DIMPLING AND RIVETING MACHINE

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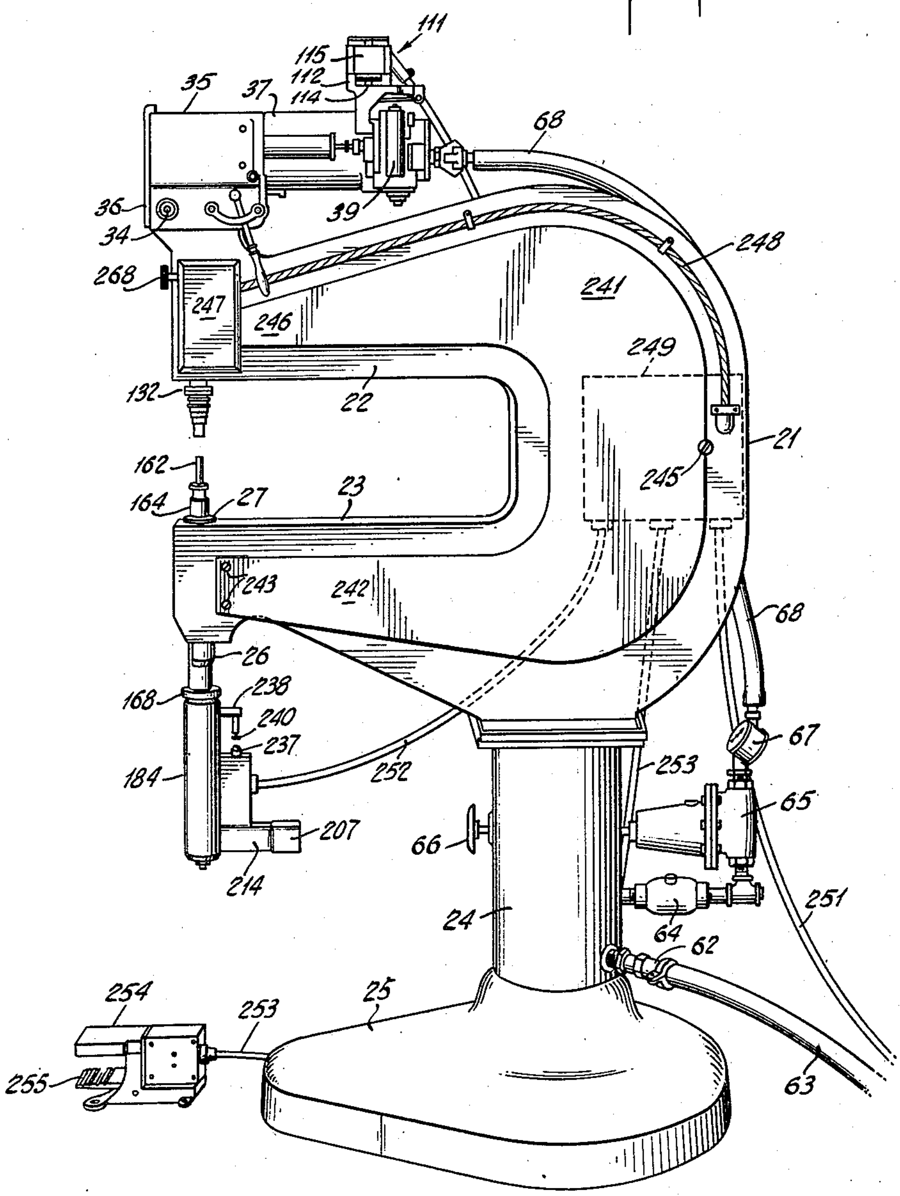
Fig. 1.



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DIMPLING AND RIVETING MACHINE

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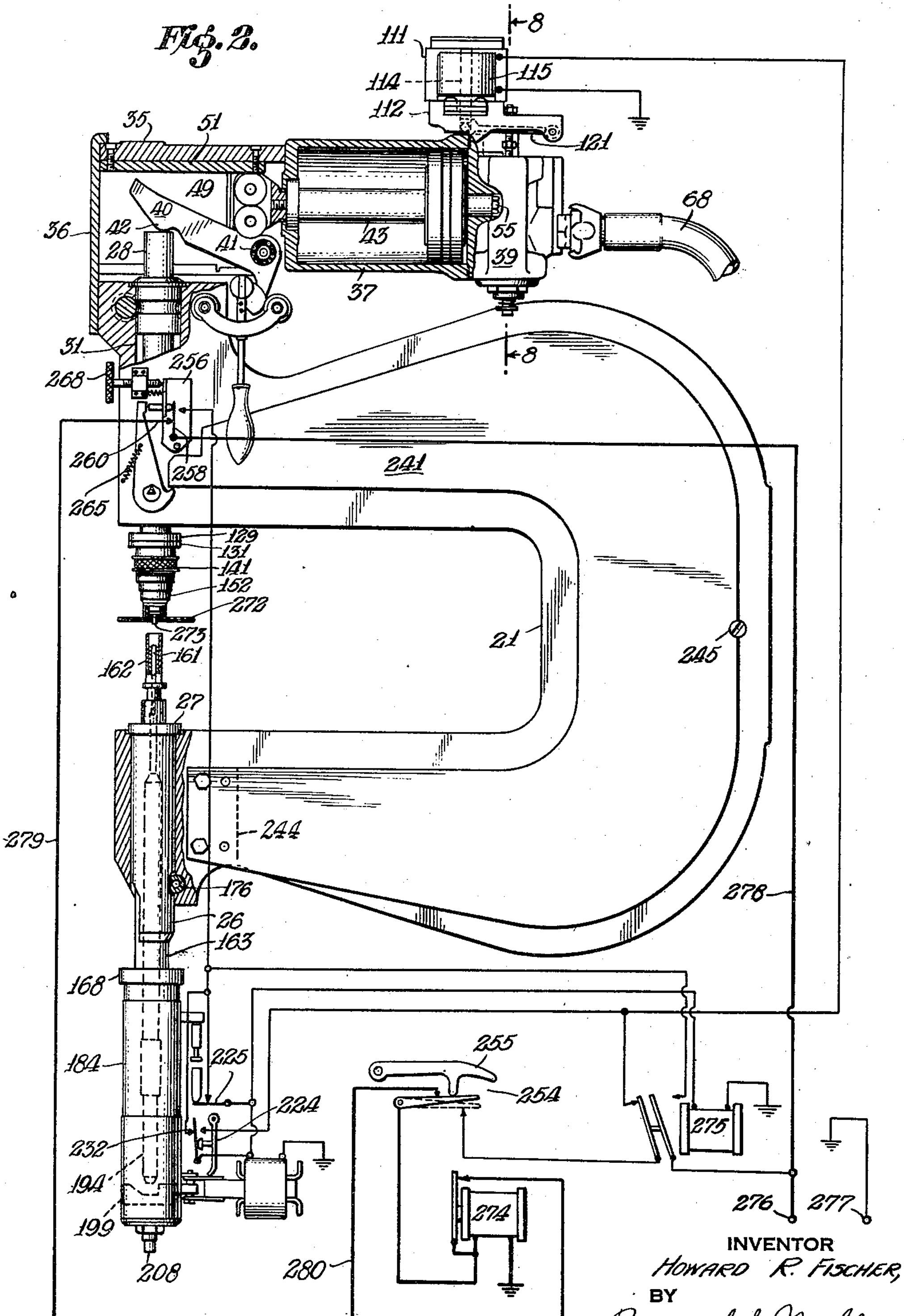
Fig. 2.



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DIMPLING AND RIVETING MACHINE

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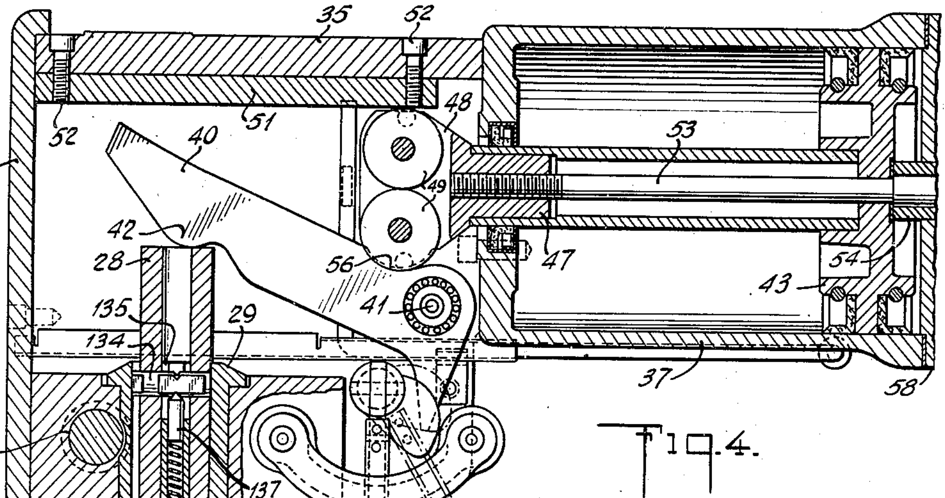
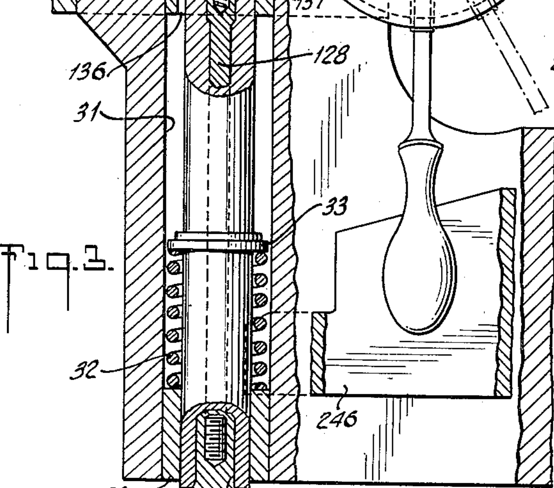
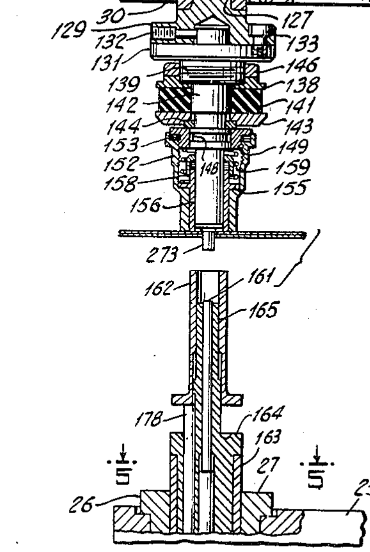

Fig. 3.

