July 6, 1948. G. D. RECHTON ET AL 2,444,787

MACHINE FOR FORMING MATERIALS

Original Filed Sept. 7, 1942 2 Sheets-Sheet 1

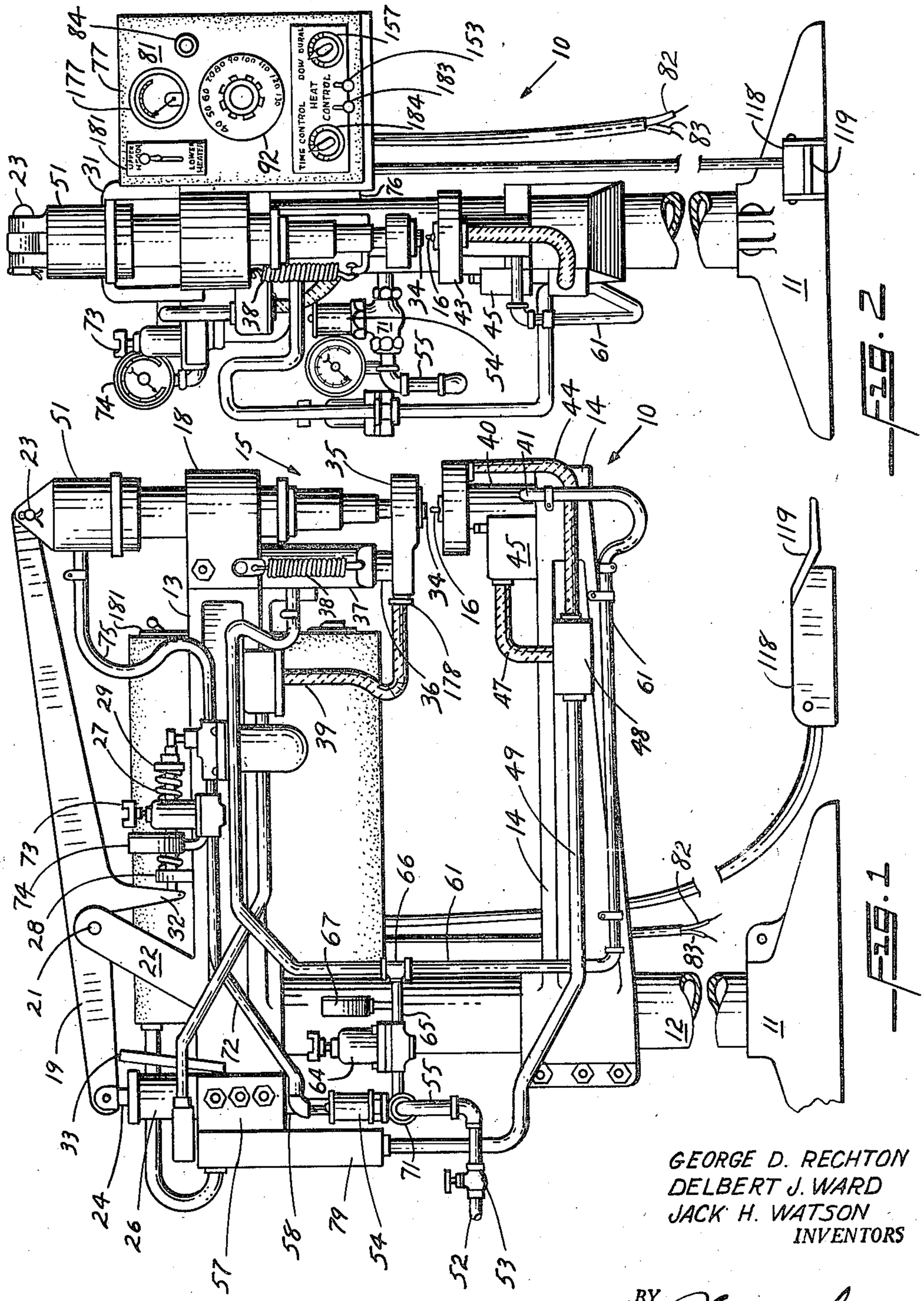

FIG. 2

FIG. 1

GEORGE D. RECHTON
DELBERT J. WARD
JACK H. WATSON
INVENTORS

BY J. Edwin Coates
ATTORNEY

July 6, 1948. G. D. RECHTON ET AL 2,444,787

MACHINE FOR FORMING MATERIALS

Original Filed Sept. 7, 1942 2 Sheets-Sheet 2

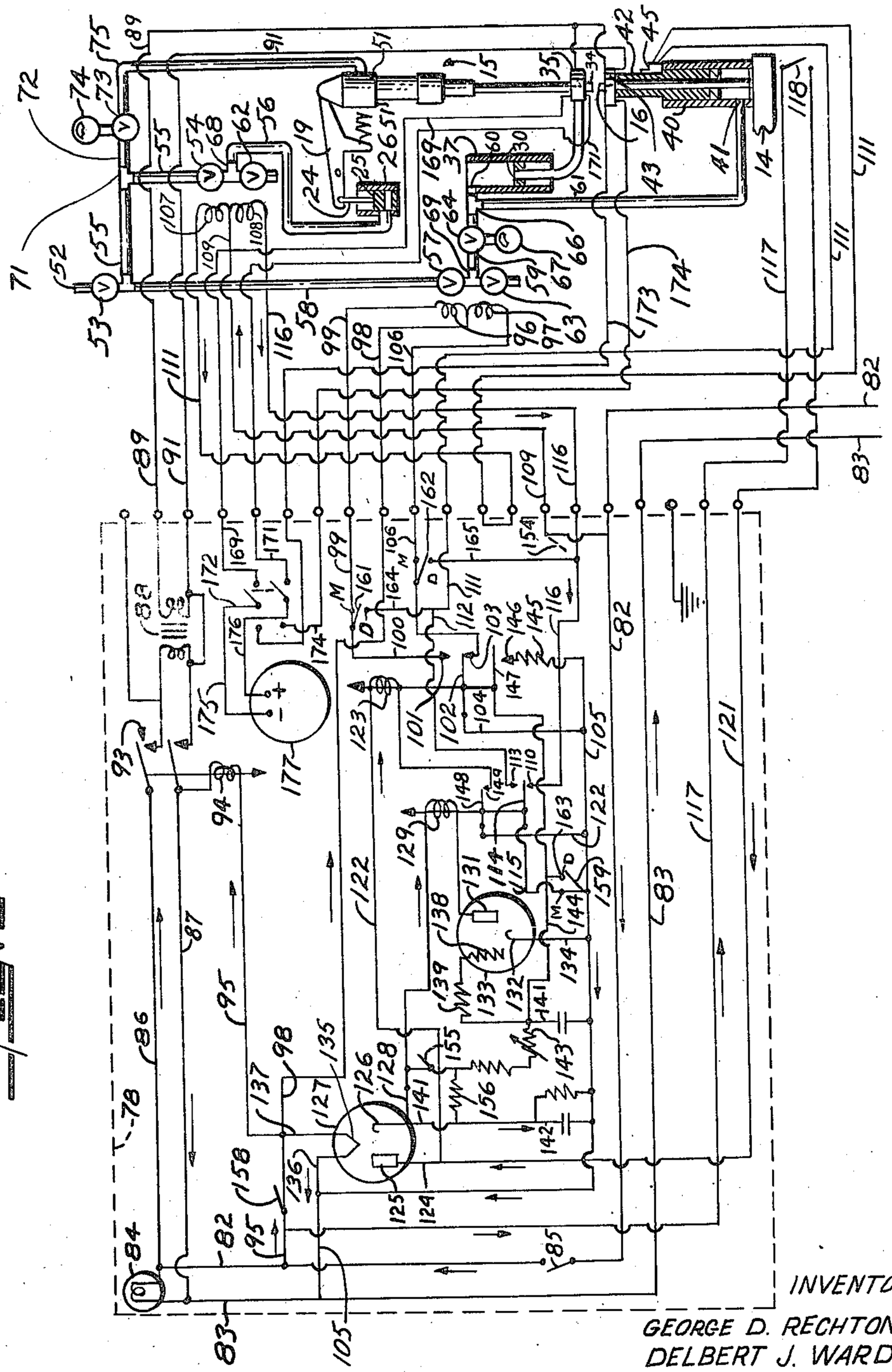

Fig. 2

INVENTORS
GEORGE D. RECHTON
DELBERT J. WARD
JACK H. WATSON
BY J. Edwin Coates
ATTORNEY

Patented July 6, 1948 2,444,787

UNITED STATES PATENT OFFICE

2,444,787

MACHINE FOR FORMING MATERIAL

George D. Rechton, Los Angeles, Delbert J. Ward, Sherman Oaks, and Jack H. Watson, Los Angeles, Calif., assignors to Douglas Aircraft Company, Inc., Santa Monica, Calif.

Original application September 7, 1942, Serial No. 457,630. Divided and this application September 20, 1944, Serial No. 555,027

5 Claims. (Cl. 153—21)

1

This invention relates to a machine for forming sheet material, and more particularly to an automatic machine for forming sheet materials which can be efficiently used by inexperienced personnel.

This application is a division of our application Serial No. 457,630, Machine for forming material, filed September 7, 1942, now Patent No. 2,372,516.

In the illustrated embodiment of the machine of the present invention the forming operation is produced by a pair of forming tools which are mounted for relative movement and which cooperate to bring about the desired forming action. One of the tools is controlled by an operator which is so formed that it is operative to actuate the tool only after the tool has been moved into contact with the work piece and is applying a predetermined pressure to the same.

