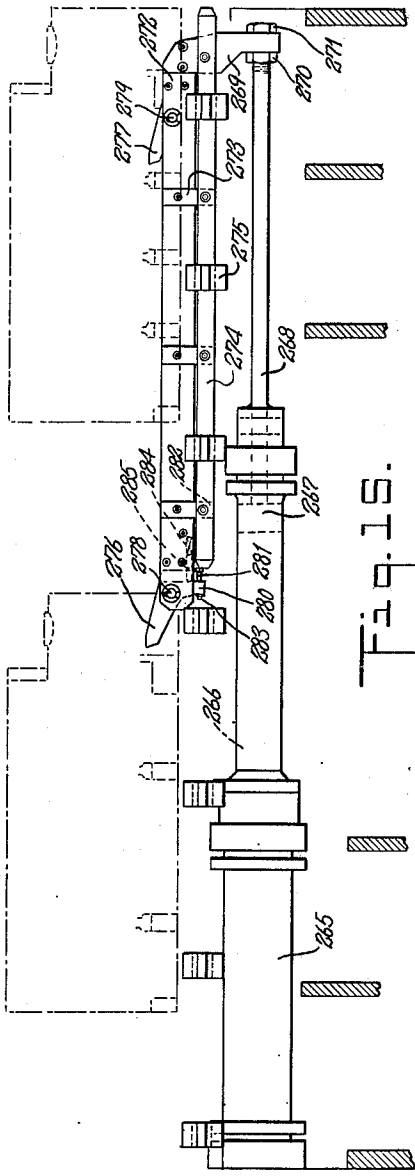


Fig. 15.

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TRANSFER MECHANISM

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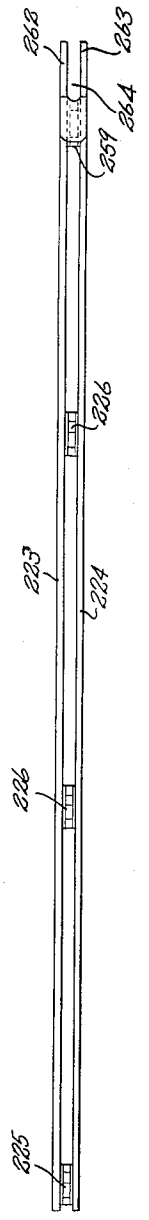


Fig. 13.

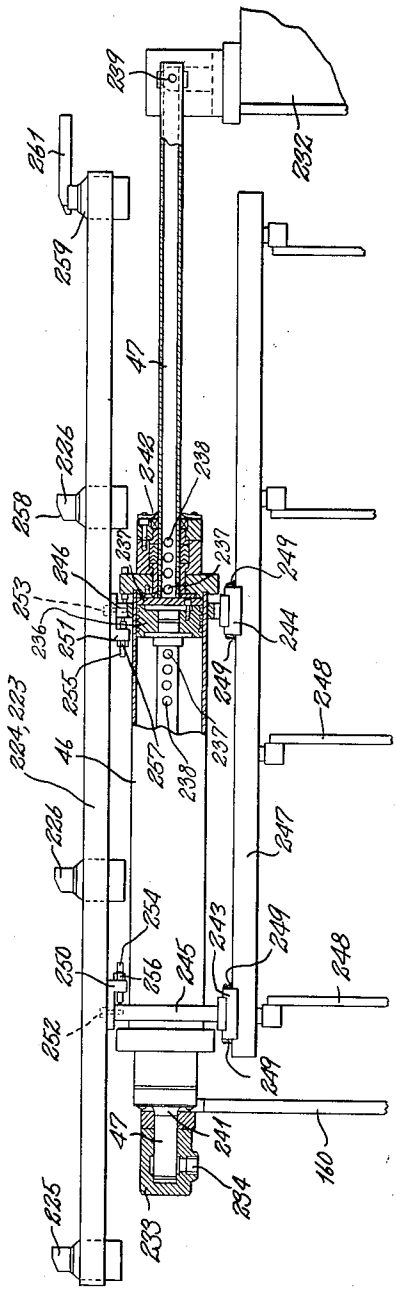


Fig. 14.

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TRANSFER MECHANISM

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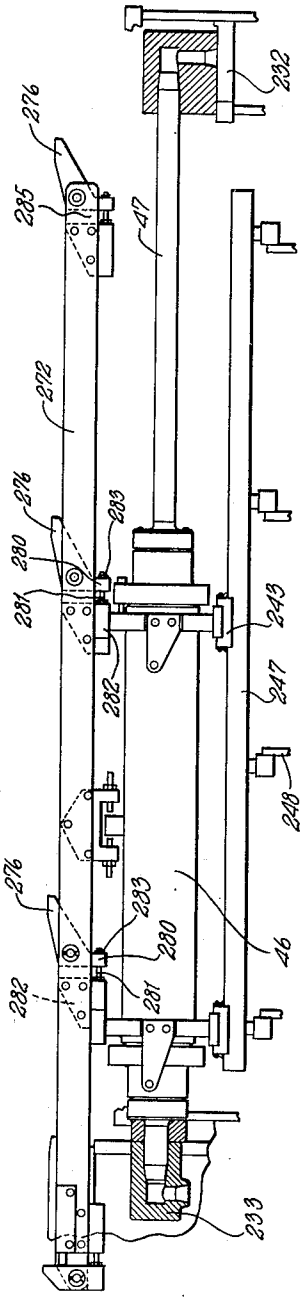


Fig. 17.

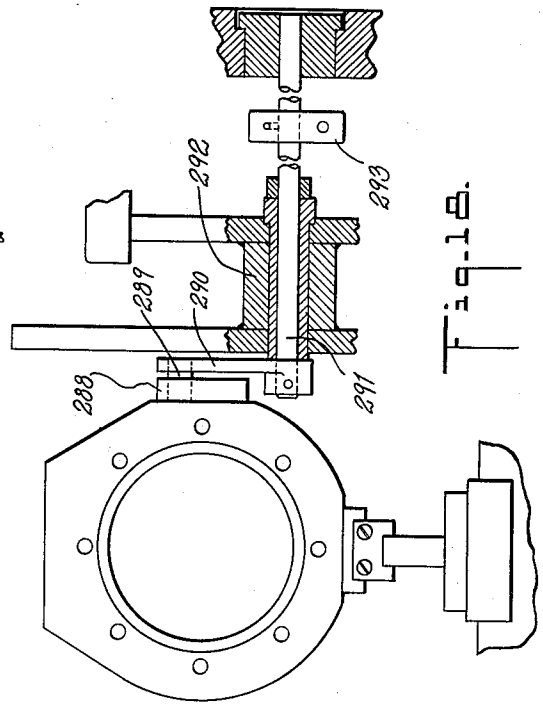


Fig. 18.

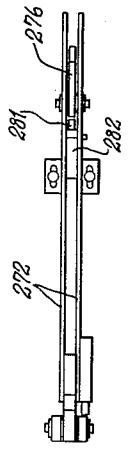


Fig. 16.

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TRANSFER MECHANISM

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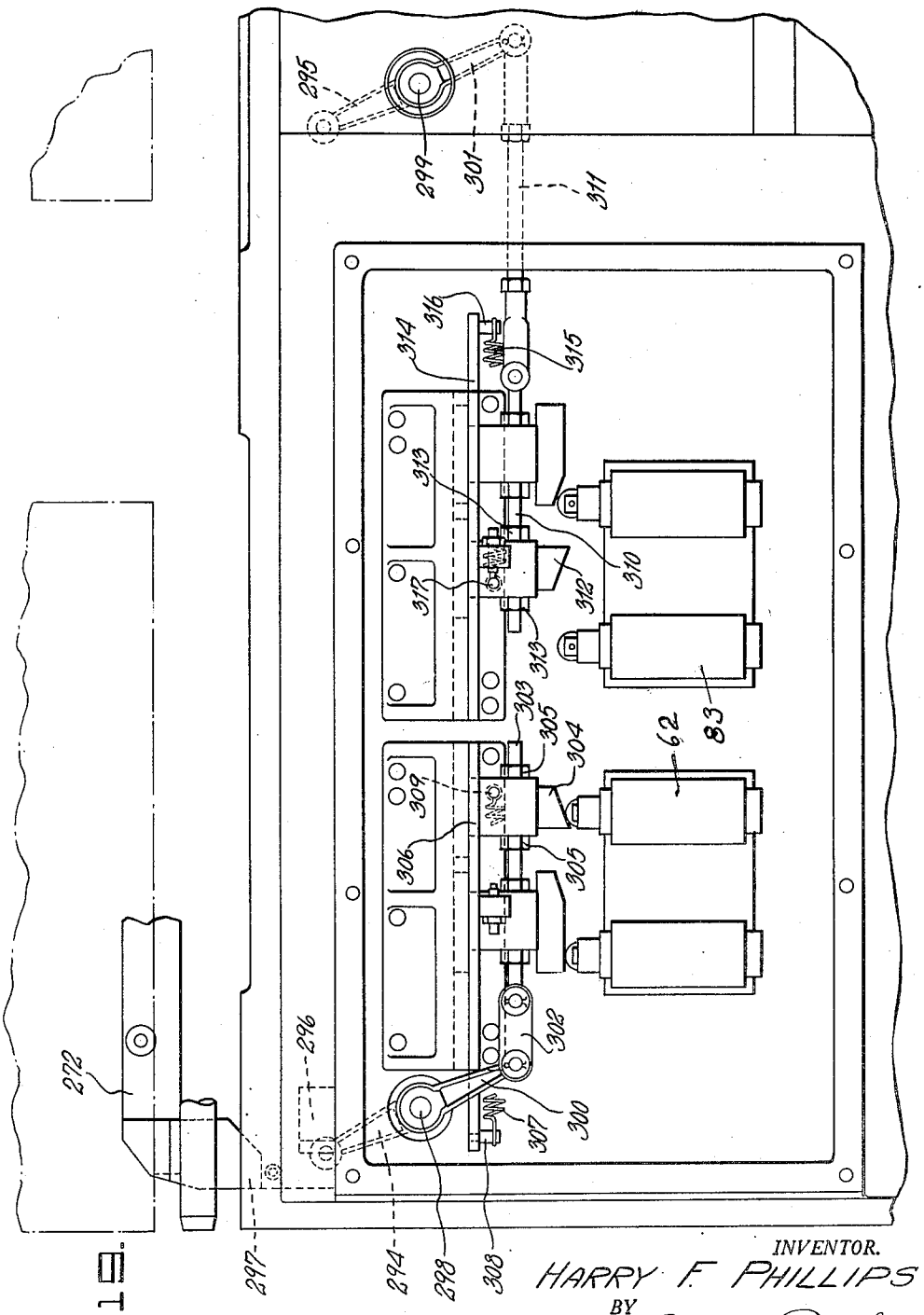