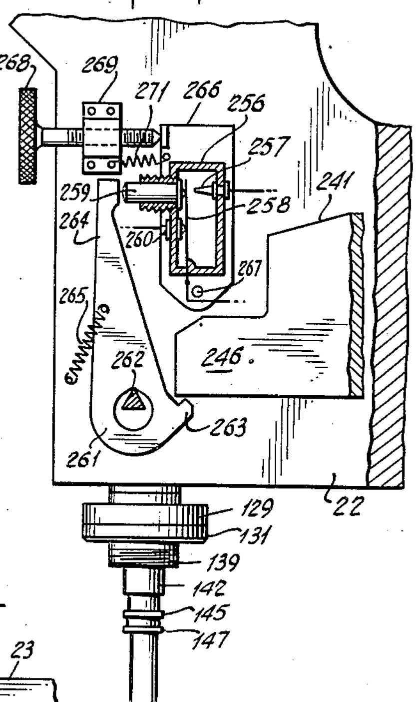

Fig. 4.

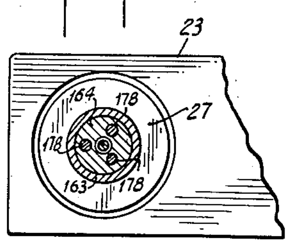

Fig. 5.

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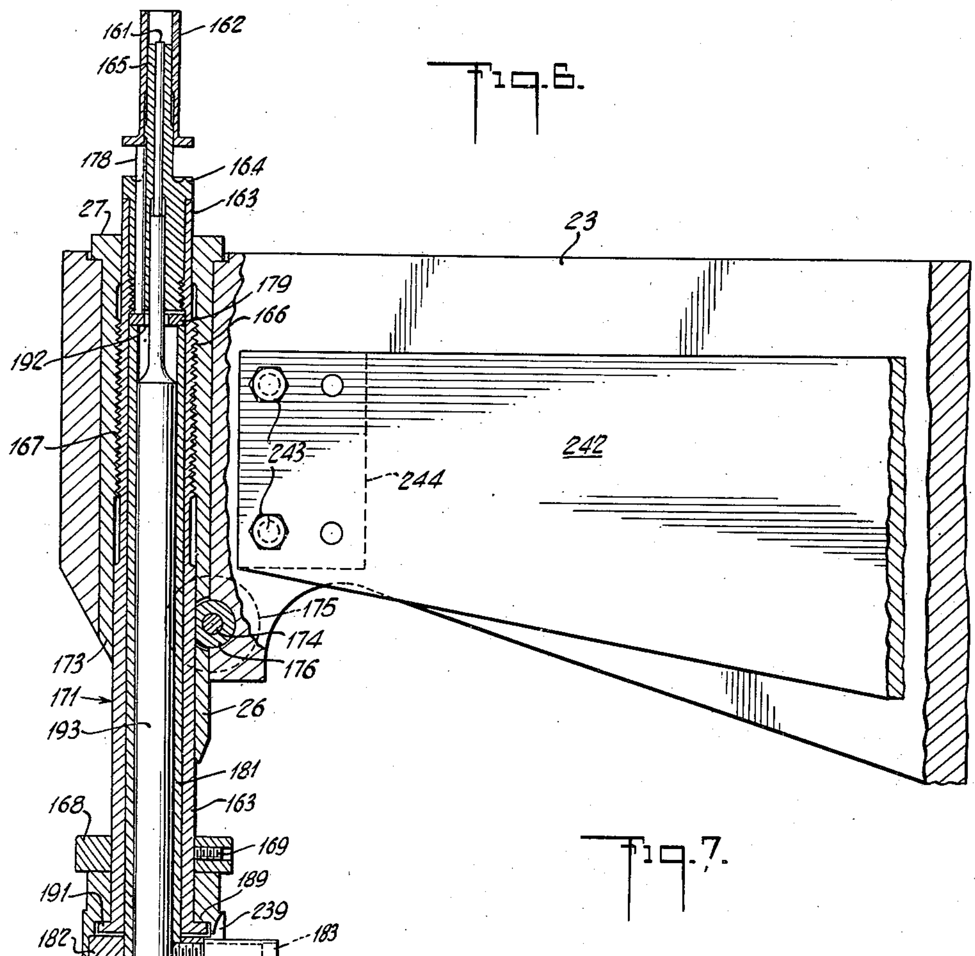
Fig. 6.



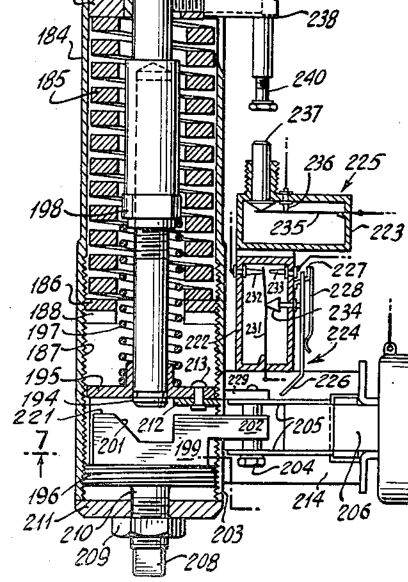
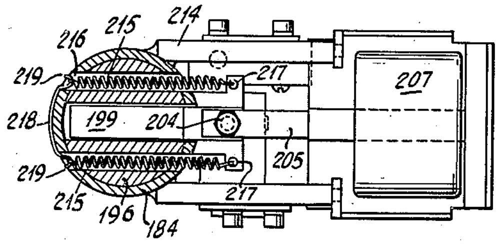


Fig. 7.



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DIMPLING AND RIVETING MACHINE

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Fig. 8.

Fig. 9.

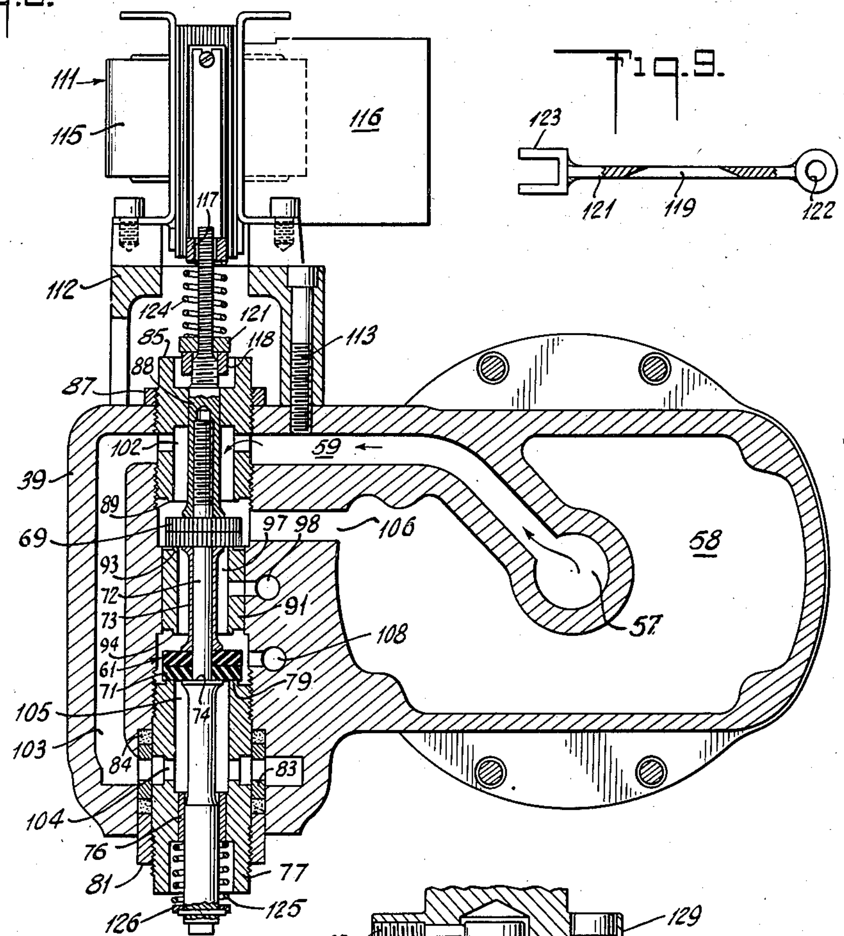

Fig. 10.