To render the operator operative, means are provided for moving the same to cause the tool controlled thereby to move into progressively increasing pressural engagement with the work piece. The means for moving the tool controlled by the operator into engagement with the work piece comprises a spring-loaded pivoted lever normally holding the operator with its tool out of work-engaging position. The tool is moved into work-engaging position by a pneumatically operated piston connected to the lever and adapted to rock the same against the spring to move the operator and force the tool into engagement with the work.

The air supplied to the cylinder of the piston is regulated by an electrical control system including a pair of solenoids, the circuits of which are controlled by relay operated switches. The solenoids control inlet and exhaust valves and are so associated with the valves that the latter are open when the solenoids are energized.

A manually operable switch under the control of the operator of the machine when closed results in the energization of the inlet valve solenoid to bring about movement of the piston and the lever interconnecting the same and the tool operator to urge the tool carried by the latter into engagement with the work. The tool operator after it has been moved at a distance sufficient to cause the tool controlled thereby to apply the predetermined pressure against the work will apply a percussive force to the tool to complete the forming operation.

As the percussive force applied by the actuator is adjustable, work pieces of different materials as well as shapes and sizes can be effectively

2

formed by the machine of the present invention.

After the actual forming operation has been completed the operator of the machine opens the manually operable switch which de-energizes the relay resulting in the opening of the circuit of the solenoid controlling the inlet valve and the closing of the exhaust solenoid circuit. The energization of the exhaust valve solenoid opens the exhaust valve and the spring pressed lever returns the piston to its normal position and the actuator is moved to the position in which the tool controlled thereby is out of engagement with the work piece.

The machine is capable of high production being limited only by the movement of the work piece into and out of the work station of the machine as the only skill necessary to the efficient operation of the machine is the ability to ascertain whether the work is properly aligned with the forming tools prior to the forming operation. Therefore, personnel having little or no mechanical experience can successfully be assigned to the machine.

Other features and advantages of the machine of the present invention will be apparent from the following description taken in connection with the accompanying drawings, in which:

Figure 1 is a side elevation of a machine embodying this invention;

Figure 2 is a front elevation of the machine shown in Figure 1; and

Figure 3 is a schematic view showing the forming devices, the pneumatic mechanism for their operation, and a wiring diagram for the control of the pneumatic mechanism.

While a dimpling machine has been selected to disclose this invention, it will be understood that, as to some of its features, the invention is not restricted to a dimpling machine but is applicable to other forming machines.