Fig. 13.

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TRANSFER MECHANISM

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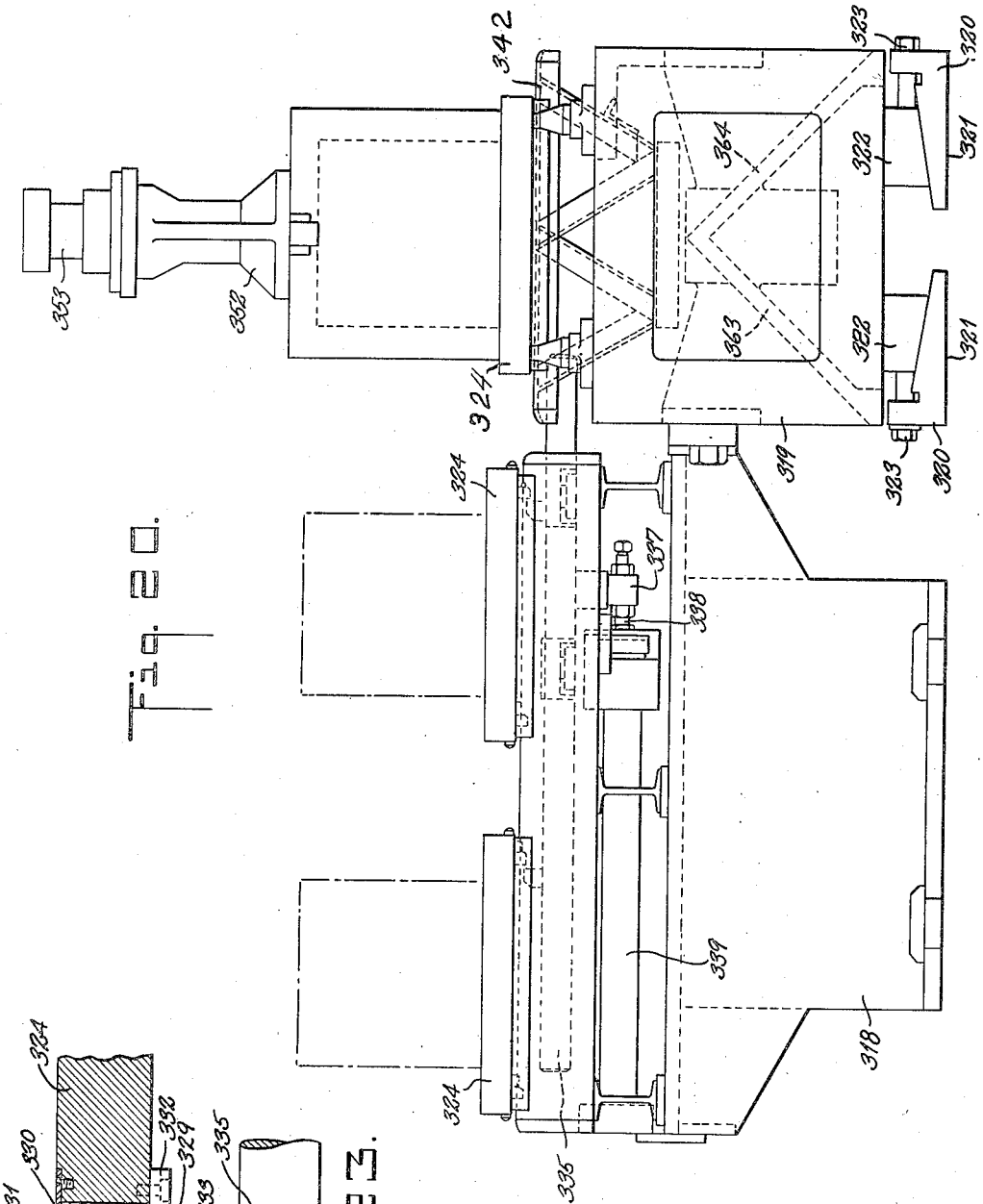


Fig. 2D.

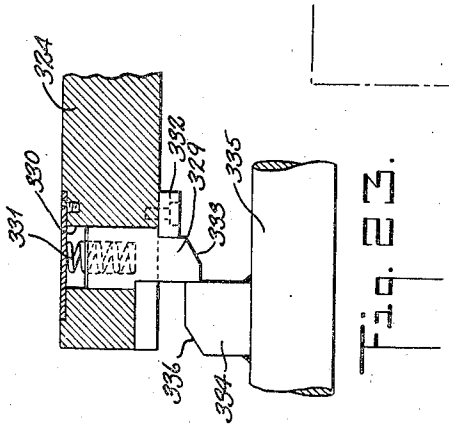


Fig. 2E.

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TRANSFER MECHANISM

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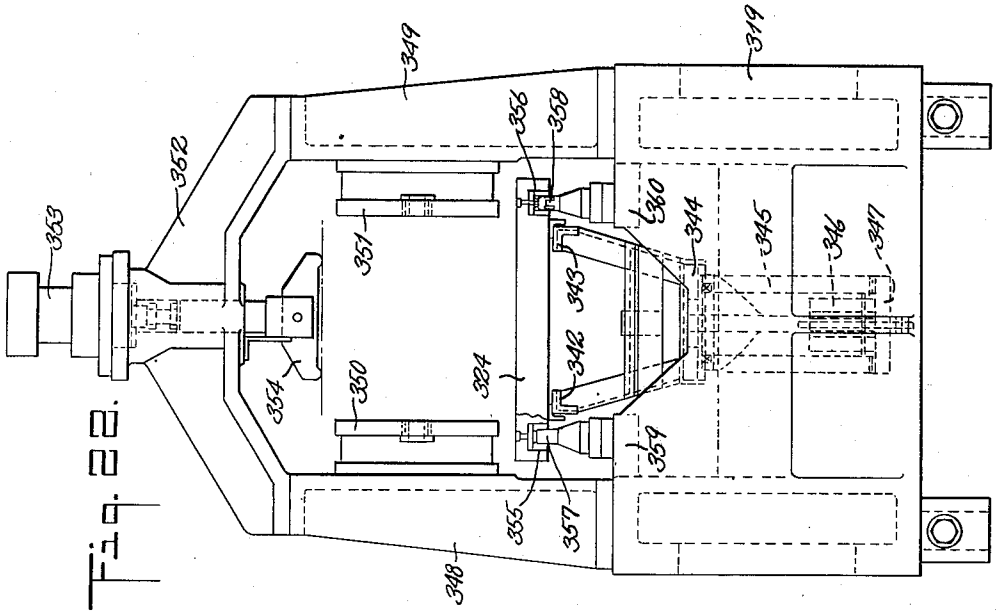


Fig. 22.