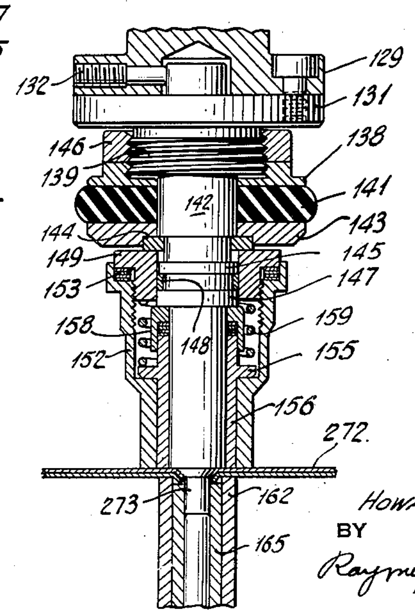

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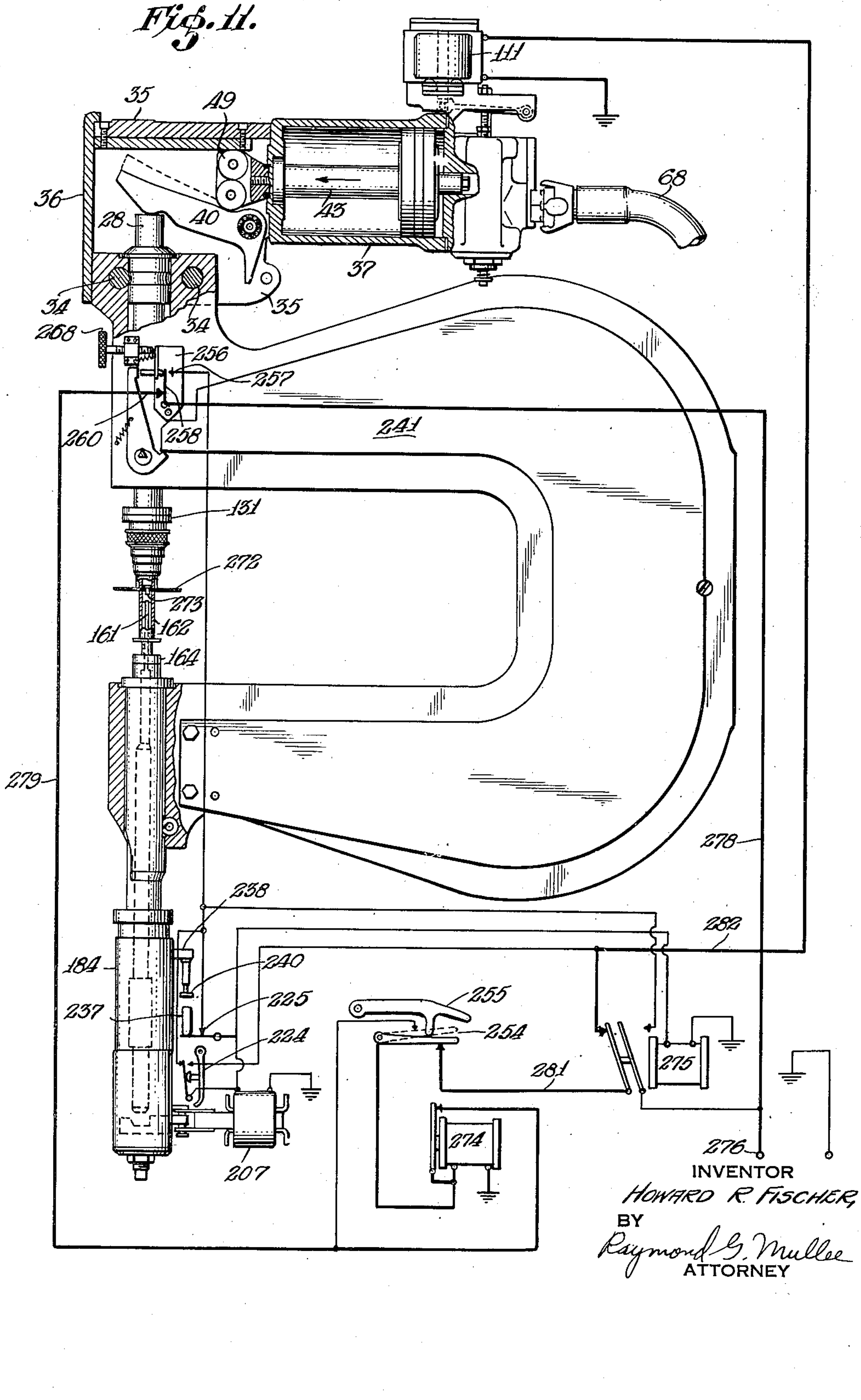
Fig. 11.



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DIMPLING AND RIVETING MACHINE

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Fig. 12.

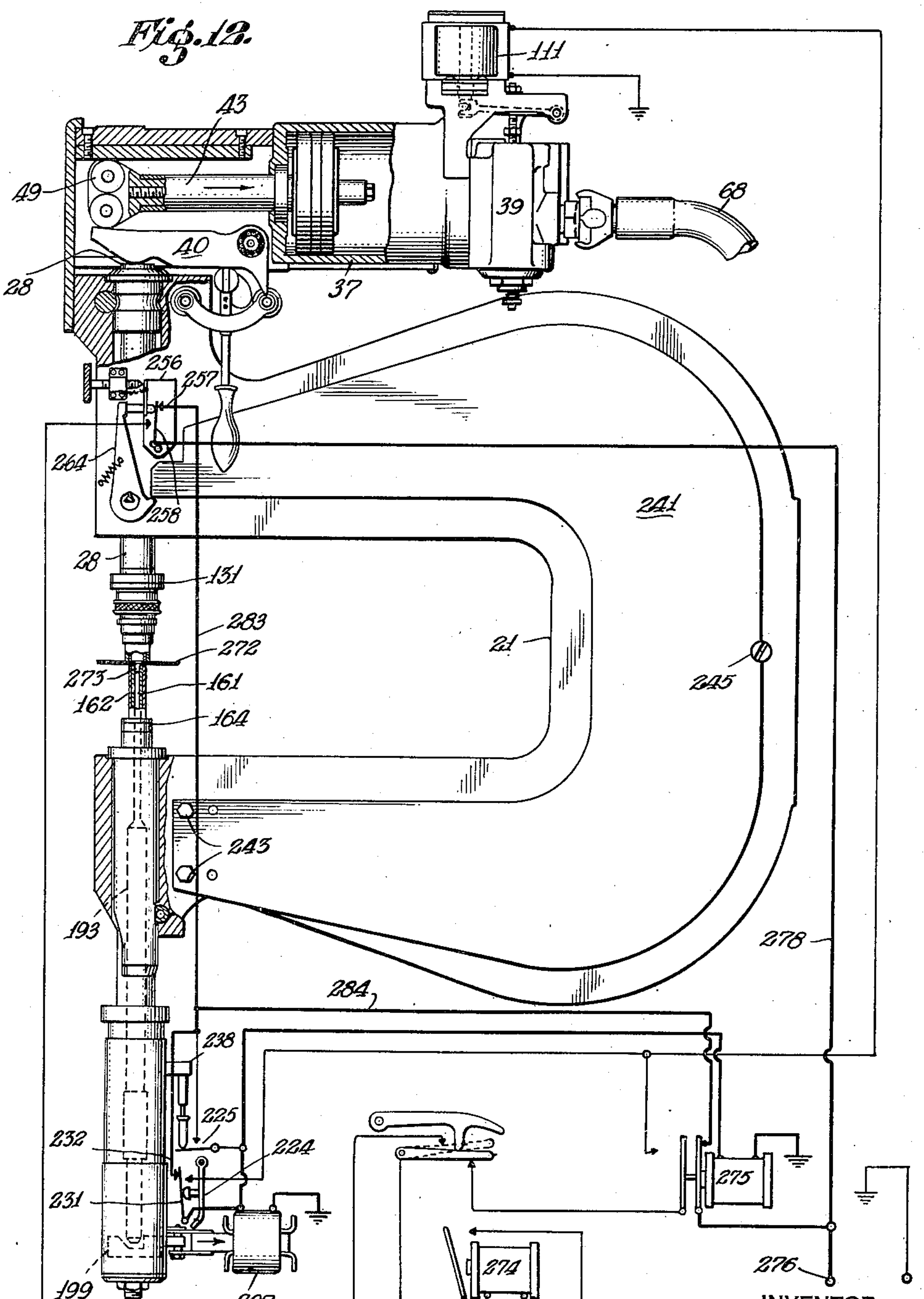

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Fig. 13.

