April 4, 1961 N. P. BORETTI ET AL 2,978,569

METHOD AND APPARATUS FOR FORMING HOLES IN SHEET METAL

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2 Sheets-Sheet 1

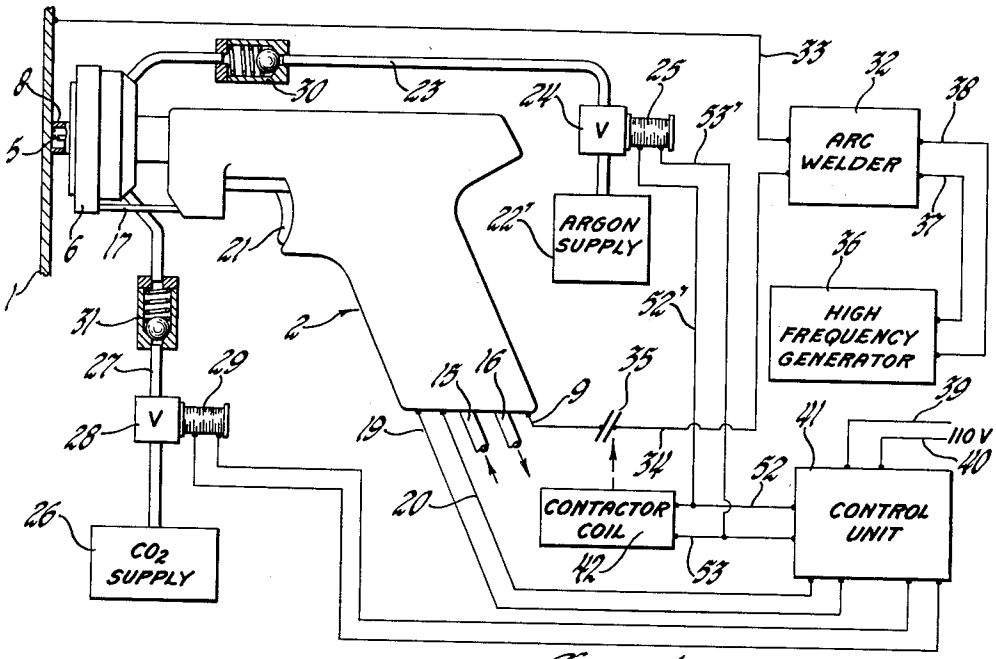


Fig. 1

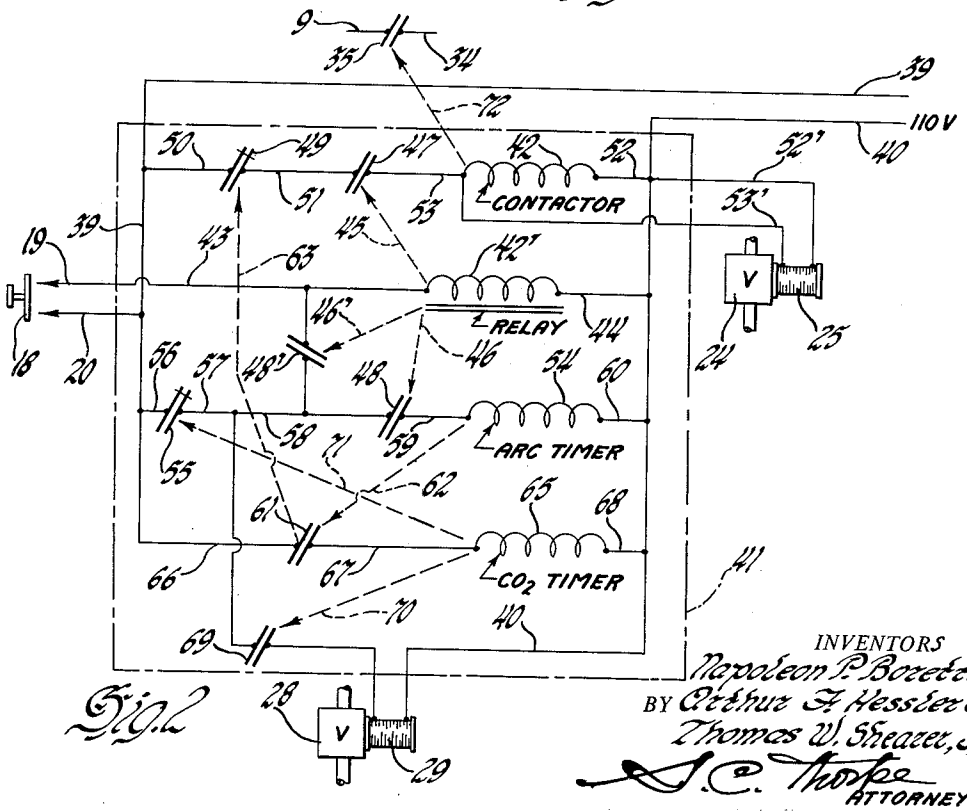


Fig. 2

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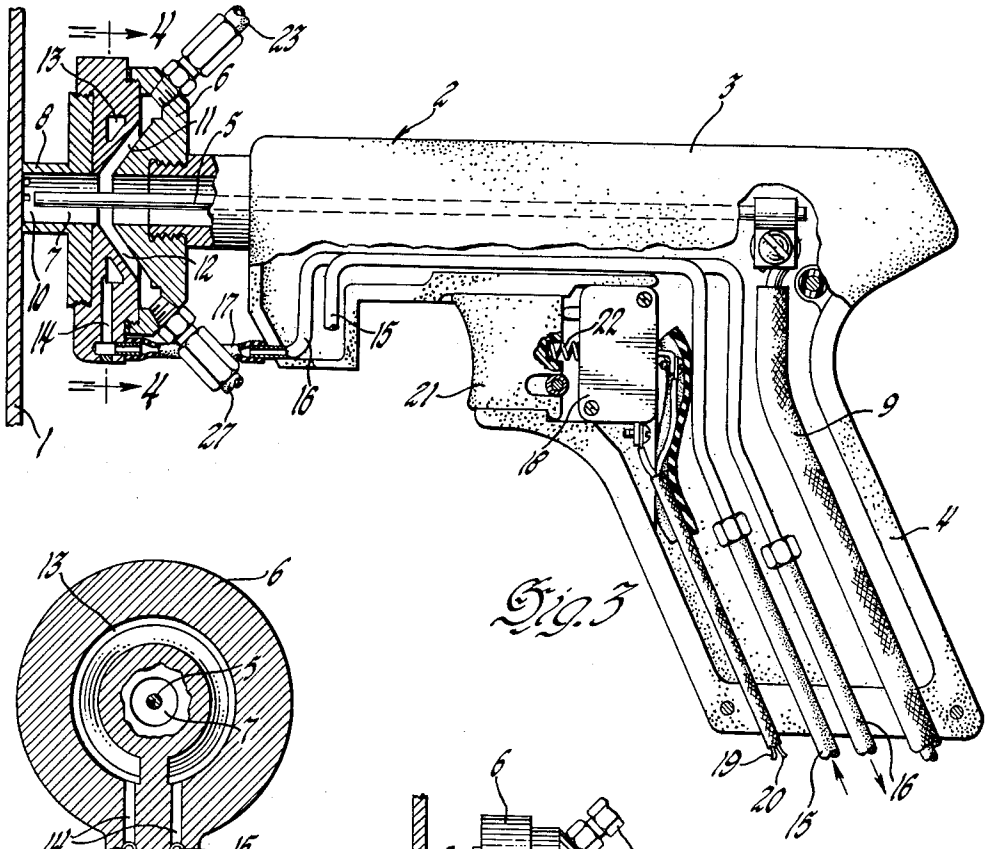


Fig. 3

Fig. 4

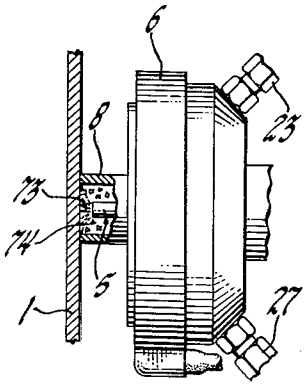


Fig. 5

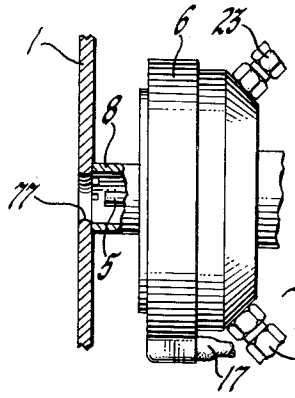


Fig. 7

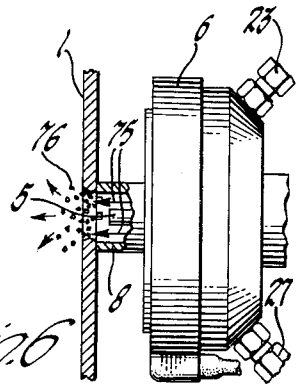


Fig. 6

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METHOD AND APPARATUS FOR FORMING HOLES IN SHEET METAL

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6 Claims. (Cl. 219—69)

This invention relates to forming holes in sheet metal for insertion of rivets, threaded fasteners, etc.