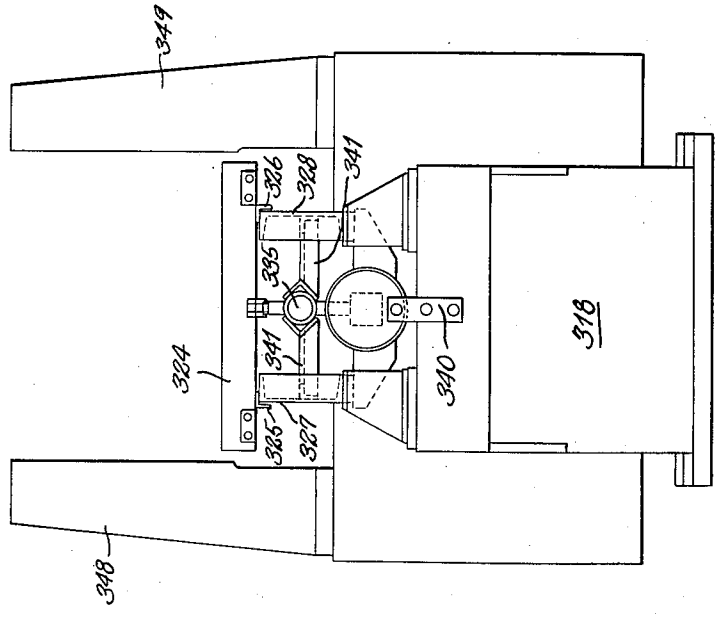


Fig. 21.

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TRANSFER MECHANISM

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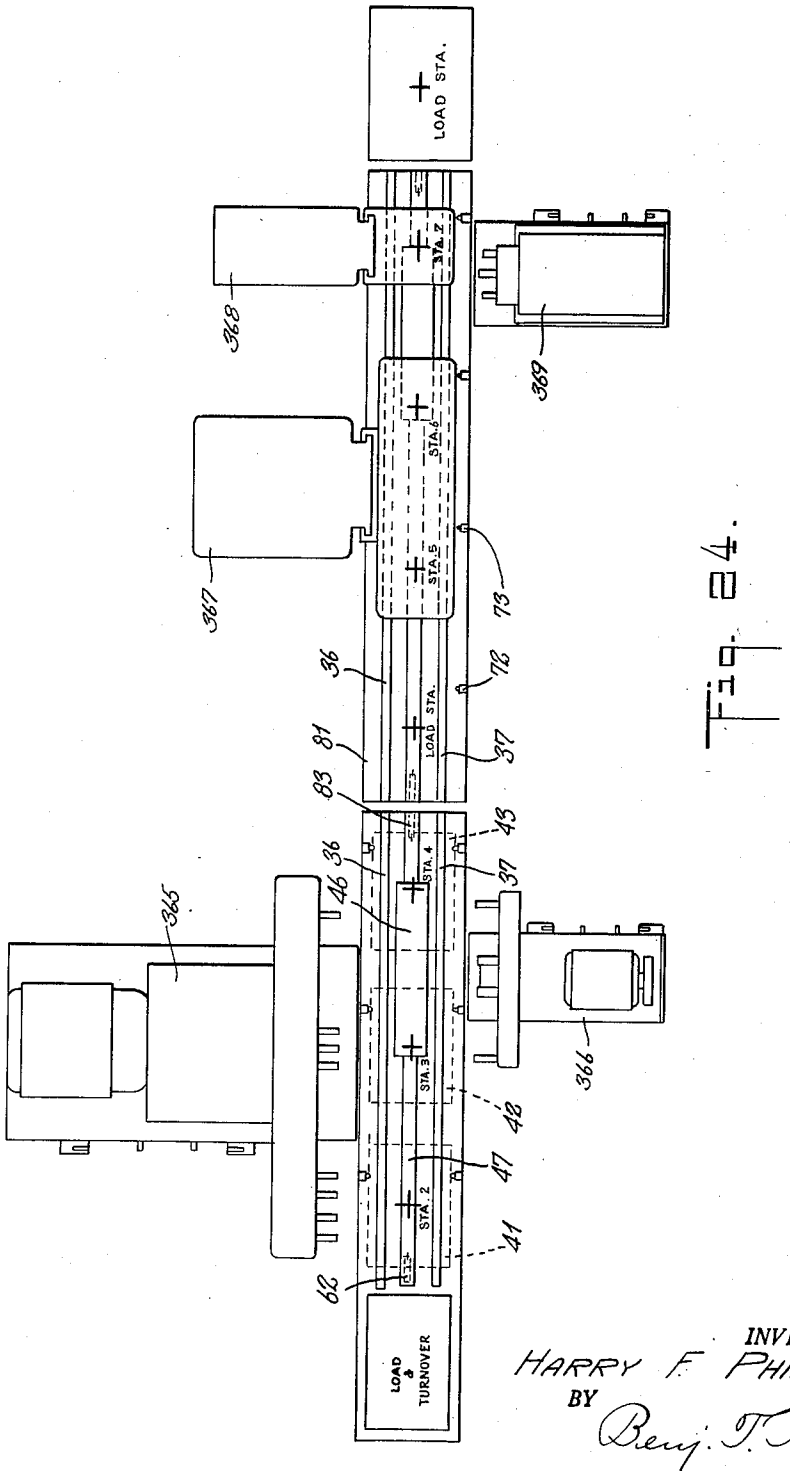


Fig. 24.

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Patented July 3, 1951

2,559,369

UNITED STATES PATENT OFFICE

2,559,369

TRANSFER MECHANISM

Harry F. Phillips, Springfield, Mass., assignor to Baush Machine Tool Company, Springfield, Mass., a corporation of Massachusetts

Application June 18, 1948, Serial No. 33,853

8 Claims. (Cl. 214—1)

1

My present invention relates to a mechanism whereby work pieces to be machined may be transferred in ordered sequence through one or more stations relative to machining units and may be accurately positioned at each station.

This application is a continuation in part of my co-pending application Ser. No. 736,034, filed March 20, 1947.

In the mechanism of my invention work pieces are successively placed in starting position of an initial transfer machine and are then trasferred in successive steps from one position or station of the machine to the next, and to the next machine or to a delivery station without further intervention by the operator except to start or stop the transfer machine or machines and the unit or units associated therewith. Any number of transfer machines and their associated machine units may be arranged in sequence and the work pieces are then transferred automatically from one mechanism to a succeeding mechanism.

Each transfer machine is under the control of the machine unit associated with it so that a work piece is not moved to a working station until the unit, such as a drilling machine, is ready to start the machining operation at that station and is not moved to the next succeeding station until the machine has completed its operation and is ready to receive a succeeding piece.

When transfer mechanisms are arranged in sequence, the starting or loading station of one mechanism must be vacant before the preceding mechanism is set in operation to deliver a work piece. The operation of each machine is controlled by the next successive machine to permit the transfer of a work piece only when the receiving station of the successive machine is free to receive it.

It will be apparent, therefore, that no work piece can be moved into a station until the unit at that station is ready to receive it and until the machining operation on a preceding work piece has been completed. The successive transfer machines are thereby timed to the slowest machine although each may itself be otherwise independent.

Inasmuch as each transfer machine is a complete and separate entity, any number of machines may be combined with a corresponding number of units to accomplish any desired number of unit operations and may be readily changed about or adapted to changes in the order or types of units and unit operations.

In assembling a succession of transfer machines it is sufficient that the work piece may slide or move securely from one to the next.

2

The units which operate on the work pieces may be of any type, such as a drilling machine, boring machine, planer or shaper or profiler, or a mechanism for turning the work piece to a different position for a succeeding operation, or it may be apparatus for inspecting the work accomplished in preceding units.

The work piece is moved to and through the successive stations of each transfer machine by any suitable propellant, mechanical, electrical, pneumatic, hydraulic, reciprocating or otherwise which moves forwardly from one station to the next at successive controlled intervals. A hydraulically operated reciprocating transfer element having a stroke equal to the distance between the stations is an example of a suitable propellent element.

As a piece arrives at a working station it is located accurately by locating devices, such as pins actuated by a yielding force, such as fluid under pressure, which move into accurately positioned openings or holes in the work piece, or in piece secured to it, when it is in correct position. When the work piece is located in a station by the locating pins it is clamped securely in position by clamping means or plates, preferably actuated by fluid pressure, which hold it throughout the machining operation.

The propellent element may carry a pin, latch or similar mechanism, which engages the work piece on each forward movement from station to station but which is depressed to move underneath a work piece when the element moves reversely.

When hydraulic or pressure fluid is used to actuate the machines it is preferably controlled by valves so arranged that each element of the machine may move only in its proper sequence and timing. Thus the valves are so arranged that the clamping plate is lowered into clamping position only when the locating pins or elements have moved to locating position.

The transfer element moves in reverse direction when the clamping plate is clamped. As it reaches its rearmost or starting position it then operates a control valve to cause the clamping plate and the locating pin to be retracted, whereupon the transfer bar moves forwardly carrying with it the work piece from each station to the next. At the end of its stroke it operates a control valve to permit the locating pin to move to locating position, and when this is accom-

plished it in turn permits the clamping plate to clamp the work piece in its located position.

These hydraulically operated valve mechanisms insure that each of these movements will take place in its proper sequence and only when the preceding operation has been successfully and fully completed.

These hydraulic mechanisms are in turn electrically controlled jointly by the unit or units associated with the transfer machine and by control switches at the loading stations of the machine and the next succeeding machine. This control circuit releases the hydraulic mechanism to advance a work piece when the unit has completed its operation and withdrawn, when the loading station of the machine is loaded and that of the next succeeding machine is empty. It also comprises a starting switch for the machine actuated by the clamping of the clamping mechanism and a switch actuated by the withdrawal of the locating pins to permit forward movement of the transfer element.