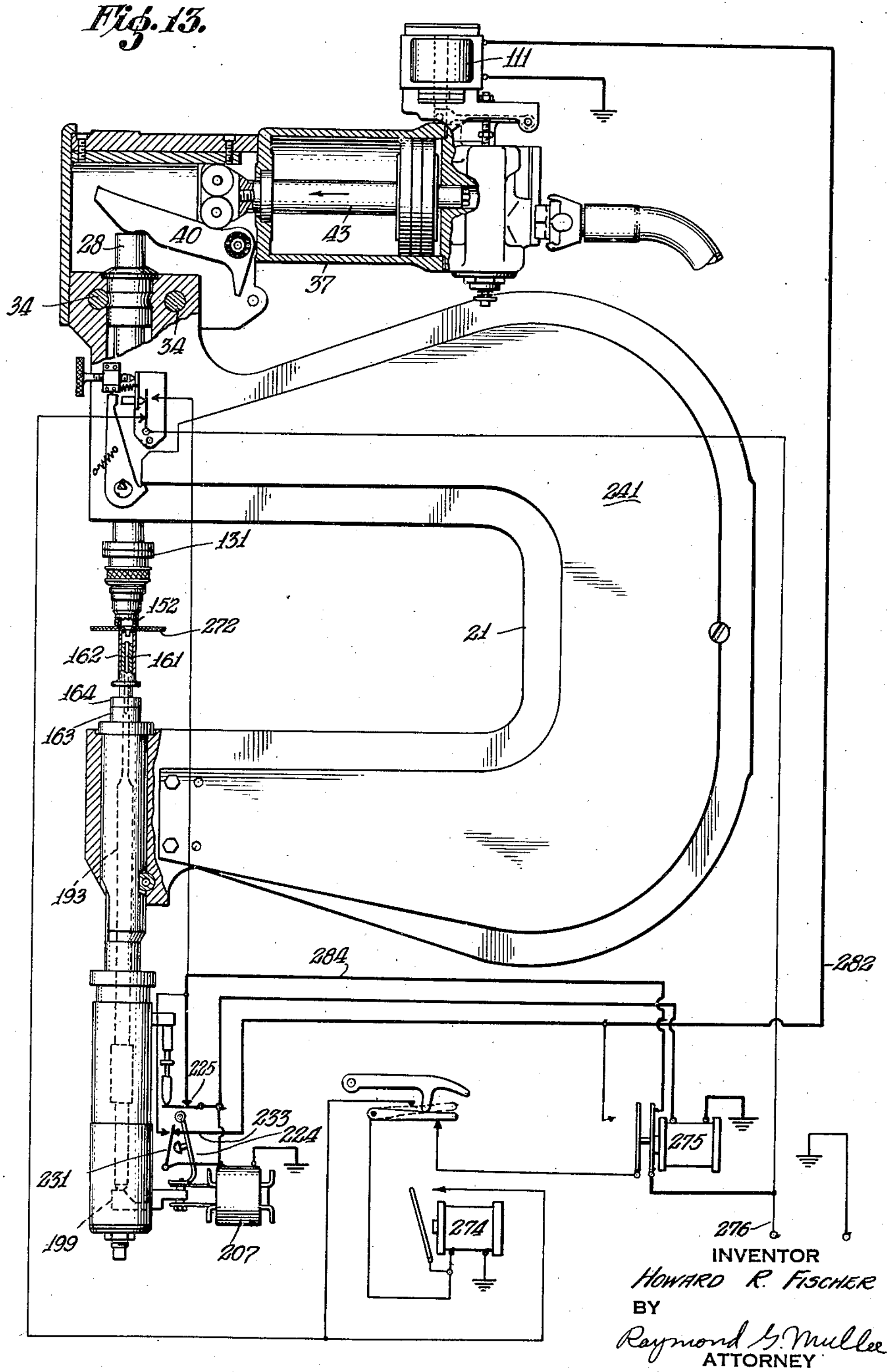

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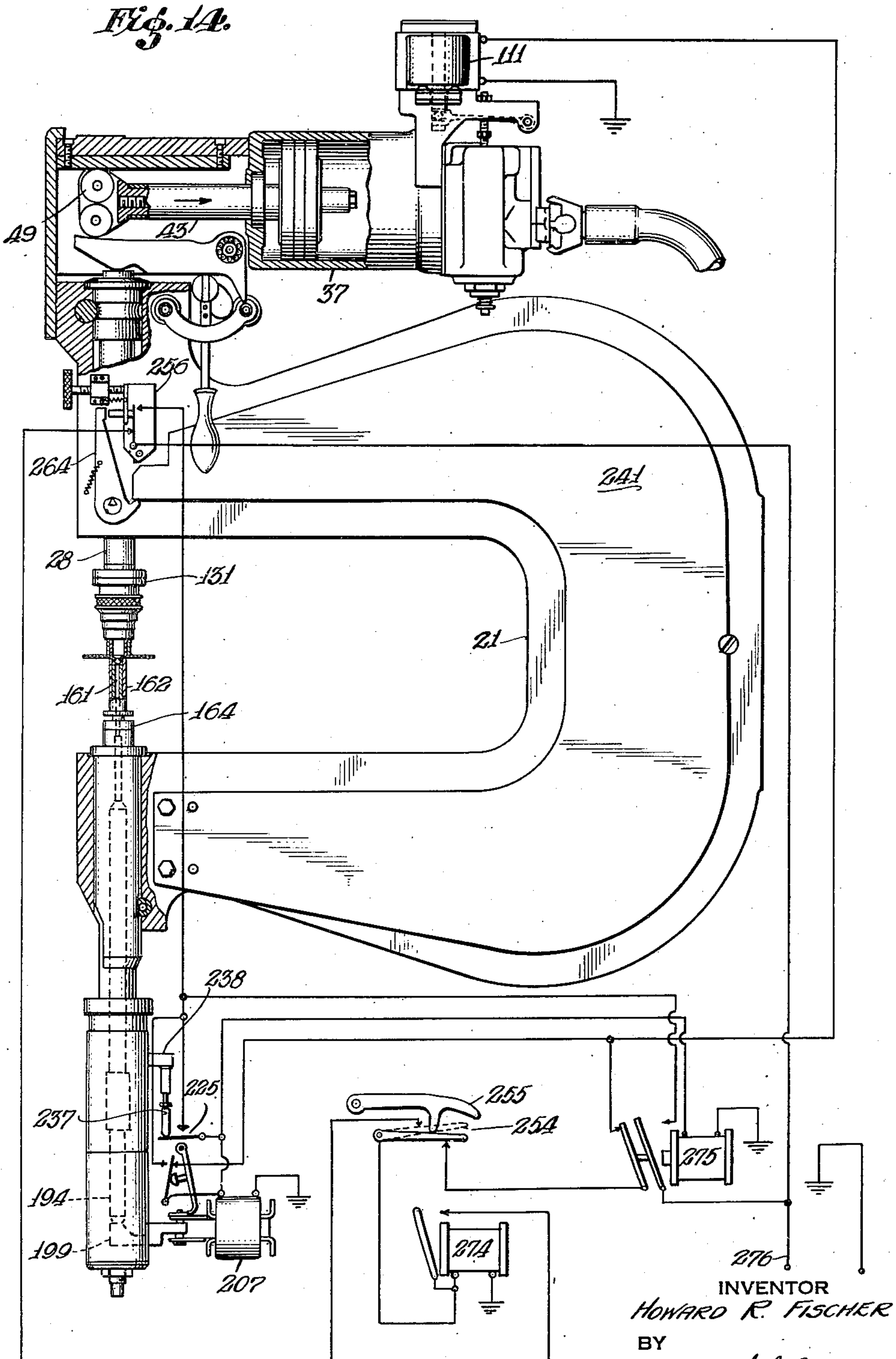
Fig. 14.



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Patented June 8, 1948

2,442,949

UNITED STATES PATENT OFFICE

2,442,949

DIMPLING AND RIVETING MACHINE

Howard R. Fischer, Detroit, Mich., assignor to Chicago Pneumatic Tool Company, New York, N. Y., a corporation of New Jersey

Application February 15, 1945, Serial No. 577,953

6 Claims. (Cl. 78—48)

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This invention relates to dimpling and riveting machines and particularly to a type of machine adapted to dimple the work or sheet metal by means of a rivet introduced into a hole therein and thereafter to set the rivet in the dimpled portion of the work. This type of machine is especially suited for the assembly of aluminum sheets to form the skin covering on the wings, fuselage and other exposed parts of an airplane.

The main object of the invention is to equip a dimpling and/or riveting machine with facilities for using a flush type countersunk head rivet for forming a dimple in the work by the pressure of the rivet head against the sheets.

Another object is to have such a machine equipped with instrumentalities to set the rivet in situ following the dimpling step performed by said rivet and thus insure a perfect fit of the latter in the dimpled portion of the work.

A further object is to save time and eliminate needless steps and motions usually considered conventional and necessary in dimpling and riveting operations by causing the riveting operation to follow as a later stage of the dimpling operation without in any way shifting or disturbing the work between stages.

It is also an object to have the dimpling and riveting machine provided with means for automatically carrying out the entire operation of dimpling and subsequent riveting when the cycle of operation has once been started.

Other objects and advantages of the invention will appear more fully in the following specification when noted in conjunction with the accompanying drawings, in which:

Fig. 1 is a general perspective view of a dimpling and riveting machine equipped with apparatus embodying the invention in a practical form;

Fig. 2 is an enlarged side elevation of the main portion of the machine with parts in section while electrical equipment associated therewith is shown in diagrammatic form, the machine being disposed in its initial stage and having a rivet inserted in the work piece;

Fig. 3 is a further enlarged fragmentary view, chiefly in section, of the upper front portion of the machine disclosing part of the upper jaw and part of the lower jaw with the dimpling and riveting tools therein;

Fig. 4 is a fragmentary view of the upper jaw of the same machine showing the deflection switch in detail;

Fig. 5 is a transverse section of part of Fig. 3 taken on line 5—5;

Fig. 6 is an enlarged fragmentary view, chiefly in section, of the lower front portion of the machine;

Fig. 7 is a section of the lower part of Fig. 6 taken on line 7—7 therein;

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Fig. 8, which is on a larger scale than that of Figs. 3–7, is a sectional view of a control valve of the machine taken on line 8—8 in Fig. 2, and showing the electrical solenoid device for operating the valve;

Fig. 9 is a side elevation, partly in section, of a lever associated with the valve and solenoid device of Fig. 8;

Fig. 10 is a fragmentary longitudinal section, still further enlarged, showing the dimpling tools or dies in operative relation to the work sheets at the completion of the dimpling operation;

Fig. 11 is a side elevation similar to Fig. 2 but showing the foot or pedal switch depressed, with the parts of the machine in operative position near the start of the second or dimpling stage of operation;

Fig. 12 is yet another side elevation showing the rivet pressed into the work piece to dimple the latter, the apparatus starting in the third stage of operation;

Fig. 13 is a further side elevation with the machine starting the fourth or riveting stage of operation; and

Fig. 14 is likewise a side elevation with the machine starting the fifth stage of operation and showing the rivet set in situ in the dimpled portion of the work piece prior to the release of said work piece.

In the industries dealing with the riveting of metal sheets and especially sheets of aluminum and aluminum alloys it is common practice first to dimple the sheets in a separate preliminary operation and frequently on a special machine, and then to remove the sheets from the latter or vice versa, after which said sheets are placed on a riveting machine or a riveting apparatus applied to the work sheets (the rivet being inserted into a hole through the work sheets at some stage of the operation) and the rivet then set. In such conventional procedures time is lost in shifting the work sheets or the apparatus from one operation to the other, not to mention that much lost motion is involved without in any way improving the result.

Hence in order to avoid such disadvantages of conventional practice and particularly with the foregoing objects in view, it is now proposed to dimple work sheets by means of a rivet inserted at the beginning of the operation and finally set in a later stage of said operation without shifting the work sheets from the machine upon which the operation first started.