Figures 1 and 2 show a dimpling machine 10 having a base 11 upon which is mounted a supporting column 12. A pair of generally horizontal laterally extending arms 13 and 14 are clamped to the column 12, the upper arm 13 supporting at its outer end a pneumatic tool operator 15 and the lower arm 14 supporting at its outer end a lower dimpling anvil assembly 16.

The tool operator 15 is mounted for vertical movement in the guide 18 at the outer end of the upper arm 13 by a lever 19 which is fulcrumed at 21 between ears 22 extending upwardly from the upper arm 13 and which is connected at its outer end to the upper end of the tool operator 15 at 23 and is connected at its inner end to a piston

rod 24 of a piston 25 (shown only in Figure 3) which reciprocates within a pneumatic cylinder 26 mounted upon the rear end of the upper arm 13. The lever 19 is spring loaded by a spring 27 compressed between a stationary lug 28 and a collar nut 29 on a bolt 31 which passes through an eye in the lug 28 and is pivoted at its outer end to the free end of a depending arm 32 on the lever 19. As the spring 27 tends to move the left end of the lever 19 downwardly as viewed in Figure 1, stop bar 33 is mounted on the arm 13 to engage the under side of the rear end of the lever 19 to prevent the piston 25 from striking the bottom of the cylinder 26.

The lower end of the tool operator 15, carries a forming tool or female die 34 and is surrounded by a heating element 35 of annular form. The heating element 35 is held in position laterally with respect to the tool operator 15 and supported vertically by a piston 36 which is vertically reciprocably movable within a pneumatic cylinder 37 mounted upon the outer end of the upper arm 13 adjacent the inner side of the tool operator 15. Admission of air to the pneumatic cylinder 37 moves the heating element downwardly and upon exhaust of air from this cylinder, the heating element is retracted to its normal position by the action of a tension spring 38 secured at its upper and lower ends to the guide 18 and piston 36 respectively. A cable 39 contains the electrical conductors for heating the element 35 and registering its temperature.

To the upper face of the outer end of the arm 14 is secured a pneumatic cylinder 40 to which air is supplied at an inlet 41. A tubular piston 42 reciprocates in the cylinder and carries at its upper end a heating element or heating body 43 which is apertured for the accommodation of the stationary male dimpling die 16. The support for the die 16 extends downwardly through the piston 42 and is mounted upon the lower arm 14. The heating element 43 is thus vertically slidable with respect to the stationary dimpling die 16 from a lower retracted position to an upper position in which it makes contact with the metal sheet to be dimpled. A cable 44 contains the conductor wires for supplying the energy to heat the heating element 43 and to register its temperature.

The heating elements 35 and 43 per se or their use as heating elements form no part of the present invention, being disclosed and claimed in our copending application above identified. The heating element 43, in the illustrated embodiment of the machine of the present invention, closes a microswitch 45 connected to the control mechanism by a cable 47. The cables 44 and 47 lead to a junction box 48 from which electrical connections are made to the control and indicating devices by the cable 49.

The system of air conduits and pneumatic control devices for operation of the pneumatic cylinders 26, 37, and 40, and for operation of the pneumatic cylinder 51 of the tool operator 15, are shown schematically in Figure 3, some of the conduits and control devices appearing in the structural views, Figures 1 and 2. Air enters the machine under pressure 52 through a gate valve 53 and may proceed to an electrically controlled valve 54 through the pipe 55 and thence, when valve 54 is opened, through a pipe 56 to cylinder 26 to actuate the lever 19 to depress the tool operator 15.

Air may also pass from the gate valve 53 to the electrically controlled valve 57 through pipe

58, for transmission when valve 57 is in open position through supply conduit 59 and then pipes 60 and 61 to cylinders 37 and 41 respectively for movement of the heating elements 35 and 43 respectively from their retracted position to their position of contact with the metal sheet to be dimpled. Electrically controlled exhaust valves 62 and 63 are in closed position when valves 54 and 57 respectively are in open position, and vice versa. They function to relieve the air pressure in cylinder 26 and in cylinders 37 and 40 respectively for the elevation of the dimpling gun in the case of cylinder 26 and the retraction of the heating elements 35 and 43 in the case of the cylinders 37 and 40.