The various features of the invention are illustrated, by way of example, in the accompanying drawings in which—

Fig. 1 is a diagram in perspective of a machine embodying the invention, details of construction being omitted for the sake of clearness;

Fig. 2 is a wiring diagram of the control system for the machine of Fig. 1;

Fig. 3 is a diagram of a hydraulic or fluid pressure system for the apparatus of Fig. 1;

Fig. 4 is a front view of a machine embodying a preferred form of the invention;

Fig. 5 is an elevation, taken from the right of Fig. 4, of a turnover mechanism and supporting structure.

Fig. 6 is a plan of the mechanism of Fig. 5;

Fig. 7 is a side view of the front end of the machine taken from the right of Fig. 4;

Fig. 8 is a side view, taken from the left of Fig. 4 of the front end of the machine of Fig. 4;

Fig. 9 is a plan view of a transfer machine, partly broken away to show locating and clamping mechanisms at the sides;

Fig. 10 is a horizontal section taken at the lever of a supporting bar of a transfer machine having locator pins at the bottom and showing details of the transfer bar and actuating mechanisms;

Fig. 11 is a front view of a part of a transfer mechanism of modified form;

Fig. 12 is a side view of a machine showing the actuating mechanisms for the locators of Fig. 10;

Fig. 13 is a plan view of a transfer bar, and Fig. 14 a side view of the bar and of fluid pressure actuating means therefor;

Fig. 15 is a view similar to that of Fig. 14 of a modified form of transfer bar and actuating mechanism;

Fig. 16 is a plan view of a part of the modification of the transfer bar shown in Fig. 15, and Fig. 17 a side view of a modification of transfer bar and fluid pressure actuating means;

Fig. 18 is a front view, partly in section, showing parts of a limit switch operating mechanism;

Fig. 19 is a side view of a part of the machine illustrated and a form of limit switch mechanism actuated by the transfer bar;

Fig. 20 is a side view of another form of embodiment of the transfer machine;

Fig. 21 is a front elevation, and Fig. 22 a rear elevation of the machine shown in Fig. 20;

Fig. 23 is a side view of a part of a transfer bar and carrier plate for the embodiment of Fig. 20, and Fig. 24 is a diagrammatic plan view showing an arrangement of a train of transfer machines and machining units embodying the invention.

Transfer and timing mechanism

In the machine of Fig. 1 a work piece 25 is placed on a turnover or turn down element 26. The work pieces are illustrated as rectangular blocks but may be of any suitable shape, such as cylinder blocks, gear cases, or other shapes, to be machined, drilled, etc.

The turnover element has supporting frames 27 and 28 fixed at right angles to each other on a horizontal rock shaft 29 to rotate from the position shown in broken lines to that shown in full lines.

When the work piece is placed on the frame 27, in the position shown in broken lines, it operates a control switch 30 whereupon, through the control system illustrated in Fig. 2, an electromagnet 31 is energized to admit fluid through a valve 32 and connecting pipe 33 to one end of a cylinder and piston 34 which thereupon act through an arm or other transmission element 35 and rotate the turnover element to upright position, shown in full lines.

The turnover element has a pair of rails 36 and 37 which, in upright or raised position of the element, are in alignment with supporting rails 38 and 39 of the machine. When in this position the work piece actuates a switch 40 which causes a propelling agent to move to a position to engage the work piece for movement on the rails 38 and 39 forwardly to the station indicated at 41 and then successively to the stations indicated at 42 and 43. This propelling member may be of any suitable mechanism for moving the work piece forwardly at successive intervals.

In the diagrammatic embodiment shown in Fig. 1 the propelling member is a sliding transfer bar 44 having pins or latches 45, one for each station, including the turn over element, which lower or are depressed to pass beneath the work pieces when the transfer bar moves in reverse direction and then rise to engage the work pieces when the transfer bar moves forwardly and thereby carry them forwardly to the next station.

The transfer bar may be reciprocated forwardly and in reverse by any suitable mechanism. In the embodiment of Fig. 1 it is secured directly to a ram or cylinder 46 slidable on a piston rod 47 and actuated by pressure fluid admitted from a valve 48 through a pipe 49 to move the transfer bar in reverse to starting position and, alternatively, through a pipe 50 to move it forwardly to the next station. Admission of fluid through the valve 48 to the pipes 49 and 50 is controlled by electromagnets 51 and 52 respectively. When switch 40 is closed electromagnet 51 is energized, fluid is admitted to pipe 49 and the cylinder 46 and transfer bar 44 moves in reverse to starting position. The latches 45 thereupon rise to a position to engage the work pieces at 25, 41, 42 and 43. Upon admission of fluid through the pipe 50, and release of fluid from pipe 49, as the electromagnet 51 is de-energized and electromagnet 52 is energized, the cylinder and transfer bar move forwardly.

During the reverse movement of the transfer bar work pieces at stations 41, 42 and 43 are held in their stations by clamps and locators. These, and the tools of the machine units must be with-

drawn before the transfer bar moves forwardly so as to permit the work pieces to advance without interference. The clamps, indicated at 53, 54 and 55 for the work pieces 41, 42 and 43 respectively, are actuated by pressure fluid admitted through a valve 56 to a pipe 57 leading to the upper ends of cylinders 58, 59 and 60 to move the clamps to clamping position or, alternatively, to exhaust fluid through pipe 57 and admit it through pipe 61 to the lower or opposite end of the cylinder to raise or withdraw the clamp. Admission of pressure fluid to pipe 61 is controlled by a limit switch 62 actuated by the transfer mechanism, as it reaches the limit of its reverse movement, to energize an electromagnet 63 of the valve 56 for the admission of fluid to pipe 61. The clamps thereupon rise or are withdrawn.

As each clamp rises it actuates a limit switch 64. These limit switches are in series and serve to energize an electromagnet 65 of a fluid pressure valve 66 to admit pressure fluid through a pipe 67 and branch pipes 68, 69 and 70 to one end of a fluid actuated cylinder and piston 71 for withdrawing the locators.

The locators comprise elements which move transversely of the path of the work pieces in position to locate the work pieces accurately at their respective stations and in precise spacial relation to the machining units. They may be of any suitable form to engage complementary surfaces of the work pieces and, in case a work piece should not be precisely placed by the transfer bar, to shift it to its proper place.

In the embodiment illustrated in Fig. 1 and in Figs. 4 and 7, the locators comprise pins 72 and 73 slidable in guides or bushings in the frame of the machine and tapered or pointed at the ends projecting toward the work piece to enter corresponding openings in the work piece, or in a plate or member secured thereon, even though the openings be not exactly centered relative to the pins. As the pins move forward into the openings, which they fit closely, the work pieces are brought to precise position. Two locator pins are shown, by way of example, in the accompanying drawings. They may be placed in any convenient position, at the side or bottom of the station as conditions may require.

The several locator pins of each station are secured to and actuated by crank arms 74 and 75 fixed on a rock shaft 76 journaled in the frame of the machine and, in turn, rocked by a crank arm 77 and a link 78 connected to the piston of the cylinder 71. When fluid is admitted to the cylinder through the pipe 68 the shaft 76 is rotated to withdraw the pins. The work pieces are thereby released to move to the next station and be replaced by a succeeding piece. The drills or other tools of the machining units will also have been withdrawn from the path of the work pieces.

As the rock shaft 76 rotates to withdraw the pins it actuates a control switch to energize the electric control system for advancing the transfer bar 44. This switch may be a double acting switch or one of a pair of switches. In the diagrammatic sketch of Fig. 1 it is a switch 79 actuated by an arm 80 projecting from the shaft 76. As the switches of the several locators, in series, close they energize the electromagnet 52 of the valve 48 to admit fluid through pipe 50 to the transfer bar cylinder 46 and exhaust fluid through pipe 49 causing the cylinder and bar to move forwardly provided the receiving station of the next machine 81 is free, releasing the contact switch 82.

As the transfer bar reaches the end of its forward movement it trips a limit switch 83. This switch controls a number of electromagnets, one of which is a magnet 84 on the valve 31 to admit fluid through pipe 85 to the cylinder 34 and exhaust it through the pipe 33 thereby swinging or lowering the turnover element to receiving or lowered position. When in lowered position the turnover element trips a limit switch 86 which prevents the transfer bar from moving in reverse until the turnover element is raised.

The limit switch 86 also controls an electromagnet 87 on the locator valve 65 to admit fluid through a pipe 88 and branch pipes 89 to the ends of the cylinders 71 causing the rock shafts 76 to rotate in a direction to move the locator pins 72 into locating position, fluid being exhausted through the opposite branch pipes 68, pipe 67 and valve 66 to exhaust. In the event that the movement of any of the locator pins should be obstructed, as for example by a work piece being too far from its proper position for the pin to enter the openings, further operation of the machine, and accordingly of all similar machines in series with it, would be blocked. This condition would be indicated by the position of the locator pins or by a suitable signal and could then be readily corrected by shifting the work piece.