The machine which is preferably used for the purpose of the present invention is mainly that shown and described in the copending application Serial No. 514,068, filed December 13, 1943 for Compression riveter, certain modifications and additions being now included to embody the features of this invention. Thus referring again to the drawings, the illustrative dimpling and riveting machine comprises a massive yoke 21 terminating at the front of the machine in opposed jaws 22, 23, the yoke being substantially U-shaped and supported upon a column 24 fixed on a wide base 25. The jaws have considerable length in order to accommodate wide work pieces when necessary and the yoke is therefore made of material having great strength, toughness and elasticity, such as boiler plate steel in order to allow development of riveting pressures of many tons, with consequent spreading apart of jaws 22 and 23, but without straining the yoke beyond the elastic or endurance limit of the steel. A stationary dolly supporting sleeve 26 extends vertically through the lower jaw 23, terminating at the upper end in a retaining flange 27 resting on said jaw and the sleeve projecting below the lower end of said jaw for a purpose which will presently appear.

The upper jaw 22 at its front end has a correspondingly opposite plunger 28 (Fig. 3) slidably mounted for movement toward or from dolly sleeve 26 in a pair of bushings 29, 30, spaced apart in bore 31 and axially alined with the dolly sleeve. Plunger 28 is normally urged upward into initial idle position by a return spring 32 mounted on the plunger beneath collar 33 which is fixed on the latter, the spring engaging against said collar and resting on bushing 30. The jaw 22 extends upwardly and cooperates with a pair of transverse bolts 34 in supporting an upper frame or superstructure 35, the latter being preferably U-shaped in cross section and straddling the upward extension of jaw 22. The front end of frame 35 is closed by a plate 36. The rear end of the frame is bolted to a fluid drive cylinder 37 which in turn is bolted to a control valve housing 39. Within said frame 35 an operating cam lever 40 is pivoted at 41 and provided with a nose 42 making active contact with the upper end of the tool plunger 28 and during operation serving to depress the same to dimple work sheets or set a rivet.

The cylinder contains a reciprocable piston 43 provided with a hollow piston rod extending slidably through the front end wall of the cylinder, the forward end of said piston rod receiving a boss 47, Fig. 3, forming an extension upon a forked roller block 48 in which a pair of rotatable rollers 49 are mounted one above the other. The lower roller rides upon the upper approximately straight surface of the cam lever 40 while the upper roller rolls along the under surface of a rail 51 secured within the top of the upper frame 35 by screws 52. As shown in Figs. 2, 3 and 11–14, the rollers roll over each other, thereby relieving the forked block of a large part of the reaction which is transmitted from the cam lever and upwardly through the rollers to the track and yoke. An inner piston rod 53 is screwed at its forward end into the boss 47 of the roller block and passes through the piston, on the rear end of which it has an increased diameter portion surrounded by a sleeve 54 retained in association therewith by a nut 55 screwed on the rear end of said rod. Thus if the piston is in a rearward position the roller block will also occupy a rearward withdrawn position in which the lower roller engages in a recessed portion 56 of the cam lever near the pivot 41 thereof which allows the spring urged plunger 28 to rise and thereby swing the cam lever upward to a high inclined position about its pivot (Figs. 2 and 3). When the roller block is forced forward, by the forward travel of the piston upon the latter being driven by pressure fluid entering cylinder 37, the rollers engaging against rail 51 and cam lever 40 will obviously swing the latter down progressively and thereby cause the tool plunger to descend. The upper surface of the cam lever 40 is so shaped that the lever and plunger 28 are moved first rapidly and then more slowly but with a substantially uniform mechanical advantage or speed ratio between piston 43 and plunger 28.

In order to actuate the piston as just indicated and thereby the cam lever and plunger, a pressure fluid port 57 in the rear wall 58 of the cylinder (Fig. 8) is arranged to receive pressure fluid from a passage 59 in valve housing 39 under control of a valve 61, the fluid being introduced into the machine through a fixture 62 (Fig. 1) from a flexible tube or hose line 63 which is connected to an appropriate source of pressure fluid. From the entrance fixture 62 the pressure fluid passes through an air line oiler 64 and a pressure regulator 65 controlled by a regulating screw 66, past the pressure gauge 67 and thence up through a hose line 68 to the valve housing 39. Within the latter the valve 61 (Fig. 8) has two spaced pairs of valve heads 69, 71 mounted on a reciprocating valve stem 72, and providing four individual seating type valves, mounted in pairs, back-to-back. Valve heads 69 and 71 consist of soft rubber discs each of which is perforated to fit and closely surround the valve stem 72. The discs in each pair abut each other while the pairs or heads are separated by a spacer sleeve 73. The lower disc 71 seats against a shoulder 74 on the valve stem. Near its lower end the valve stem has a cylindrical portion slidable in a bushing 76 firmly fixed in a sleeve 77. Said sleeve 77 is secured by engaging in a threaded portion of the valve housing 39 and extends downwardly from said threaded portion but is formed upon its upper end with a valve seat 79 engaged by the lower surface of valve head 71. The sleeve 77 is centered at its lower end by internally threaded ring 81 screwed on the sleeve and fitted into a counterbore in the valve housing, ring 81 serving to retain the inner ring 83 as well as appropriate packing 84 above and below the same in compressed condition to prevent leakage above sleeve 77.

In the upper portion of valve housing 39 a sleeve 85 is secured by screaw threads and is locked in position in the housing by a lock nut 87. An upper section 88 of the valve stem is slidably supported in sleeve 85. Section 88 screws on to the upper end of stem section 72 and engages the upper face of rubber disc 69 to hold all four discs under adjustable axial compression. Sleeve 85 has a valve seat 89 at its lower end adapted to be engaged by the upper surface of valve head 69 in raised position of the valve. Between the two valve heads is located a valve seat bushing 91 held rigidly in an intermediate bore in the valve housing, this bushing having an upper valve seat 93 engaged by the lower surface of valve head 69 and a lower valve seat 94 adapted to be engaged by the upper face of the other valve head 71 in raised position of the valve. It is thus evident that valve head 69 is movable from valve seat 89 to seat 93 while valve head 71 is correspondingly movable therewith between valve seats 94 and 79. Between the seats 93 and 94 is an annular connecting passage 97 alternately closed by valve head 69 or by head 71, while a port 98 opening into said passage 97 communicates with the front end of the cylinder 37.

The previously mentioned passage 59 communicates through a series of ports in sleeve 85 with an upper annular valve passage 102, said passage 59 and passage 102 connecting with a passage 103 which extends down in the valve housing along one side toward the lower end thereof and communicates through ports 104 in the sleeve 77 and ring 83 with a lower annular valve chamber 105. Adjacent the upper valve head 69 is a passage 106 leading to exhaust. Adjacent the lower valve head 71 is a port 108 constantly supplied with live air by hose lines 63 and 68 and suitable air connections (not shown).

The control valve 61 is raised and lowered in response to an electro-magnetic coil device or solenoid 111. The solenoid is supported on a frame 112 which is mounted on control valve housing 39 and secured thereto by bolts 113 (one being shown). The solenoid comprises a core 114 (Fig. 2) reciprocating in a coil 115 rigidly mounted upon frame 112 and connected to a terminal box 116.

The upper valve stem 88 is screw-threaded for the reception of two spaced adjusting nuts 117 and 118. Above nut 118, the sides of valve stem 88 are flattened to fit a rectangular slot 119 milled in a lever 121 (see Figs. 2, 8 and 9). The rear end of the lever has a hole 122 cooperating with a pivotal support on frame 112. The front end has a forked portion 123 engaging a horizontal pin carried by solenoid core 114 whereby the reciprocating movement of the core causes the lever to rock about its pivot. Lever 121 seats on adjusting nut 118 and is held in contact therewith by a compression spring 124 which encircles valve stem 88 and which is interposed between the lever and the upper adjusting nut 117. The two adjustment nuts and the compression spring are effective to transmit motion from the valve lever to the control valve 61. The spring 124 and nut 117 actuate the control valve on the upward or power stroke, whereas on the return stroke the valve 61 is carried down with the lever in contact with the adjusting nut 118. Downward movement of the valve 61 is aided by a compression spring 125 surrounding the lower end of the valve stem and extending between a shoulder on sleeve member 77 and a collar 126 pinned to the valve stem. The purpose of the spring 124 is to prevent injury to the valve seats due to the inertia of the solenoid core 114 and also to obviate the necessity of close adjustments.

The plunger 28 already referred to terminates at the bottom in a tool socket 127 (Fig. 3) while a tool anchoring rod 128 extends longitudinally through the plunger to establish a detachable threaded connection with a rivet set holder 129. A rivet set 131 is secured to the latter by the set screws 132, 133. A double splined key 134 extends transversely through the slotted hollow upper portion 135 of the rod with one end projecting slidably into a keyway 136 in bushing 29 in all positions of the plunger so as to allow axial movement of said plunger but preventing rotation thereof in the bushing when the rivet set holder is screwed on to the lower end of rod 128 and also preventing the rod from rotating relatively to the plunger. A small spring pressed plunger 137 slidably mounted in the hollow upper end 135 of rod 128 pressed upwardly against key 134 and thus resiliently urges the rod downwardly relative to the plunger 28 but allows it to rise against spring pressure in the event that

an upward force is applied to this rod. The purpose of seating the rod in a resilient manner is to prevent injury to the threaded connection between the lower end of rod 128 and rivet set holder 129. Should this connection work loose and the set holder drop down from plunger 28, no damage will result for the reason that when the machine is operated the shoulder of the set holder strikes the lower extremity of said plunger 28, while the slotted upper end of rod 128 is free to slide up and down on the splined key 134, eliminating any possibility of injury to the threaded connection which might have resulted if the set holder were screwed directly to a rigid part of plunger 28.

The rivet set holder associated with the plunger as described is provided with a pad plate 138, Fig. 10, surrounding the set beneath a threaded intermediate shoulder portion 139 and surrounding part of the latter without effective engagement therewith. A resilient hold down pressure pad or cushion 141 of rubber or other resilient material is mounted beneath the plate about a second intermediate diameter portion 142. A hold down pad washer 143 is held against the pressure pad by a split retaining ring 144 slidable between portion or step 142 and an annular rib 145 (Fig. 4) on the rivet set while above pad plate 138 (Fig. 3) an adjusting collar 146 is screwed on threaded portion 139 against the plate and presses upon pad 141 and thereby holds washer 143 down against ring 144 and thus normally holds the latter down against rib 145. In Fig. 4 the rivet set is shown completely stripped of all the cooperating parts normally associated therewith and shown in section in Figs. 3 and 10, which parts together constitute a hold down pad rivet set assembly. A second rib 147 is spaced downwardly a small distance from rib 145 (Figs. 3, 4 and 10) so as to present a retaining groove therebetween accommodating a friction ring 148 located within an externally threaded collar 149 having a flange upon the upper end and disposed slidably upon the two ribs while engaging against retaining ring 144.