A valve 64 and a pressure gauge 67 in the supply conduit 59 leading to the T connection 66 joining the conduit 59 and the pipes 60 and 61 provide means for regulating the air pressure transmitted to cylinders 37 and 40 at any desired value, thus regulating the degree of pressure at which the heating elements engage the metal sheet. The section of exhaust pipe in which exhaust valve 62 is placed, the air supply pipe 55 and the pipe 56 leading to the cylinder 26 are connected as shown by a T 68. The exhaust pipe in which valve 63 is placed, the air supply pipe 58 and the conduit 59 leading to the T 66 are connected as shown by means of a T 69.

To T 71 interposed in the air supply pipe 55 is connected a pipe 72 leading to a pressure regulating valve 73, which in conjunction with a pressure gauge 74 serves to regulate the air pressure in pipe 75 leading to the cylinder 51 of the tool operator 15 and tripping the pneumatic firing device for applying an impulse force to the dimpling die when the pressure between the upper and lower dimpling dies reaches a prescribed value after the tool operator has been lowered and the two dies brought into engagement with the metal sheet to be dimpled through depression of the tool operator 15 by the lever 19 upon actuation of the piston 25 operating in cylinder 26.

Upon an angle support 76 secured to the upper arm 13 is mounted a control box 77 which houses the electrical control equipment for sequential control of the electrical devices for the actuation of valves 54, 62, 57, and 63. These devices and their connections are enclosed within dash lines on Figure 3 and designated by the numeral 78. The valves 54, 62, 57, and 63 are electrically actuated by solenoids in a manner to be hereinafter explained, the conductors from the control box 77 to the various valve operating solenoids passing through a connection box 79 mounted on the inner end of the upper arm 13.

The front face of the control box 77 serves as a control panel 81 upon which are mounted the several dial switches and other manual controls, and the value registering instruments for use in operating the machine. These several control devices and registering instruments will be referred to and described in the course of the following explanation of the wiring diagram of Figure 3. On this diagram the arrows indicate the direction of potential drop.

Electrical energy is supplied to the control box by a lead-in cable comprising conductors 82 and 83. A warning light 84, connected across these main conductors 82 and 83, is placed on the panel to indicate passage of current to the control devices of the control box and thence to the heating elements and electrically operated valves. A line switch 85 controls the supply of current to

the machine. Conductors 86 and 87 constitute a shunt heating circuit connected to the wires 82 and 83 of the power circuit, and supply electrical energy through a transformer 88 to the heating elements 35 and 43 in parallel through wires 89 and 91. The transformer 88 is of the variable tap type and includes an adjusting knob 92 mounted on the control panel of the machine. The transformer 88 controls the wattage input and consequently the temperature of the heaters 35 and 43. The primary of the transformer 88 is connected to the conductors 86 and 87 by a normally open switch 93. This switch is automatically closed upon closing of the main switch 85 by a relay coil 94 which is connected between power lines 82 and 83 by the conductor 87 and a conductor 95.

The pressure valve 57 and the exhaust 63 are operated by solenoids 96 and 97 respectively, each valve being spring retracted to closed position upon the de-energization of the associated solenoid. The solenoids 96 and 97 are formed with a common terminal connected by lead 98 to the conductor 95 and the power line 82. The other terminal of solenoid 96 is connected to the line 83 by a shunt circuit comprising the conductors 99, 100, contact 101, switch arm 102, movable between contacts 101 and 103, and conductors 104 and 105. The other end of the solenoid 97 is connected to the power line 83 by a shunt circuit comprising conductor 106, contact 103, switch arm 102, and conductors 104 and 105.

The pressure valve 54 and the discharge valve 62 for operation of the piston 25 are actuated by solenoids 107 and 108 respectively, each valve being spring retracted to its closed position. Solenoid 107 is connected to the power line 82 by the conductor 109 and to power line 83 by a shunt circuit comprising the conductor 111 including the micro switch 45, conductor 112, contact 113, switch arm 114 and conductors 115 and 105. Solenoid 108 is connected to the power line 82 by the common conductor 109 and to line 83 by a shunt circuit comprising conductor 116, contact 110, switch arm 114, conductor 115 and conductor 105.