Normally the locator pins move in, the rock shaft rotating under the force of the pressure fluid. An arm 90 on the rock shaft is thereby swung to trip a switch 91 which controls the clamping of the work piece. As the switch 91 is tripped, it energizes an electromagnet 92 which actuates the valve to admit fluid through pipe 57 to the upper ends of the cylinders 58, 59 and 60 and exhaust it through pipes 61. The clamps are thereby forced downwardly into contact with the work pieces at their respective stations. With this arrangement of the locators and clamps the work pieces are accurately positioned before being clamped and are then secured by the clamps for the machining units.

The movement of the clamping mechanism to clamping position serves to energize and start the forward feed of the machining units, such as drills, boring rods, etc. For this purpose a limit switch 93, one for each clamping mechanism, is mounted in position to be tripped by the clamping mechanism as it reaches clamping position. The tripping of the switch 93 energizes an electromagnet 94 of a valve 95 controlling the feed of the respective machine unit to advance the drills or other tools.

When each machine unit reaches the limit of its advance movement or completes its machining operation it trips a limit switch 96 on the respective unit which thereupon actuates an electromagnet 97 on the valve 95 to reverse the feed. The switches 93 and 96 may also serve to start and stop a tool rotating motor, a timer being preferably provided in connection with the switch 96 to delay the stopping of the motor during the initial part of the reverse of the feed mechanism. As the units reach the limit of their reverse movements they trip limit switches 98 to set the machine for another cycle. When a work piece is placed on the frame 27 of the turnover device the above cycle repeats, provided the receiving station of the next machine is not occupied.

Each machine is a self contained unit capable of carrying on its successive steps but is also capable of co-operation with other machines

placed to receive work pieces from it or deliver them to it, depending on their position in a series or train of machines. For this purpose the machines in such a series are interconnected as by the switch 82 so that none may operate until the receiving, or initial station of the next is clear or unoccupied and until its receiving or starting station is occupied by a work piece. For example, the machine described above cannot begin its cycle of steps until the starting station of the next machine 31 is clear and until a work piece is placed on the turnover element. In case the work piece moves from one machine to the next without turning, a turnover element is not required for the succeeding machine, nor is it required for the initial machine when the work piece is supplied in upright position. The end machine of the series may be fitted to a take off platform with or without a control switch similar to 82.

As each machine is independently operated any number of them may be arranged in series, it being necessary only that the supporting rails of one be sufficiently aligned with those of the preceding machine to enable a work piece to slide from one to the next.

The various control switches and valve electromagnets of each machine may be arranged in a suitable wiring arrangement independently of adjacent machines except for connection to the switch 82 of the next machine. A simplified wiring diagram for this purpose is illustrated by way of example in Fig. 2. Where two or more circuits are controlled by a single switch, they are shown separated in this diagram but indicated by the same reference numeral to avoid, as much as possible, the crossing of lead wires and complexity that might result therefrom. In practice they may be connected mechanically or by relays as convenience may make desirable.

Wiring system

In the diagram of Fig. 2, electric current is supplied from a supply main 99 through a switch 100 either to a lead wire or main 101 of a manual control system or, as shown, to a main 102 of the automatic control system. From the latter main, current is supplied to a line 103. This line comprises the back limit switches 98 of the machine units, only one being shown in the diagram, which are closed when the units are in full reverse position. In series with the switch 98 is a latched relay switch 104, which may be opened to stop the system but which, in normal operation is closed, and the locator switch 91 which is closed at the start of the cycle. Next in sequence are the clamp limit switch 93, the transfer limit switch 83, and the turn over limit switch 86 all of which are also closed at the start of the cycle. Next in the series of switches is the transfer limit switch 62 which is closed when the transfer mechanism is forward, as at the start of the cycle and the limit switch 82 on the next machine 31 which is closed when the receiving station of this machine is unoccupied and therefore ready to receive a work piece. Following in the series is the load switch 30, which is closed when the turn over element is loaded and a stop realy 105 which is closed when the machine is operating. When the elements of the machine are in starting position, the starting station of the next machine empty and the starting station, the turn over element, is loaded, all of the switches are closed and the circuit closed through the electromagnet 32 to a return main 106. The valve 31, therefore, supplies fluid to raise the turn over element, closing switch 40 and releasing limit switch 30.

A branch circuit 107 leading from the line 103 in advance of switch 86 is then closed through a normally closed push button switch 108, a branch 86a of switch 86, which is closed when switch 86 is open, and the switch 40, which is closed as the turn over element is raised, to the electromagnet 51 and main 106. Valve 48 is thereupon operated to admit fluid through pipe 49 to move the transfer bar 44 in reverse. As the transfer bar 44 reaches the limit of its reverse movement it trips limit switch 62.

As limit switch 62 is closed it closes a circuit from the line 103 immediately beyond switch 93 through a branch circuit 109 and electromagnet 63 to main 106. The valve 56 is then operated to supply fluid through pipe 61 to cylinders 58, 59, 60 to withdraw the clamps 53, 54 and 55. As the clamps are withdrawn they trip switches 64.

As switches 64, only one being indicated in the diagram, are tripped they close a circuit from line 103, immediately beyond switch 91, through a branch circuit 110, and normally closed push button 111 to electromagnet 65 and then to return main 106. As electromagnet 65 is energized it operates valve 66 to supply fluid to the pipes 67 and 68 to withdraw the locators which thereupon trip switch 79.

As switch 79 is tripped it closes a circuit from line 103 through branch circuit 112, push button switch 113, branch relay switch 86b of switch 86, which is closed when switch 86 is open and is therefore closed at this period, to the switch 82 of the load station of the next machine 31. When this station is empty switch 82 is closed, closing the circuit through electromagnet 52 to main 106. Valve 48 is thereupon operated to supply fluid through pipe 50 to move the transfer mechanism forward and trip limit switch 83.

As switch 83 is closed a branch circuit 114 is closed from the line 103 through the switch branches 62 and 40, which are closed in this branch circuit when they are not tripped, and thence through the electromagnet 84 of valve 31 to the return main 106. The electromagnet 84 is thereupon energized to admit fluid through the pipe 79 to the cylinder 34 and exhaust it through pipe 33. The turn over element then lowers to receiving position, tripping the switch 86a. This breaks the circuit through branch circuit 107 to the magnet 51 of valve 48 and prevents the reverse movement of the transfer bar 44.

From the branch circuit 114 beyond the switches 83, 62 and 40 is an extension 115, in parallel, through a push button 116, and switches 64, in series only one being shown, which are closed when the clamps are raised or withdrawn to the magnet 87 of valve 66. When the magnet 87 is energized fluid is admitted through pipe 88 and branches 89, Fig. 1, and exhausted through pipe 67 to move the locators into locating position.

As the locators move in they trip switches 91, one being shown in Fig. 2. Thereupon a circuit is closed from branch 114 through a side branch 117 through branch switches 86 and 91, and also switches 93 which are closed when the clamps are out of clamping position, to the electromagnet 92 of valve 56. From the electromagnet 92 the circuit passes to return main 106. Upon energizing the magnet 92 the valve 56 supplies pressure fluid through pipes 57 to upper ends of cylinders 58, 59 and 60 and exhausts it through

pipe 61 thereby moving the clamps to clamping position.

As the clamps move to clamping position they energize limit switches 93, closing a circuit from branch circuit 117, switches 86 and 91 being closed, through a branch 119 which contains the switch 93, switch 96 which is closed until tripped and push button switch 120. This circuit is completed through the electromagnet 94 of valve 95 to return main 106. The valve 95 thereupon supplies fluid to the forward feed mechanism of the respective units of which two, 121 and 122, are shown for the first machine.

As the feed mechanisms of the respective machines reach the limit of their forward movement they trip their respective limit switches 96 thereby breaking the circuit 119 and closing a circuit 123 from the main 102 directly through an electromagnet 97 controlling the reverse feed of the unit. The machine is now in position to begin a new cycle of operations upon placing a work piece on the turn over frame 27.

The diagram of Fig. 2 also has a cycle stop circuit 123 whereby the machine may be stopped and started upon completion of a cycle. For this purpose this circuit has in series, a reset push button 124, a cycle stop push button 125 and an electromagnet 126 of a number of relays. One of these relays 127 is in a shunt circuit 128 bypassing the push button 125 so that, once the circuit is closed, it remains closed through the shunt circuit after the push button 125 is released and until the push button 125 is opened. Another relay closes a switch 128 in a branch circuit 129 from the line 103 beyond the switches 98, 91, 93, 83, 36 and 62 and in advance of switches 82, 30 and 105. This in turn energizes a solenoid 129 which opens the relay 105. This opens the circuit through electromagnet 32 and therefore the turn over element cannot rise. To start the cycle the push button 124 is pushed open which breaks the circuits through the by-pass 128 and branch 123 and thereby releases and opens the switch 128 and circuit 129 causing the relay switch 105 to close.