Upon the threaded collar 149 a hold down sleeve 152 is screwed with a number of shims 153 clamped between the upper end of the sleeve and the flange of collar 149. The sleeve 152 has an intermediate internal shoulder serving as a stop or seat for a flange 155 on an internal rivet centering sleeve 156 slidably mounted on the lower reduced portion of the rivet set. A cap 158 is fitted over the upper end of inner sleeve 156 (with a stack of shims therebetween) to limit upward movement of the inner sleeve by said cap 158 engaging against rib 147, the spring 159 disposed externally of cap 158 between the lower end of collar 149 and flange 155 being centered by said cap tending resiliently to hold internal sleeve 156 down with its flange 155 against the shoulder on sleeve 152 while allowing said internal sleeve to be independently movable in upward direction within the mentioned limits. The lower end of the hold down sleeve 152 fits slidably upon the internal sleeve and as the threaded collar 149 rigid with said sleeve is also slidable on ribs 145 and 147, sleeve 152 is kept in alignment with the axis of the rivet set 131 and through collar 149 engaging against retaining ring 144 of washer 143. Thus the hold down sleeve 152 is resiliently held in its lowest position by the hold down pad 141, allowing the sleeve to be forcibly raised while compressing said pad, as will be referred to further on.

Completing the hold down pad rivet set assembly of the upper jaw, a rivet upsetting pin 161 and tubular dimpling sleeve 162 are supported by the dolly sleeve 26 in the lower jaw 23 as will now be considered. A hollow adjustable spindle consisting of spindle sleeve 163 (Figs. 3 and 6) screwed into dolly sleeve 26 is surmounted by a spindle cap 164 screwed into the spindle sleeve and having a central upwardly projecting tubular portion 165 of reduced external diameter forming a guide upon which the tubular dimpling sleeve 162 is slidably mounted, the latter initially projecting a distance above the upper end of said reduced portion 165. Both of these members namely, reduced portion 165 and tubular dimpling sleeve 162 may be adjusted in height by rotation in either direction of the spindle sleeve 163, the latter having its thread 166 engaging with the internal thread 167 of the dolly sleeve and below said sleeve having a knurled ring 168 fixed upon sleeve 163 by a set screw 169 by which to rotate said sleeve manually. A series of scale markings (not shown) may be applied approximately at 171 upon the spindle sleeve to cooperate in conventional manner with corresponding scale markings along one side of the cut-out portion 173 (Figs. 2 and 6). A locking screw 174 having a manually rotating knob 175 and threaded into a locking nut 176 is adapted to release or lock the spindle sleeve in known manner in any attained position of adjustment, at will.

The lower end of tubular dimpling sleeve 162 is flanged and rests upon three equidistantly spaced pins 178 (Figs. 5 and 6) which extend slidably down through the spindle cap 164 to the internal cap 179 within the spindle sleeve 163. Cap 179 rests on the upper end of slidable spring sleeve 181 which is independently movable relatively to the spindle sleeve and at the lower end extends down into a trip collar 182 to which it is secured by a long set screw 183. The trip collar is normally sustained in its highest position within the spring casing 184 by a compression spring 185 supported on supporting cap 186 engaging thread 187 in the casing and capable of being screwed up or down in the latter for proper adjustment of the spring by engagement of an appropriate wrench or key with lugs 188 to turn said cap. The upper end of the spring casing has an internal shoulder 189 supported by a flange 191 integral with the lower end of spindle sleeve 163, allowing the latter to be rotated by ring 168 without also rotating the spring casing, certain means yet to be described preventing such undesired rotation. The spring casing 184 thus virtually hangs suspended on the lower end of the spindle sleeve 163 and is therefore raised or lowered therewith when ring 168 is rotated in order to adjust the sleeve.

Within the spindle cap 164 and its central tubular extension 165, the previously mentioned rivet upsetting pin 161 is slidably disposed, continuing down in aperture 192 past cap 179 and through the inner spring sleeve 181 in which it has an increased diameter to form the cylindrical guide portion 193 slidable within said sleeve and extending down into spring 185 within which it receives the rivet upsetting pin plunger 194 adjustably screwed into the same. The mentioned plunger extends slidably down through the upper portion 195 of a bottom cap 196 screwed into the internal thread 187 of the spring casing and located a distance below cap 186. A compression spring 197 rests on cap portion 195 and engages beneath lock nut 198 upon the threaded portion of plunger 194 to resiliently support the latter and the rivet upsetting pin 161 in initial raised position. Below plunger 194 a shiftable cam slide block 199 is supported in the bottom cap 196 and has an inclined cam portion 201 and a rearward projection 202 extending through slot 203 in the rear of the spring casing and connected by a bolt 204 to a pair of connecting strips 205 rigid with the core 206 of an electric solenoid device 207. The bottom cap 196 is adjustable by engaging a wrench or the like with the small head 208 and screwing the cap in thread 187 to proper position to support the cam slide block at a proper level with respect to said solenoid device, the cap being held in place by the lock nut 209 on threaded shank 210 engaging against end closure plate 211, closing the lower end of the spring casing. When once the proper position of the bottom cap 196 has been attained, further adjustments will not be necessary and thus a stop plate 212 is fixed by a screw or rivet 213 to portion 195 of said cap in effective position to project into slot 203, thus preventing rotation of this cap.

The solenoid device is provided with a frame 214 (Fig. 7) brazed or welded to the spring casing, the cam slide block and solenoid being normally retained resiliently in extreme forward position by a pair of tension springs 215 extending through slots 216 from lugs 217 associated with strips 205 of the core to an arcuate anchoring hook member 218 located exteriorly of the cylindrical spring casing 184 and provided with end hooks 219 engaging with the outer ends of said springs. When solenoid 207 is energized the core 206 is drawn into said solenoid and simultaneously draws cam slide block 199 toward the rear against the tension of springs 215 and places the flat top 221 of the cam slide block directly beneath plunger 194, thereby enabling the associated rivet upsetting pin 161 to act as a riveting dolly. When the dolly solenoid 207 is de-energized, the springs return said cam slide block to the initial position shown in Figs. 6 and 7, thereby permitting the rivet upsetting pin to yield downwardly.

Upon the solenoid frame two switch housings 222, 223 of a pair of micro-switches generally indicated at 224, 225 are supported one above the other (Fig. 6). The lower micro-switch 224, which is associated with the dolly slide block 199, has a swingable arm 226 pendently supported upon a lug 227 fixed upon housing 222 thereof which lug also supports a spring 228 strongly biased toward said housing and tending to hold arm 226 in the path of a block 229 fixed by bolt 204 upon the upper core strip 205, so that when the core is attracted rearwardly by the solenoid, the block 229 will shift the lower end of arm 226 rearwardly away from the switch housing. Within the latter the dolly switch 224 includes a resilient contact member 231 fixed at the lower end of the housing and extending upward between two stationary contacts 232, 233 which are spaced a limited distance apart. Contact member 231 is capable of alternatively making contact with either of said stationary contacts but is normally retained against contact 232. A switch operating plunger 234 is slidably mounted for limited movement in the wall of micro-switch housing 222 between arm 226 and contact member 231 and is of such length that when arm 226 is held in the initial position of Fig. 6 by the spring 228, the plunger holds said contact member away from contact 233 and against contact 232. Upon actuation of core 206 and rearward movement of block 229 with consequent rearward swinging of arm 226 against the pressure of spring 228, contact member 231 assumes a position in which it makes contact with stationary contact 233 while displacing plunger 234 a limited distance rearwardly through casing 222. Return of the core to initial position as already outlined removes block 229 toward spring casing 184 and allows spring 228 to return arm 226 toward the switch housing and simultaneously causes the arm to push plunger 234 into said housing and thereby shift contact member 231 to engage with contact 232.

The upper micro-switch 225 also includes a resilient contact member 235 within housing 223, normally biased upward against the stationary contact 236 and simultaneously supporting a slidable micro-switch plunger 237 projecting vertically from the upper portion of said housing. The previously mentioned trip collar 182 has a rearwardly extending trip arm 238 rigid therewith extending rearwardly through a further casing slot 239 and carrying an adjusting screw 240 directly overhanging plunger 237 and adapted to depress said plunger and thereby open micro-switch 225 when the sleeves 162 and 181 are depressed by a predetermined amount. The screw 183 which fixes the trip collar 182 to the spindle sleeve 163 (Fig. 6) is long enough to extend through and secure the trip arm 238 at its inner end to the trip collar while extending through the latter into the wall of the sleeve, thus uniting the spindle sleeve, trip collar and trip arm into a rigid assembly which is movable as a unit. The purpose of the switch 225 is to discontinue the power after the rivet has been headed to a predetermined height.

A third micro-switch (Fig. 4) is also associated with the machine to form part of the operating instrumentalities thereof and will be described with the means for actuating the same. Yoke 21 which is substantially of U-shape has a deflection plate 241 (Fig. 2) of somewhat similar form disposed on one side thereof. The lower arm 242 of the deflection plate is secured at its end by screws 243 or the like to the lower jaw 23 but is spaced a small distance from the latter by a spacing block 244 (Figs. 2 and 6), so that the plate as a whole is held out of actual contact with the yoke. A screw 245 at the rear of the yoke serves to keep the deflection plate from swinging or bending out away from said yoke and prevents any material change in the spacing between the latter and said plate.