A control circuit which is connected to the power lines 82 and 83 comprises the conductor 117, the switch 118 operated by the foot pedal 119 as best seen in Figures 1 and 2, and conductor 121 and conductor 122 in which is disposed the relay coil 123.

Another control circuit which is also closed by the foot operated switch 118 and is arranged in parallel with the circuit of the relay 123 comprises conductors 117, 121, and 124, anode 125, and cathode 126 of a rectifier tube 127, conductor 128, relay coil 129, anode 131 and cathode 132 of a gas trigger tube 133, and conductors 134 and 105. The filament 135 of the rectifier tube 127 is connected to the power line 82 by conductors 137 and 95 and to line 83 by conductors 136 and 105. The effect of the rectifier tube is to impress a direct current potential upon the control relay coil 129 and the anode 131 of the trigger tube 133.

Current flow from anode 131 to cathode 132 of the gas trigger tube 133 occurs upon charging of the grid 138 to a predetermined value, the resistor 139 limiting current flow from the grid 138 to cathode 132. The grid is charged with a positive voltage to the prescribed value by an RC voltage accumulator circuit 141 connected between the cathode 126 of the rectifier tube 127 and the conductor 105. This circuit includes a

filtering circuit 142 for filtering the same and the circuit of the relay 129. As usual this accumulator circuit comprises resistance and condenser elements as shown, the time interval required for the voltage build-up being regulated by the variable resistor 143. Discharge of the RC circuit is provided for by a discharge circuit comprising the conductor 144 in which is interposed the usual resistance element 145 having a contact terminal 146 adapted to be engaged by a movable switch arm 147.

When the switch 118 is closed, the relay 123 is energized and moves switch arm 102 into engagement with contact 101, connecting conductors 100 and 104 to complete the circuit by which the solenoid 96 is energized for the operation of the valve 57.

Energization of relay 123 also moves the switch arm 147 out of engagement with the contact terminal 146 of the resistor 145 to open the discharge circuit 144 and the accumulator circuit 141 begins to charge. When the accumulator circuit is charged with the predetermined voltage the grid 138 actuates the trigger tube 133 allowing current to flow from the anode 131 to cathode 132 to energize the relay 129.

Energization of the relay 129 moves the switch arm 148 out of engagement with the contact 149 thereby de-energizing relay coil 123. De-energization of the relay coil 123 causes the switch arm 102 to be moved into engagement with the contact 103 to electrically connect conductor 106 with conductor 104 to complete the circuit for energization of solenoid 97 for the operation of the valve 63. Energization of the relay coil 129 also causes switch arm 114 to engage the contact 113 to electrically connect conductor 112 with conductor 115 and thus energize the solenoid 107 which opens the pressure valve 54 for the lowering of the tool operator 15. When the switch 118 is opened the relay 129 is de-energized and the switch arm 148 again engages contact 149. The de-energization of the relay 129 also causes the switch arm 114 to be moved into engagement with contact 110 to connect conductor 116 with conductor 115 and thus complete the circuit for energization of the solenoid 108 for opening the discharge valve 62 resulting in the elevation of the tool operator 15.

The micro switch 45 is in closed position when the heater element 43 is in its lower-most position and opens at the initiation of the upward movement of this heater in response to opening of the valve 62. The microswitch 45 is interposed on the conductor 111 and prevents operation of the solenoid 107 in response to closing of the switch 113, 114 until the heater 43 has reached the lower limit of its travel .

A switch operator, which is shown on the panel 81 at 153 operates a normally closed switch 154 interposed in conductor 109 and a normally closed switch 155 which normally short circuits a high resistance element 156 of the voltage accumulator circuit 141. The operator 153 in one position closes the switches 154 and 155 but when the operator 153 is thrown to its other position, switches 154 and 155 are opened, having the effect of preventing movement of the tool operator 15 and increasing the time interval required to charge the grid 138 sufficiently for passage of current from anode 131 to cathode 132 of the gas trigger tube 133.