The automatic operation of the machine may be interrupted at any point by throwing the switch 100 from line 102 to line 101. In this position the line 102 is disconnected from main 99 and the manual line 101 is energized. By suitable circuits such as 130, 131, 132, 133 and 134, various elements of the machine may be operated individually. Thus by closing the push button 108, a circuit will be closed through the magnet 51 causing the transfer bar to reverse, provided switches 86^a and 40 are closed. By closing push button 113 a circuit will be closed through magnet 52, if switches 86^b and 82 are closed. On closing push button 111 a circuit is closed through magnet 65 to move the locators in, and by closing push button 116 to close a circuit through magnet 87 and withdraw the locators, provided the clamps are withdrawn and switches 64 closed. On closing push button 120 magnet 94 is energized to reverse the unit feed and withdraw the tools.

Through the above mechanism, which is diagrammatic of a preferred embodiment, each machine may operate as a unit but may be interconnected with other similar machines, as by the switch 82, to operate in sequential relation thereto as a unit in a series of machines. This permits flexibility in the arrangement and assembly of the machines and also simplicity in operation as a failure to function may be located in a single machine and corrected without changing the assembly or affecting the operation of the other machines of the series.

Hydraulic system

Although the apparatus shown diagrammatically in Figs. 1 and 2 may be operated by any suitable source of energy, a hydraulic fluid operated mechanism is particularly suited for it. Such a system is shown diagrammatically in Fig. 3. In this system fluid such as an oil or other non-corrosive liquid is drawn from a supply container 135 through a suction line 136 to a pump 137 driven by a motor 138 and supplied under pressure to a main 139. This main supplies fluid to the valves 31, 66, 48 and 56 of Figs. 1 and 2. Fluid for the valve 31 passes from the main through a pressure relief check valve 140 to a supply pipe 141 leading to the valve 31. The pipe is provided with a pressure relief valve 142 to which it is connected by a branch 143. Overflow from the valve 142 may flow back to the tank 135 through a return pipe 144. The valves 140 and 142 serve to provide a pressure fluid under a limited pressure. The valve 31 serves to supply fluid to and exhaust it from opposite ends of the cylinder 34 as described above, the fluid being returned to tank 135 through a return pipe. A pressure check valve 145 is provided in line 33 to limit the pressure of the forward stroke.

Pressure fluid is supplied from line 139 through a branch pipe 147 and check valve 148 to the valve 66, the exhaust fluid being returned to the tank by return pipe 149. In the pipe 67, a manual closing valve 150 may be provided by a by-pass through a check valve 151 to enable the locators to be locked in withdrawn position.

Fluid may be supplied directly to the valve 48 through a branch 152 and returned to the tank through a return pipe 153. The exhaust through the pipe 50 on the forward stroke may be controlled by a flow control 154 connected to the pipe by a branch 155 to retard the forward stroke.

The main 139 delivers to the valve 56 through a check valve 156, the return to the tank being through a return pipe 157.

Structural features

Various structural forms of embodiments of the invention are illustrated in Figs. 4 to 23 inclusive.

For example as shown in Fig. 4 the various elements of the invention are supported in an enclosing framework comprising a base 160 which supports and carries the supporting rails 38 and 39 and the transfer or propelling mechanism.

Mounted on the base 160 are a pair of uprights 161 and 162 spaced apart to provide a passage 163 for the work pieces as they progress from one station to the next. Closing the top of the passage 163 is a cross piece 164 supported on the upper end of the uprights 161 and 162. These uprights are securely bolted to the base 160 and the cross piece is bolted or secured to the uprights to form a rigid structure.

Mounted on the front of the base is a bracket 165, as shown in Figs. 4, 5 and 6, having bearings 166 and 167 for supporting the turnover device 26. For this purpose a rod 29 is mounted in the bearings 166 and 167 extending from one to the other and on which are mounted bearings 168 and 169 of the turnover device. The arms 27 and 28 are integral with the bearings 168 and 169 as is also the crank arm 35. As shown in these figures, the switch 86 is mounted below the

bracket 165 having a stem 170 extending upwardly in alignment with a sliding rod 171 mounted in the bracket 165 in such a manner that its upper ends immediately beneath one of the arms 27 so that it is depressed and depresses the switch stem 170 when the turnover device is rotated to the right, Fig. 4, to bring the arm 27 downwardly. The switch 86 may be supported from the lower surface of the bracket 165 by a depending plate 172.

The switch 30 may be mounted between the arms 27 of the turnover device on the bracket 165 in such position that an arm 173 of the switch projects upwardly above the pair of supporting rails, 174—175, on the arms 27. Accordingly when a workpiece is placed on the rails 174—175 the arm 173 is depressed, dropping the switch.

The cylinder 34 is mounted at its lower end on a bracket 176 having a pivotal support 177 for the cylinder so that the latter may swing slightly as its piston moves inwardly and outwardly.

The rails 36 and 37 of the turnover device are in substantial alignment with the supporting rails 38 and 39 of the machine so that the workpiece may slide freely from the turnover device to the rails 38 and 39. The level of the rails 36—39 is above the upper surface of the transfer bar, as indicated in dotted lines in Fig. 4, and somewhat below the uppermost projection of the latches or pins 45.

The turnover rails 174 and 175 when in the position shown in Fig. 4 are approximately coplanar with the side guide rail 178 mounted on the upright 162. A similar guide rail 179 is mounted on the opposite upright 161. The workpiece is guided accurately between the spaced guide rails 178 and 179.

In the embodiment of the invention as shown in Figs. 4–9 inclusive, the locating pins 72 and 73 are mounted on the side of the machine, that is, on the right side as viewed in Fig. 4.

As shown in Fig. 7 the crank arm 77 and the actuating cylinder 71 are mounted between the locating pins 72 and 73 for convenience of location, and the cylinder secured to the outer face of the upright 162 by means of a bracket 180 secured to the upright 162 and having a pivotal connection 181 to the end of the cylinder. In this embodiment also switches 79 and 91 are placed together and operated by a common crank arm 182 secured to the lower end of the rock shaft 76 so that it will operate one switch when rotated in one direction and the other switch when rotated in the opposite direction. In this embodiment also the clamping is sidewise, that is, from the left as viewed in Fig. 4. To take the thrust of clamping means a pair of spaced guiding rails 183 and 184 extending lengthwise of the machine are securely mounted on the inner face of upright 162.

It will be noted in Fig. 4 that the locating pins may project inwardly beyond the supporting faces of the rails 183 and 184 for the purpose of locating the workpieces.

In the diagrammatic drawing of Fig. 1 the clamping plates are shown for the sake of simplicity as being actuated by cylinders 58, 59 and 60. In the embodiment shown in Figs. 4, 8 and 9, however, the clamping plates are actuated from the cylinders through a cam and lever mechanism which greatly multiplies the force of the pressure fluid, thus enabling the relatively low pressure fluid used in the apparatus to be employed without a correspondingly large cylinder.

In Fig. 9 only two of the clamping plates and actuating mechanisms are disclosed, indicated as cylinders 58 and 59 and clamping plates 53 and 54. The cylinders 58 and 59 are mounted on the cross piece 164 and each has a piston rod 185 extending horizontally and carrying a rack bar 186 slidable in a guide 187 on the upright 161.

The rack bar 186 meshes with a pinion or gear wheel 188 mounted on a vertical rock shaft 189 extending vertically through a pair of bearings 190 and 191, Fig. 8, on the upright 161. Between these bearings is mounted on the shaft 189 a pair of cams 192 and 193 which are fixed in angular position on the shaft by stepped collars 194 and 195 keyed to the shaft and spaced by a spacer collar 196. When pressure fluid is admitted to the cylinder 59 to clamp the clamping plates the shaft 189 is rotated in such a direction that the part of the cams 192 and 193 of larger radius bears down on arms 197 and 198 pivoted on a rock shaft 199 which is secured to the side of the upright 161 by a pair of brackets 200. As shown in Fig. 9 particularly, the arms 197 and 198 are secured at approximately their mid points to the plates 53, 54. The clamping plates are mounted by means of adjustable screws or bolts 201 so that they may be accurately adjusted to clamp the plates in the right position for machining. The limit switches 93 and 94 may be located between the arms 197 and 198 and the side of the upright 161 as indicated diagrammatically in Figs. 8 and 9. Locating and clamping from the side in this manner may be advantageous when the workpiece is to be machined from the top as, for example, through an opening 202 or 203, Fig. 9. Where the workpiece is to be machined from the side it is preferable to locate the workpiece from the bottom and clamp it from the top.

As the workpiece may be machined both vertically and horizontally, machines may be disposed in a series for clamping and locating from either position.

Embodiments whereby the workpiece may be located from the bottom and clamped from the top are shown in Figs. 10 to 12 inclusive. As shown in these figures, particularly Figs. 10 and 11, a pair of supporting rails 204 and 205 are mounted on opposite sides of a transfer bar mechanism 206 to support a workpiece 207 slidable lengthwise of the supporting rails. For each station a pair of locator pins 208 and 209 are provided at properly spaced intervals. These pins may be approximately in line with one of the rails as, for example, 205 as shown in Fig. 10, which are interrupted for this purpose. These pins are slidable vertically in bushings 210 and 211. The lower ends of the pins project below the bushings and are provided with rack teeth 212 which mesh with pinion teeth 213 at one end of a transverse shaft 214 guided in suitable bearings, not shown. The opposite end of the shaft 214 is also provided with pinion teeth 215 which mesh with rack teeth 216 of a longitudinal slidable bar 217. This slidable bar is connected through an adjustable connector 218 to the piston stem 219 of a cylinder and piston 220. The cylinder 220 is supplied at opposite ends with pressure fluid from the valve 66. This fluid forces the rod 217 to the right or left lowering or raising the pins 208 and 209 simultaneously. In the event that either pin should be prevented from rising the action of the machine could be interrupted as previously described.