In conventional sheet metal piercing operations, such as drilling or punching, it is necessary that the adjacent area of the sheet be supported in order that substantial thrust may be applied by the hole forming tool. In many situations, however, it is difficult or impractical to provide such adequate support for the sheet metal, with the result that the hole forming must be done at a relatively slow rate or with the sheet metal member removed from other parts associated with it. It is accordingly among the principal objects of this invention to provide an improved method and apparatus for forming holes in sheet metal which does not require any backing force applied to the work during the piercing operation.

More specifically, the invention provides for forming such holes in a novel manner by the use of an electric arc to melt a section of the desired hole size in the sheet, followed by forceably displacing the molten metal through the sheet with gas under pressure.

Other objects relate to means for establishing the proper length of arc, shielding the heated parts from the atmosphere during maintenance of the arc, and the means for automatically controlling the arc duration and timing of the gaseous blast so as to produce cleanly defined holes in the sheet metal.

The invention will be more clearly described with reference to the drawings which show a preferred embodiment wherein:

Figure 1 is a generally diagrammatic view of the apparatus shown in relation to the sheet metal work to be pierced.

Figure 2 is a circuit diagram of the control unit indicated in Figure 1.

Figure 3 is a structural view of the gun type housing unit indicated in Figure 1 and shown in position preparatory to forming a hole in the work, parts being broken away and in section.

Figure 4 is a transverse sectional view of the head of the gun unit, taken substantially along the line 4—4 of Figure 3.

Figures 5, 6 and 7 are fragmentary views of the head in hole-forming association with the work, parts being broken away and in section to illustrate the stages in the hole forming operation.

Referring now to the drawings, and first to Figures 3 and 4, a section of sheet metal to be pierced is indicated at 1, and opposite one side thereof is shown the portable gun unit 2. The latter comprises a generally pistol shaped housing 3 of electrically non-conducting material having a handle 4 and mounting a non-consumable electrode 5 within the main body portion. The electrode extends outwardly thereof through a head 6 which forms a concentric chamber 7 and terminates at its forward end with a tubular portion 8 adapted to abut one side of the sheet metal to be pierced. The opposite end of the

electrode is connected by a lead wire 9 of high current carrying capacity and which preferably extends out of the housing through the handle portion. As shown, the tubular head portion 8 extends beyond the electrode sufficient distance to provide for maintaining the necessary gap 10 for an electric arc to be established and maintained between the electrode and the work. Inlet passages 11 and 12 extend through the head 6 to the chamber 7 for introduction or argon and carbon dioxide gases, later herein referred to, and coolant passages 13 and 14 are also provided in the head for introduction and return of coolant via inlet and outlet tubes 15, 16 which likewise extend through the handle and main body portion of the housing 3. 17 indicates one of the two hose connections between these coolant tubes and the head 6. Also mounted in the housing is a normally open control switch 18 with its lead-in terminals 19, 20 extending through the handle, and a finger actuatable push button 21 for closing the switch 18. Spring 22 reacts between the push button and the body of switch to effect return of the push button when finger pressure is released.

Figure 1 diagrammatically shows the other units of the hole forming apparatus. 22' indicates a source of argon gas under pressure which is connected by conduit means 23 to the head 6 (at inlet 11, Figure 3) of the gun unit 2. Flow of this argon gas to the head is controlled by a normally closed valve 24, openable by a solenoid 25. Similarly, a source of carbon dioxide gas under pressure 26 is connected to the head 6 (at inlet passage 12, Figure 3) by conduit means 27 and flow is controlled by a normally closed valve 28, openable by a solenoid 29. Check valves 30 and 31 serve to prevent reverse flow through these conduits from the head. The heavy electrical current required for establishing and maintaining the arc between the electrode 5 and the sheet metal 1 and the control current therefor may be supplied from a common electricity source. However in the arrangement shown, the arc current is supplied by a suitable "arc welder" unit 32 connected in series with the sheet metal 1 and the electrode 5 via circuit lines 33, 34, normally open switch 35 and the electrode lead-in wire 9 to the gun 2. A "high frequency generator" 36 for facilitating initial establishment of the arc is shown connected to the welder by leads 37 and 38. The control circuit includes the switch 18 (Figure 3), switch leads 19 and 20, and 110 volt supply lines 39 and 40 which connect with switch leads 19, 20 through a control unit 41. Also connectible with the 110 volt supply through the control unit are a contactor coil 42 and the solenoids 25 and 29 for opening the argon and carbon dioxide valves 24, 28, respectively.