The machine of the present invention is particularly designed for dimpling "Dural" or other metals which may be worked cold without the de-

velopment of structural weakness. A switch operator mounted on the panel 81, and indicated in Figure 2 by the numeral 157, operates four switches which appear on the wiring diagram of Figure 3 and are designated by the numerals 158, 159, 161, and 162. Switch 158 is interposed in conductor 95 and when open prevents energization of the relay coil 94 which controls the heater circuit. Switch 159 has two positions, designated on the diagram as M and D. When this switch is in position M conductor 115 is connected to conductor 105 permitting operation of the pressure valve 57 and discharge valve 63. When it is in position D it short-circuits the voltage accumulator discharge circuit 144, connecting this circuit through conductor 163 to conductor 105.

Switch 161 has two positions, indicated by the letters M and D. When in the position M conductors 99 and 100 are connected completing the circuit for operation of the valve 57. When in position D conductor 111 is connected to conductor 100 through a cross-circuit conductor 164 for energization of solenoid 107 for the operation of pressure valve 54 to lower the tool operator 15.

Switch 162 has two positions, designated by the letters M and D. When this switch is in position M the circuit for the solenoid 97 is complete and the discharge valve 63 may be operated to retract the heating elements to their normal positions. When this switch is in position D it connects conductor 116 with conductor 106 through the cross circuit conductor 165, completing a circuit for the operation of solenoid 108 which actuates discharge valve 62 for the elevation of the tool operator 15.

When the operator 157 is turned to the right hand position designated "Dural," switch 158 is opened and the other three switches are in their D position. With the switch 158 open the relay 94 is de-energized and the switch 93 is opened so that the heating elements are no longer connected to the power lines 82 and 83. Movement of the switch 159 to the D position short circuits the voltage accumulator 141 preventing charging of the grid 138 of the gas trigger tube 133 thus rendering inoperative the control relay 129.

When the foot pedal switch 118 is now closed current flows through relay coil 123 which causes the switch arm 102 to move into engagement with contact 101 to complete a circuit through conductor 109, solenoid 107, conductor 111, including micro switch 45 now held closed by the heater 43, conductor 164, switch 161, conductor 100, switch 101—102, and conductors 104 and 105. As previously explained, energization of the solenoid 107 actuates the valve 54 to lower the tool operator 15 to bring the tool 34 into engagement with a work piece not shown in the drawing but placed between the dies 34 and 16. As explained above, the tool operator is such that it will apply a percussive force to the tool 34 after the tool has been moved into engagement with the work piece and is applying a predetermined force against the same.

After the die 34 has, in cooperation with the die 16, formed the work piece, the foot pedal switch 118 is raised, which de-energizes the relay coil 123 and moves the switch arm 102 into engagement with the contact 103. The closing of the switch 102—103 completes a circuit comprising conductors 109, solenoid 108, conductor 116, conductor 165, switch 162, conductor 106, switch 102, 103, and conductor 104 to energize the solenoid 108. The energization of the solenoid

108 actuates valve 62 to permit the lever 19 to return the piston to its original position and raise the tool operator 15. The tool 34 as it is connected to the operator 15 moves out of engagement with the work piece and the same may be removed from the machine or a new area presented to the dies of the same. In either case the machine is immediately ready for another work operation which may initiated by closing of the foot operated switch 118.

While there have been described herein certain embodiments now preferred, it is to be understood that the invention is not to be confined to the particular embodiments illustrated for it is susceptible to changes in form and detail coming within the scope of the appended claims.

We claim:

1. A sheet metal forming machine comprising: a frame having a work receiving throat and comprising a pair of vertically spaced laterally extending arms; a tool fixed to one of said arms; tool operating means; means for mounting said operating means on the other of said arms for movement toward and away from the fixed tool; a tool carried by said operating means and adapted to be moved by said operating means into working engagement with a sheet of material disposed in said throat; a lever pivotally mounted intermediate the end thereof to the arm carrying said operating means; means interconnecting one end of said lever and said operating means; resilient means normally holding said lever in a position in which the tool carried by said operating means is in an inoperative position; means connected to and adapted to move the other end of said lever in one direction whereby the end connected to said operating means moves in the opposite direction to move said operating means and the tool carried thereby into gradual, unimpacted engagement with a sheet of material disposed in said throat; and means made operative upon the application of a predetermined force resulting from the engagement between the tool carried by said operating means and said sheet for actuating the latter to cause said tool to percussively impact and angularly form said sheet, with planar and rectilinear surfaces that define a dimple for a flush-type rivet, said resilient means returning said lever to its normal position after the work operation to permit a different area of said sheet to be moved into said throat.