The sliding bar 217 is guided in suitable brackets 221 secured to the frame of the machine as shown in Fig. 12. A contact element 222 may be mounted on the bar 217 in position to trip limit switches 80 and 91. This contact may be adjustable on the

rod relative to the position of the locator pins, and secured by suitable lock nuts.

Figs. 10 and 11 also illustrate a specific embodiment of a transfer bar and actuating mechanism. In this embodiment the transfer bar comprises a pair of horizontal plates or strips 223 and 224 between and on which are mounted at suitable intervals spring latches or pins 225, 226, etc.

The bar elements 223 and 224 are welded, or otherwise suitably mounted, on supporting blocks 227 which are in turn secured to sliding rods 228 and 229 which move horizontally with the bar elements 223 and 224. The rods 228 and 229 are guided in spaced complementary guide brackets 230 and 231 secured to the guide rails 204 and 205. The transfer bars 223, 224 and sliding rods 228, 229, therefore, move longitudinally as a unit being guided in turn by successive groups of brackets 230, 231.

One embodiment of the pressure mechanism for shifting the transfer bars 223 and 224 and associated pins 225 and 226, etc., is shown in Figs. 13 and 14. In this embodiment the hollow piston rod 47, Fig. 14, is mounted at one end on the front plate of the frame 160 and the other end is mounted on a bracket 232 supported from the rear end of the base. At the front end of the piston rod 47 is mounted an inlet fixture 233 having an inlet passage 234 to the interior of the piston rod 47.

Within the cylinder, the piston rod is provided with a piston 236 on each side of which is a side port or passage 237 immediately adjacent the piston and a number of spaced ports 238. The hollow passage through the piston rod is closed at the piston 236 so that fluid admitted through one end will pass only to a corresponding side of the piston. When the pressure fluid is admitted to the right end of the piston rod it will act against the right face of the piston 236 and drive the cylinder 46 to the right. Conversely, when fluid is admitted to the left end of the piston rod, it will enter through the passages 237, 238 against the left face of the piston and drive the cylinder to the left as shown in Fig. 14. As the cylinder comes to the limit of its stroke in either direction it closes the ports 238 and restricts the flow of pressure fluid, thereby decreasing the speed of the cylinder and bringing it to a gradual stop. This minimizes the danger of throwing the workpiece beyond its proper station. Ports for the admission of pressure fluid to the right end of the piston rod are indicated at 239. Ports 234 and 239 communicate with the pressure pipes 49 and 50 respectively.

At each end of the cylinder 46 there is a wiper 241 and 242 to keep small chips or particles of metal from working into the interior of the piston.

The weight of the cylinder is supported by a pair of shoes 243 and 244 secured by welding or otherwise to rings 245 and 246 secured to the end parts of the cylinder 46. The shoes slide on a guide rail 247 which, in turn, is supported on cross ribs 248 in the base of the machine. These shoes are provided with wipers 249 to sweep chips free from the rail 247.

The transfer bars 224, 223 are supported at opposite ends of the cylinder 46 by means of brackets 250 and 251 which rest on the rings 245 and 246. The brackets are secured to the rings by screws 252 and 253 passing through suitable openings therein. The transfer bars may be adjusted lengthwise of the cylinder 46 by screws 254 and 255 so that by loosening one and tightening the other, the position of the transfer bars relative to the cylinder may be adjusted, whereupon the screws are locked in place by lock nuts 256 and 257. With this arrangement the transfer bars move with the cylinder, being guided on the rail 247.

The pins 226 are slidable upwardly and downwardly between the transfer bars and have inclined rear faces 258 which cause the pins to slide under a fixed workpiece until they pass to the rear thereof, whereupon the pins may rise, by means of suitable springs or other means.

The rearmost pin, indicated at 259, must overlap the corresponding transfer bar of the next machine and is therefore provided with an extension 261, forked to provide a pair of pusher rods 262 and 263 which will project over the end of the next machine to the loading position. In this position it will be above the level of the transfer bar of the succeeding machine. The pins 226 of the succeeding machine may rise through the space 264 between the extensions 262 and 263 to engage the workpiece for its movement through the next machine.

In the above embodiment, the structure of the transfer bar is limited to somewhat less than the length of the cylinder, which must be less than one-half the length of the machine in order to avoid overhanging of the piston rods. In such case it is necessary to provide more than one station for a machine, and if there are two working stations, this necessitates an idling station.

In the embodiment shown in Fig. 15, a pair of telescoping cylinders 265 and 266 are provided, one end of the cylinder 265 being secured to the rear end of the base 160. The smaller end of the cylinder 266 may be withdrawn into the larger cylinder 265. Within the smaller cylinder is a piston 267 having a piston rod or stem 268. It will be apparent that the stroke of the piston rod 268 may be greater than the length of the cylinder 265 inasmuch as it may pass to the front end of the cylinder 266 in its extreme forward position or to the opposite end of the cylinder 265 in its opposite position.

The free end of the piston rod 268 carries a bracket 269 adjustably secured on the piston rod by nuts 270 and 271 and in turn secured to the front end of transfer bars 272 which are the same as the transfer bars shown in Figs. 16 and 17 and similar to the bars 224 and 223 of Figs. 13 and 14. These bars are mounted by means of brackets 273 on a pair of guide and supporting rails 274 similar to the rails 229, Fig. 11. These rails are slidable through half brackets 275, similar to the brackets 230, 231 of Fig. 11, and spaced at frequent intervals lengthwise of the machine.

The transfer bars 272 are provided with latches or pawls 276 and 277 spaced to correspond to the distance between stations and pivoted on pins 278 and 279 between the bars 272. Each latch 276 has a depending leg 280 through which passes an adjustable screw 281 threaded into a bracket 282 of the transfer bar, and having a head 283 which limits the up-swing of the latch. The latch is swung upwardly by means of a coil spring 284 pressing against the leg 280 of the latch. In reverse movement, the inclined upper surface of the latch rides under, and is depressed by, the workpiece, compressing the spring 284. When it reaches the rear face of the workpiece it is pushed upwardly by the spring 284 until it reaches the limit of its movement as set by the head 283. Forward movement of the

transfer bar serves to hold the latch in its uppermost position.

It will be understood that the transfer bar shown in Fig. 15, and shown in plan view in Fig. 16, may be applied to a single cylinder and piston of the type shown in Fig. 15. In this case a transfer bar is mounted directly on the cylinder being supported by brackets 287. This is illustrated in Fig. 17 in which the same reference characters are employed as in the preceding figures for equivalement elements.

When the double cylinder of Fig. 15 is employed the piston stroke may be made greater than one-half the length of the transfer machine and, when there are two work stations the transfer may be made directly from one to the next. When, however, but a single cylinder is employed, as in Figs. 14 and 17, the stroke of the piston must be less than one-half the length of the machine if the cylinder and piston are not to extend beyond the next of the machines, and consequently there must be more than three stations.

For example, when there are two work stations it is necessary to have an idling station and to make the transfer in two strokes of the piston. In this case also more of the latches 276 and 226 are required because of the increased number of stations.

The limit switches 62 and 83 may be operated either from the transfer bar or from the moving cylinder or piston or parts moving with them as illustrated in Figs. 11, 18 and 19.

As shown in Figs. 11 and 18 a projection 288 extends sidewise from the cylinder 46 in the path of a pair of pins 289 each mounted on its independent crank 290 fixed on a rock shaft 291. Each rock shaft is mounted in and projects from bearings 292 on the frame of the machine and carries on its projecting end a crank arm 293 which operates gears for operating the limit switches as shown in Fig. 19.

In Fig. 19 the crank arm mechanisms are similar, there being a pair of crank arms 294 and 295 having pins projecting into the path of a block 296 mounted on a bracket 297 depending from the transfer bars 272. In the reverse movement the block 296 contacts with and moves the crank arm 294 counterclockwise and in its limit of forward advancement contacts the crank arm 295 and moves it clockwise. The crank arms 294 and 295 are respectively mounted on rock shafts 298 and 299 which carry crank arms 300 and 301. To the crank arm 300 is secured, by means of a link 302, a push rod 303 on which in turn is mounted a cam 304 in position to trip or actuate the limit switch 62. The cam 304 is secured to the rod 303 by adjusting screws 305, one on each side of the cam, and is guided in guides 306. As the transfer bar 272 begins its forward movement and the block 296 is withdrawn in contact with the crank arm 294 the cam 304 is drawn to the left by means of a tension spring 307 secured at one end to a pin 308 on the guide 306 and on the other end to a pin 309 on the cam 304. Similarly when the block 296 moves forwardly to contact with and swing the crank arms 295 and 301 clockwise a push rod 310 secured by a link 311 to the crank arm 301 is moved to the left carrying with it a cam 312 secured on the rod 310 by lock nuts 313 into contact with the limit switch 83 to trip or actuate the latter.