The upper forward end 246 (Fig. 4) of the deflection plate extends into a switch cover or box 247 upon the upper jaw 22 at the front of the machine (Fig. 1). Conductors 248 lead from the switch cover to a relay box 249 located on the other side of yoke 21 at the rear of the machine. A cable 251 leads from an outside source of current to the relay box on the machine while multi-conductor cables 252 and 253 respectively also lead to said relay box from the switches 224, 225 and from a foot switch 254 which is provided with a pedal 255.

Within the cover or box 247 is housed a deflection switch assembly, shown best in Fig. 4, comprising an inner switch box 256. The latter supports a fixed contact 257 and a resilient contact 258 normally biased away from contact 257 toward a slidably mounted switch plunger 259 extending into said switch box through a wall thereof, and simultaneously disposed against contact 260. Plunger 259 is capable of being pushed further into the switch box against the pressure of resilient contact 258 in order to flex the latter away from contact 260 and against fixed contact 257. A deflection switch lever 261 is rockably mounted on a knife edge fulcrum member 262 fixed on the upper jaw 22 with the short lever arm 263 extending beneath the upper end 246 of the deflection plate and the longer arm 264 of said lever disposed adjacent to the outer end of the switch plunger. It is evident that a small downward movement of the end 246 of the deflection plate while in physical contact with arm 263 will cause the upwardly projecting longer arm 264 to rock clockwise and push plunger 259 and thereby bring contact 258 into effective engagement with the stationary contact 257. The effect is the same when the deflection plate remains stationary and undeformed, while the jaws 22 and 23 are expanded apart during dimpling or riveting, and as the lower forward end 242 of the plate is attached to the lower jaw 23, the upper jaw 22 will raise fulcrum member 262 while upper end 246 of the plate prevents short arm 263 of the lever from rising with the fulcrum member, and the lever will consequently be rocked clockwise to push the switch plunger inward and close the switch as just set forth. A tension spring 265 is connected to the upper yoke jaw at one end and at the other end to the long arm 264 of lever 261 in order to retain the shorter arm 263 in constant engagement with the upper end 246 of the deflection plate so that the lever will be directly responsive to the slightest change in the relative position of upper jaw 22 with respect to that of end 246 of said deflection plate.

In order to adjust the deflection plate switch so that the latter will operate to close the circuit thereof with the desired amount of lost motion on the part of lever 261 relative to plunger 259, the switch box with its contacts and switch plunger is mounted on a shiftable switch plate 266 pivoted at 267 on the upper jaw 22. An adjusting screw 268 is threaded into a screw block 269 secured on said jaw, the screw engaging with its inner end against the side of the upper free end of the switch plate, and a tension spring 271 is attached to the latter and to the screw block in order to bias the switch plate toward the screw and resiliently retain the plate in contact with the screw. By turning the latter, the switch box 256 can be adjusted to a position in which the lever arm 264 is spaced the desired distance from switch plunger 259 while the shorter arm 263 is in effective contact with arm 246 of the deflection plate in normal idle condition of the machine. The purpose of the deflection switch 256 is to terminate the dimpling stroke when the yoke jaws 22, 23 spread apart by a predetermined distance.

When a cycle of operation is followed through, a pair of metal sheets herein termed the work piece 272 is assumed to have been drilled to receive a flush type countersunk head rivet 273 (Figs. 2 and 3) the work piece having first been manoeuvred to register the rivet head, within the bore of internal sleeve 156 carried by the rivet set holder, to accurately align the rivet with the dimpling sleeve 162 and rivet upsetting pin 161. The work piece is then held up against hold down sleeve 152.

It has been pointed out that the electrical control apparatus of this invention includes: a foot switch 254; a solenoid 111 for operating the control valve 61 that supplies pressure fluid to the power cylinder 37; a deflection switch 256 which breaks one contact and makes another to terminate the dimpling stroke upon the development of a predetermined strain on the yoke; a solenoid 207 which operates a slide block 199 to obstruct downward movement of the rivet upsetting pin 161, 193, thereby enabling the pin to act as a dolly for heading the rivet; a dolly switch 224 which breaks one contact and makes another upon movement of the slide block 199 to operative position; and a rivet height switch 225 which breaks contact and thereby terminates the riveting stroke of the piston upon a predetermined movement of the rivet set 131 and work sheets 272 toward the rivet upsetting pin 161. In addition the electrical apparatus includes a starting relay 274 which must be energized prior to the closing of the foot switch 254 in order to start a cycle of operation; and a dolly relay 275 connected in parallel with the dolly solenoid 207 and energized whenever said solenoid is operated to condition the machine for a riveting stroke.

In the first stage of operation, as illustrated in Fig. 2, the main switch (not shown) is closed, connecting the terminals 276, 277 to a source of electro-motive force of, say, 110 volts at 60 cycles. The pedal 255 of foot switch 254 is up at this time, thereby closing a circuit from live terminal 276 through conductor 278, normally closed contacts 258 and 260 of deflection switch 256, conductors 279 and 280, upper and movable contacts of foot switch 254, and then through the winding of starting relay 274 to ground. Upon being energized, relay 274 engages the armature with the front contact and thereby locks itself in energized condition independently of the foot switch as long as deflection switch 256 remains in its normal position. The first stage ends and the second begins when the operator depresses foot pedal 255 to shift the movable contact thereof away from the upper and into engagement with the lower contact associated therewith.

Near the start of the second stage of operation, the parts are as shown in Fig. 11. Starting relay 274 remains energized, as above stated, and in cooperation with the depressed foot switch 254 completes a circuit for energizing the valve solenoid 111. The course of the circuit is as follows: live terminal 276, conductor 278, deflection switch 256, conductor 279, front contact and armature of starting relay 274, movable and lower contacts of foot switch 254, conductor 281, left armature and back contact of dolly relay 275, conductor 282, and through the winding of valve solenoid 111 to ground. When the solenoid 111 becomes energized it pulls valve 61 upwardly thereby reversing the pressure fluid connections to the cylinder 37 and causing movement of the piston 43 forwardly or to the left as seen in Fig. 11. As the piston advances it acts through the rollers 49 and cam lever 40 to depress plunger 28 and rivet set 131. Accompanying the rivet set in its descent are the rivet 273, the metal sheets 272, and later the tubular dimpling sleeve 162, the three pins 178, cap 179, spring supported sleeve 181, trip collar 182, trip arm 238 and screw 240, the latter tripping the rivet height switch 225 although without affecting any circuit as it strikes the switch plunger 237. Shortly thereafter the dimpling sleeve 162 seats on the spindle cap 164. Upon further downward movement the rivet set 131 acts through the frusto-conical head of rivet 273 to dimple the sheets 272 as shown in Fig. 10. The rivet upsetting pin 161 moves downward out of the path of the rivet as the dimple is being formed in the sheet metal. Upon the development of a predetermined dimpling pressure, the strain on the yoke 21 causes deflection switch 256 to trip, shifting its movable contact 258 away from stationary contact 260 and into engagement with the other contact 257, which reverses piston 43.

At the start of the third stage of operation, the control parts occupy the positions shown in Fig. 12. The tripping of the deflection switch 256 has operated to de-energize starting relay 274 and to energize dolly relay 275 and dolly solenoid 207. The newly established circuit extends from terminal 276 through conductor 278, contacts 258 and 257 of deflection switch 256, conductor 283, normally closed contacts 232, 231 of dolly switch 224 and then along parallel paths through the dolly solenoid 207 and dolly relay 275 respectively to ground. When the dolly relay 275 is energized, its right armature engages the front contact to connect the source 276 through conductor 284 to the conductor 283 aforementioned, thereby continuing the supply of current to the latter after the deflection switch 256 is restored to normal. In this stage of operation the piston 43 moves to the right and the plunger 28 rises to its normal position, due to the fact that the valve solenoid 111 is de-energized. Also during this stage the spring supported sleeve 181 rises and the rivet height switch 225 is restored to its closed position thereby shunting dolly switch 224 to provide an additional or independent connection between conductor 284 and dolly solenoid 207. The third stage ends when the dolly block 199 is completely shifted into the path of the rivet upsetting pin 161, 193, at which time the dolly switch 224 is operated.

The fourth stage of operation commences with the parts in the Fig. 13 position. The piston has not returned completely to its normal or rearmost position, and the sleeve 152 has not broken contact with the upper face of the sheet metal 272. The dolly switch 224 in its operated position is effective to energize valve solenoid 111, the circuit extending from live terminal 276 through the right armature and front contact of relay 275, conductor 284, rivet height switch 225, live terminal of dolly solenoid 207, contacts 231 and 233 of dolly switch 224, conductor 282 and winding of solenoid 111 to ground. Dolly solenoid 207 and dolly relay 274 continue to be energized as in the preceding stage. The operation of the valve solenoid 111 is effective to cause the piston 43 to advance, and the plunger 28 and rivet set 131 to descend, as in the case of the second stage shown in Fig. 11. In the fourth stage, however, the rivet upsetting pin 161 is held against downward movement by the dolly slide block 199 and acts as a buck bar or dolly to head the shank end of the rivet as the latter is pressed down by the rivet set 131. Upon a predetermined approach of the rivet set relative to the rivet upsetting pin 161, that is after the rivet has been headed to a predetermined height, the rivet height switch 225 is operated.

As the fifth step begins, the control elements occupy the positions shown in Fig. 14. The rivet height switch 225 has just been opened thereby de-energizing both the solenoids 207 and 111 and relay 275. The piston 43 returns to its normal or rearward position as in the case of the third stage. Although the operator continues to depress the pedal 255, a new cycle of operation does not begin because the starting relay 274 is de-energized. To start a new cycle the pedal 255 must first be released to energize relay 274 and then depressed to energize the valve solenoid 111.

The various stages of operation are shown symbolically in the following diagram:

Stage	1st	2nd	3rd	4th	5th
Drawing Fig	2	11	12	13	14
Starting relay 274	E	E	D	D	D
Foot switch 254	N [1]	O	O	O	O [1]
Valve solenoid 111	D	E	D	E	D
Piston 43	R	MF	MR	MF	MR
Deflection switch 256	N	N [1]	O, N	N	N
Dolly solenoid 207	D	D	E	E	D
Dolly relay 275	D	D	E	E	D
Dolly switch 224	N	N	N [1]	O	O, N
Rivet height switch 225	N	N, O	O, N	N [1]	O, N

Symbols:
E—energized.
D—de-energized.
N—normal position.
O—operated position.
R—rearward.
MF—moving forward.
MR—moving rearward.