2. In a sheet metal forming machine, the combination of: a frame providing a work receiving throat and comprising an upright and a pair of laterally extending arms on the two sides of said throat respectively; a support carried by the frame for work disposed in said throat; a first forming tool carried by one of said arms; a percussive tool gun carrying a pneumatically operated, impulse-stroke, second forming tool, said gun being mounted on the other of said arms and reciprocably movable with respect to said support, said second tool being reciprocably operable by said gun in response to a predetermined pressure applied to the metal sheet by said first and second tools when in engagement with said metal sheet; fluid pressure operated means for moving said gun to bring said tool into progressively increasing pressural engagement with said sheet, said fluid pressure operated means including a spring retracted, single-acting piston-cylinder means, one element of which is stationarily mounted on said frame and the other element of which is connected to reciprocably move said gun,

said cylinder having associated therewith a pressure inlet passage means and an exhaust passage means and a selector valve means for controlling said passage means; an electric solenoid means for operating said selector valve means; and a manually operated switch for said electric solenoid means.

3. In a sheet metal forming machine, the combination of: a frame providing a work receiving throat and comprising an upright and a pair of laterally extending arms on the two sides of said throat respectively; a support carried by the frame for work disposed in said throat; a first forming tool carried by one of said arms; a percussive tool gun carrying a pneumatically operated, impulse-stroke, second forming tool, said gun being mounted on the other of said arms and reciprocably movable with respect to said support; said second tool being reciprocably operable by said gun in response to a predetermined pressure applied to the metal sheet by said first and second tools when in engagement with said metal sheet; fluid pressure operated means for moving said gun to bring said tool into progressively increasing pressural engagement with said sheet, said fluid pressure operated means including a spring retracted, single-acting piston-cylinder means, one element of which is stationarily mounted on said frame and the other element of which is connected to receiprocably move said gun, said cylinder having associated therewith a pressure inlet passage means and an exhaust passage means and a selector valve means for controlling said passage means; an electric solenoid means for operating said selector valve means; a manually operated switch for said electric solenoid means; and means for returning said moving means to its original position; said percussive means returning with said moving means whereby the tool carried by said percussive means is moved out of engagement with said sheet so that a different area of the same can be presented to said tool.

4. A sheet material forming machine, comprising: a stationary forming tool adapted to support a sheet of material; a movable forming tool; tool operating means carrying said movable tool; means for bodily displacing the tool operating means and the movable tool concurrently to bring

the latter into an initial and progressively increasing localized contact with said sheet; percussive means directly supporting said movable tool and independently movably mounted in said bodily movable tool operating means for movement relative to said stationary forming tool; means responsive to a predetermined amount of pressure between the movable tool and the sheet to effect independent movement of said percussive means; and means for returning the tool operating means to its original position carrying said percussive means and said movable tool.

5. A sheet material forming machine, comprising: a stationary forming tool adapted to engage a sheet of material; a movable forming tool; tool operating means carrying said movable tool; means for bodily displacing the tool operating means and the movable tool concurrently to bring the latter into an initial and progressively increasing localized contact with said sheet; fluid operative percussive means directly engaging said movable tool and independently movably mounted in said bodily movable tool operating means for movement relative to said stationary forming tool; fluid pressure means having the one terminal connected to a source of pressure and having the other terminal communicable with said percussive means at a predetermined amount of pressure between said movable tool and said sheet to effect further movement of said independently movable percussive member and urge the toool carried thereby into further and deforming contact with said sheet; and means for returning the movable-tool-carrying tool operating means to its original position carrying said percussive means and said movable tool.

GEORGE D. RECHTON.
DELBERT J. WARD.
JACK H. WATSON.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
2,269,778	Merrill	Jan. 13, 1942
2,323,015	Dent	June 29, 1943