The cam 312 is guided in a guide 314 and is withdrawn by means of a tension spring 315 secured between a pin 316 on the guide 314 and a pin 317 on the cam 312.

In the modification shown in Figs. 20, 21 and 22, an embodiment is shown which is readily adjustable to a wide range of dimensions and of sizes of work pieces. In this modification the work station is detachably secured to the loading station and may be replaced by work stations of different form or design or size.

The work piece is mounted on a plate having spaced openings to receive similarly spaced locator pins. This enables work pieces of different sizes or configurations to be mounted on the plates and passed through the transfer mechanism without the necessity of changing the positions of the locator pins as might be necessary if they had to fit openings in the workpieces themselves. The workpieces carrying plates have guides co-acting with the supporting rails so that separate guide rails are not required, which enables workpieces of different sizes or configurations to be passed through the apparatus without requiring any adjustment of the spacing of the guide rails.

The modification is shown largely in outline, certain features which may be similar or equivalent to those of previous modifications being omitted.

As shown more particularly in Fig. 20, the loading station is mounted on a base 318, and the work station on a base 319. The height of the work station is adjustable by means of leveling jacks 320 comprising complementary wedges 321, 322 and adjusting screws 323. The workpieces to be passed through the apparatus are mounted on carrying plates 324, each of which has on its under surface a pair of guide plates 325 and 326, Figs. 21, 22, 23, which have side contact with supporting rails 327 and 328 upon which the plate 324 slides.

As shown in Fig. 23 each plate 324 is provided with a latch or detent 329 slidable in a vertical guide passage 330 and pressed downwardly by means of a spring 331 against a stop 332. The lower end of the latch has an inclined surface 333 against which a complementary cam 334 mounted or welded on a transfer bar 335 and having a complementary inclined surface 336 to force the cam 329 upwardly until the cam 334 has passed to the rear whereupon the cam 329 is pushed downwardly and engaged by the cam 336 for forward movement.

The transfer bar 335 is secured by a bracket 337 to the stem 338 of a piston and cylinder 339 mounted on the base 318 by means of a bracket 340. The transfer bar 335 is guided in spaced guide brackets 341 which may be similar to the guide brackets shown in Fig. 10.

It will be apparent that as the transfer bar 335 moves in reverse the cams 334 carried by it will bear against and raise the latches 329 until the latter have been cleared and that on forward movement of the transfer bar the cams 334 will engage the latches 329 and move the plate 324 forwardly one station.

As shown in Fig. 20 there may be two stations on the base 318, one station being a loading station and the other an idling station.

The supporting bars 327 and 328 terminate at the end of the base 318 and do not extend to the work station. At the work station each plate 324 is in turn received on a pair of supporting rails 342 and 343 spaced apart a distance equal to the spacing of the supporting rails 327 and 328. The supporting plates 342 and 343 are carried on a platform 344 having a vertical supporting column 345 carried on a number of springs

346 (five for example) on a base plate 347. Normally the springs 346 support the rails 342 and 343 at about the level of the rails 327 and 328 so that the plates 324 may slide readily from the rails 327 and 328 to the supporting rails 342 and 343. The springs 346 are preferably preloaded sufficiently to take the weight of the plate and workpieces without being compressed. For example, they may be preloaded to support a pressure or weight of 180 pounds.

Extending upwardly from the base 319 are a pair of side columns 348 and 349 which carry respectively side guide plates 350 and 351 adjustably mounted on the uprights 348 and 349 to guide the workpiece accurately when additional pressure is applied to compress the springs 346. Spanning the upper ends of the uprights 348 and 349 is a yoke 352 in which is mounted a fluid pressure cylinder 353 carrying a clamping plate 354 which may be moved vertically.

When a plate carrying a workpiece is moved onto rails 343 and 342 in working position and the clamping plate 354 is forced downwardly, it forces the rails 342 and 343 downwardly, compressing the spring 346 to a greater tension as, for example, a pressure of 540 pounds.

During the downward movement of the clamping plate 354 and of the workpiece supporting plates 324, locator openings 355 and 356 in the latter receive locator pins 357 and 358, respectively, mounted on brackets 359 and 360 of the frame 319. The locator pins also act as rest buttons to receive and support the pressure of the clamping plate over and above that supported by the springs 346. The locator pins are rounded at their upper ends so that when the plate 324 is forced downwardly it enters on the locating pins and as these pins fit the recesses 355 and 356 with precision, the plate 324 is accurately positioned and held for the working or machining operation.

In this modification it will be apparent that the apparatus may be readily adjusted from a workpiece of one size or dimension to that of another, said inasmuch as the operations of clamping and locating are combined certain of the circuits may be combined and the system somewhat simplified.

During the machining of the workpieces a large amount of chips and cuttings are formed which accumulate about and drop below the workpiece. The fluid pressure operated pistons and cylinders directly connected to the transfer bars, as shown in the various modifications, are particularly desirable as they permit chips to fall freely without danger of being caught in moving mechanisms. The base of the machine may be provided with inclined walls, as indicated at 361 and 362 in Fig. 11, to form a chute to direct these chips to a suitable receiver, or with inclined walls as shown at 363, 364 in Fig. 20, to divert the chips to the side of the base.

A number of machines may be arranged in a train or series as shown in Fig. 24. As shown, the first machine of the series has a loading and turnover station from which the workpieces pass to the second, third and fourth working stations, thence directly to the load station of the second machine and to the stations 5, 6 and 7, of this machine and then to the loading station of the third machine.

The machine unit may be arranged as at 365 to operate on a workpiece at two or more stastations, or as shown on the opposite side at 366 to operate on the opposite side of the workpiece.

In the second station, a machining unit 367 is shown in position to machine the piece from the top at stations 5 and 6, while at 386 a unit is shown to operate on station 7 on the top of the workpiece while a unit 369 operates at the same station at the side.

It will be understood that the machines may be arranged in a train of any desired number and inasmuch as each machine is a separate unit, they may be rearranged or certain machines removed or others added. All that is necessary in setting up a train of these machines is to provide that the supporting rails shall be sufficiently aligned to permit the workpiece to slide from one machine to the next and to make the interconnection between the load station of one machine and the control apparatus of the preceding machine.

Having described my invention, what is claimed is:

1. Apparatus for moving a workpiece to successive work stations which comprises successive independently operable transfer machines each having a receiving station, a work station and a transfer mechanism to move a workpiece in successive steps from the receiving station to the work station of its respective machine and thence to the receiving station of the next machine, and an individual control mechanism for each machine to actuate said transfer mechanism, said control mechanism having a control element actuated by a workpiece at the receiving station of the next machine to interrupt the forward movement of said transfer mechanism.

2. The apparatus of claim 1 in which said transfer mechanism comprises a fluid actuated conveyor to move said workpieces from one station to another of said transfer machines.

3. The apparatus of claim 1 having an electric control system for controlling said transfer mechanism, said circuit having a switch opened by a workpiece in the receiving station of the next succeeding machine.

4. The apparatus of claim 1 having an electric control circuit for controlling said transfer mechanism to actuate said transfer mechanism when closed said circuit comprising in series a switch closed by a workpiece at the receiving station of said machine and a switch opened by a workpiece in the receiving station of the next succeeding machine.

5. Apparatus for moving a workpiece to successive work stations which comprises successive independently operable transfer machines each having a receiving station, a work station and a hydraulically operated reciprocating transfer element to move the workpieces from one station of said machine to the next and to the receiving station of the next succeeding machine and an individual control for each transfer machine to actuate said hydraulic means reversely to a position to engage a workpiece at the respective stations and thence forwardly to transfer said workpiece to the next station, and comprising an element actuated by a workpiece at the receiving station of the next machine to interrupt the movement of said transfer bar.

6. Apparatus for moving a workpiece to successive work stations which comprises successive independently operable transfer machines each having a receiving station, a work station and fluid operated means to move workpieces from one station to the next, a control means to actuate said fluid operated means, said control means comprising an electric circuit having a switch

operated by a workpiece at its receiving station to operate said fluid operated means and comprising a switch closed by a workpiece at the work station of the next machine to interrupt the movement of said fluid operated means.

7. Apparatus for moving a workpiece to successive work stations which comprises successive independently operable transfer machines each having supporting rails on which a workpiece may be moved from one station to a successive station, the rails of one machine being positioned to receive a workpiece from a preceding machine, a fluid actuated reciprocating transfer element movable in forward movement to move each workpiece of its respective machine to the next work station, control means for said fluid actuating means comprising an element operated by a workpiece at the receiving station of the next succeeding machine to stop the forward movement of said fluid actuated means.

8. The transfer mechanism of claim 1 having a turnover device at the load stations of said apparatus and comprising a shaft and receiving and supporting arms mounted on said shaft, a fluid operated piston controlled by the control

mechanism of said transfer mechanism to actuate said turnover device and means actuated by said turnover device to control the movement of said transfer mechanism.

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