[1] Shifting of this switch terminates stage.

The operator may terminate the dimpling operation (second stage) prematurely by releasing the foot switch **254** prior to the tripping of deflection switch **256**, in which event the moving parts return to the Fig. 2 position. If the foot switch is released during the third or fourth stage, however, and left open, the cycle of operation will be completed in the usual manner.

In the above mentioned copending application, filed December 13, 1943, in the names of Howard R. Fischer and James A. Roberts, Serial No. 514,068, there are claims to the stroke adjuster (best shown in Fig. 3 herein) for regulating the return stroke of the plunger **28**; claims to the automatic deflection control means and switch (best shown in Fig. 4 herein); claims to the anchoring means for rivet set holder **129** (which include anchoring rod **128**, key **134** and plunger **137**, best shown in Fig. 3 herein); and claims to the height adjusting means for spindle sleeve **163** (best shown in Fig. 6 herein). In a division of that application filed July 26, 1946, by the same applicants, Serial No. 686,406, there are claims to the solenoid valve (best shown in Fig. 8 herein) which regulates the flow of the pressure fluid actuating the piston **43**. In a copending application, filed January 15, 1945, by Howard R. Fischer individually, Serial No. 572,839, there are claims to the hold down sleeve and pad assembly, best shown in Fig. 10 herein.

What is claimed is:

1. A dimpling and riveting press having a pair of mutually opposed jaws, a rivet set supported in association with one jaw and movable toward the other jaw, a recessed die supported by the latter or other jaw in alignment with said rivet set, said die being adapted to support a pair of metal sheets having a drilled hole therein in alignment with the die and set, the set being adapted to engage the head end of a tapered head rivet whose shank extends through the hole and into the recessed die, power operated means for moving the rivet set toward the die to dimple the sheet metal around the hole with the tapered rivet head acting as a punch extending into the die, means automatically operable upon the development of a predetermined pressure between the rivet set and die for reversing the stroke of the rivet set, a rivet upsetting pin engageable with the shank end of the rivet, means for moving the rivet upsetting pin into operative position within the die as the rivet set recedes from the die following a dimpling operation, means for locking said rivet upsetting pin in operative position, and means automatically operable in response to the operation of the locking means for

driving the rivet set toward the rivet upsetting pin to upset the shank end of the rivet.

2. A dimpling and riveting press according to claim 1 which includes means responsive to a predetermined approach between the rivet set and the die during the upsetting stroke for reversing the stroke of the rivet set.

3. A dimpling and riveting press having a pair of mutually opposed jaws, a plunger mounted for movement in one jaw toward and from the other jaw, a rivet set carried by said plunger and movable thereby toward the other jaw, a depressible hollow dimpling pad member mounted in association with the other jaw and having resilient means for returning the dimpling pad member from depressed to initial position, the latter member being adapted to support a work piece with a countersunk type head rivet extending through said work piece freely into said depressible dimpling pad member, said rivet set being conditioned upon movement of the plunger to depress the head of the rivet into the work piece to dimple the latter while it rests upon said dimpling pad member, a stop upon said dimpling pad member limiting the extent of the depression thereof by engaging with a portion upon said other jaw and thereby limiting the extent of the dimpling of said work piece by said rivet set, adjustable means upon said other jaw cooperating with said stop to determine the operated position of said dimpling pad member, a rivet support serving as a bucking member mounted for independent movement in proximity to said adjustable means, a shiftable member supported upon said other jaw having a portion capable in operated position thereof of obstructing the rivet support or bucking member against displacement from said operated position, means causing said bucking member to clear said shiftable member in initial idle position of the latter, shifting means controlling the position of movement of said shiftable member, and means causing the plunger to bring the rivet set down upon the head of the rivet once to dimple the work piece in idle position of said shiftable member and subsequently a second time in operated position of the shiftable member to upset the rivet upon the buckling member while the head thereof is seated in the dimpled portion of the work piece.

4. A dimpling and riveting press having a pair of mutually opposed jaws, a plunger mounted for movement in one jaw toward the other jaw, a rivet set upon the plunger, fluid operated means for operating said plunger, a movable fluid control valve and a control means therefor, said valve controlling the supply of pressure fluid to said fluid operated means for causing controlled movement thereof, a rigid guide member mounted on the other jaw and projecting toward the plunger, a hollow dimpling pad member slidably surrounding said guide member, stop means on the guide member for limiting movement of the dimpling pad member toward said other jaw, a stationary spring housing attached to the latter jaw and containing a spring conditioned to resiliently maintain the dimpling pad member in normal raised position projecting toward the plunger and adapted to support a work piece with a countersunk flush type head rivet extending through said work piece into said dimpling pad member, an independently movable rivet bucking member slidably mounted in proximate association with said guide member and said dimpling pad member, control means for shifting said rivet bucking member into effective bucking position

for the rivet and having means for supporting said bucking member in said effective position, automatic control means for first causing the fluid control valve to supply pressure fluid to drive the fluid operated means through a predetermined power stroke and drive the plunger and thereby the rivet set down upon the rivet head to dimple the work piece when the latter rests on said dimpling pad member, said automatic control means being subsequently capable of causing said fluid control valve to be reversed for supplying pressure fluid to return said fluid operated means to initial position and thereby cause the plunger and rivet set to recede from the work piece, means cooperating with said automatic control means thereafter effective to cause the control means to shift the rivet bucking means to operated position and the fluid control valve to supply pressure fluid to drive the fluid operated means a second time during the operation cycle through a power stroke and drive said plunger and rivet set down upon the rivet and thereby effect setting of said rivet upon said bucking member with the head of the rivet seated in the dimpled portion of said work piece, and means causing the fluid operated means, fluid control valve, dimpling pad member, rivet bucking member, automatic control means, controlled means and the means cooperating with the automatic control means to return to initial position in readiness for a new cycle of operation.

5. A dimpling and riveting press including a press frame having a pair of mutually opposite jaws spaced apart, a plunger reciprocable in one jaw toward and from the other jaw and having a rivet set mounted thereon, fluid operated means for reciprocating the plunger, depressible support means mounted on the other jaw for supporting a work piece having a countersunk flush type head rivet extending through the work piece into the support means, resilient means tending to restore the depressible support means to an initial raised position, a shiftable fluid control valve for controlling the flow of pressure fluid to, and exhaust of spent fluid from, the fluid operated means, the fluid control valve in operated position being effective to cause pressure fluid to drive the fluid operated means through a forward power stroke to bring the plunger and rivet set down toward the work piece on said depressible support means in order to press the rivet set into said work piece to dimple the latter, said fluid control valve in initial position being effective to cause the pressure fluid to return said fluid operated means to initial rearward position, shifting means for operating said fluid control valve, a rivet bucking member movably mounted upon said other jaw, a shiftable block capable in operated position of supporting the bucking member in effective bucking position and in initial position being clear of the latter, a second shifting means for shifting the block to operated position, stop means for limiting the depression imparted to the depressible support means to determine the depth to which the work piece is to be dimpled, initial control means operable at will for initiating an operation cycle and cause the valve shifting means to shift the fluid control valve to operated position and thereby causing the fluid operated means to drive the plunger and rivet set down upon said rivet head and dimple the work piece, dimpling operated means becoming effective upon predetermined dimpling of the work piece to cause the second shifting means to effect shifting of said block to operated position for supporting said bucking member in the bucking position and said dimpling operated means also becoming effective to neutralize operation of the first mentioned shifting means to restore the fluid control valve to initial position and cause the plunger and rivet set to recede from the work piece, further means becoming effective upon shifting of said shiftable block toward operated position to cause said first shifting means again to shift the fluid control valve to operated position and thereby cause the rivet set to be pressed down on the rivet the second time during the operation cycle while the bucking member is supported in said bucking position in order to upset the rivet upon the latter with the head of said rivet seated in the dimpled portion of said work piece, and means becoming effective to terminate the operation cycle of the press when said rivet is upset to predetermined extent and allow the press as a whole to be restored to initial condition in readiness for a new cycle of operation.

6. A dimpling press having a pair of mutually opposed jaws, a rivet set supported in association with one jaw and movable toward the other jaw, support means including a hollow member mounted on said other jaw for supporting the work piece in operative position with a countersunk flush type head rivet inserted into a hole in the work piece and extending freely into the hollow member in order to provide clearance for the rivet head to be depressed into the work piece for dimpling the work piece while resting on the hollow member, and further support means effective when said work piece has been dimpled for supporting or bucking the rivet to cause the rivet set to exert pressure on the rivet head while it remains in the dimpled portion of the work piece and thereby upset said rivet upon said further support means, said rivet set having a hold down sleeve slidably supported thereon means limiting the movement of the hold down sleeve upon the rivet set and determining an initial position thereof in which said sleeve projects a predetermined distance beyond the end of said rivet set in order to engage against the work piece in advance of the rivet, a hold down pad of resilient material mounted on the rivet set, a stop on said rivet set for said pad and means disposed on the rivet set in effective association with said hold down pad and sleeve to resiliently urge said hold down sleeve toward its initial projecting position.

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Certificate of Correction

Patent No. 2,442,949. June 8, 1948.

HOWARD R. FISCHER

It is hereby certified that errors appear in the printed specification of the above numbered patent requiring correction as follows: Column 7, line 1, for "Completing" read *Complementing*; column 14, line 47, for "buckling" read *bucking*; column 16, line 61, list of references cited, for the name "Butler" read *Butter*; line 67, for "Sheller" read *Speller*; and that the said Letters Patent should be read with these corrections therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 21st day of September, A. D. 1948.

[SEAL]

THOMAS F. MURPHY,
Assistant Commissioner of Patents.