Within the control unit 41, as shown in Figure 2, is a "relay" 42' connectible across the 110 volt supply lines 39, 40 by lines 43, 44 when the push button switch 18 is closed. The armature of this relay is linked as indicated by broken lines 45, 46 and 46', respectively, to close normally-open switches 47, 48 and 48' when the relay is energized. Switch 47 is connected in series with a normally closed switch 49 and the "contactor coil" 42 by lines 50, 51, 52 and 53 across the 110 volt supply. Connected in parallel with the contactor coil, by lines 52' and 53', is the argon control valve solenoid 25. Switch 48 is connected in series with an "arc timer" 54 (an electrically activated clock-like device of standard commercial form for actuating switches and the like at the begining and/or end of a pre-set time period) and a normally closed switch 55 across the 110 volt supply by lines 56, 57, 58, 59 and 60. Switch 48', when closed, interconnects lines 43 and 58 to maintain energization of relay 42' pending opening of switch 55. Closable by the arc timer 54 when its pre-set time period has elapsed is

a normally open switch 61 which is linked to the timer 54 as indicated by broken line 62. Linked as indicated by broken line 63 to this switch 61 so as to open when it closes, is the normally closed switch 49. Closing of normally open switch 61 connects a "CO_2 timer" 65 (a device like timer 54) across the 110 volt supply via lines 66, 67 and 68. Respectively closable by the timer 65 at the beginning of its pre-set time period, and openable thereby at the end of such period, are a normally open switch 69 and the normally closed switch 55 which are linked to the timer as indicated by broken lines 70 and 71. The normally open switch 35 in the arc circuit is closable by the armature of the contactor coil which is linked thereto as indicated by the broken line 72.

In operation, closing of the push button switch 18 energizes relay 42' to close normally open switches 47, 48 and 48'. Closing of these switches results in energizing solenoid 25 to open the argon control valve 24, closing the arc current switch 35 through the contactor coil 42 to start the arc, and starting the arc timer 54. After its pre-set time period this timer "times out," closing switch 61 and opening switch 49, with the result that the contactor coil 42 is now deenergized (extinguishing the arc) and the CO_2 timer is started on its pre-set time period. Starting of this timer 65, in turn causes immediate closing of switch 69, energizing solenoid 29 to open the CO_2 control valve 28 to supply CO_2 gas to the gun head 6. Finally, upon timer 65 "timing out," it reopens normally open switch 69 to shut off the CO_2 gas flow, and opens normally closed switch 55 to break the control current supply via lines 57, 58, switch 48' and line 43 to the relay 42'. This deenergizes the relay, reopening switches 47, 48 and 48'. Such reopening of switch 48 deactivates the arc timer 54, reopening and reclosing switches 61 and 49, respectively, deactivating timer 65 to reclose switch 55, thus completing the cycle.

Figure 5 shows the gun head 6 with its tubular portion 8 in abutment with the sheet metal work 1 when the arc (indicated at 73) is initiated. Simultaneously therewith, argon gas (indicated as at 74) entering the head via the conduit 23 fills the chamber surrounding the electrode 5. Such inert gas shielding of the arc and the heated end of the electrode has the particular advantage of preventing oxidation of the latter. A metallic electrode, such as tungsten, may accordingly be used with its attendant well known advantages in electric arc work. Figure 6 shows the parts after cessation of the arc and while the carbon dioxide gas indicated by the arrows 75 is flowing at high velocity through the tube 8, displacing the molten metal 76 through the sheet 1. Figure 7 shows the parts after completion of the carbon dioxide blast, the finished hole 77 having been formed in the sheet metal.

The terms "melt," "molten," etc., are used herein broadly to include reducing the heated portion of the metal work-piece from its normal solid state to one in which it is rendered sufficiently soft or plastic that it can be displaced under the force of the carbon dioxide or other blasting gas to be used. In fact, we find superior results in obtaining cleanly defined holes enures from heating the metal to a temperature slightly less than that which would reduce it to the liquid state.

While only a single preferred embodiment of the invention has been disclosed, it is appreciated that numerous minor changes in the construction and arrangement of the parts may be made without departing from the spirit and scope of the invention as hereinafter claimed.

We claim:

1. The method of forming a hole in sheet metal, comprising the steps of establishing an electrical arc between one side of the metal and a source of electric current of sufficient intensity and duration to melt the metal in the immediate vicinity of the arc, simultaneously shielding said arc from the surrounding atmosphere with a layer of inert gas extending between the metal and the current source, and subsequently directing a column of gas substantially coaxially of said arc and against said molten metal to displace the latter from the remainder of the sheet.

2. The method of claim 1, wherein said arc is extinguished prior to directing said column of gas against the molten metal.

3. The method of forming a hole in sheet metal, comprising the steps of establishing an electrical arc between one side of the metal and a source of electric current of sufficient intensity and duration to melt the metal in the vicinity of the arc, simultaneously directing inert gas toward said side of the metal in a column coaxially of and embracing the arc to shield the arc and molten metal from the surrounding atmosphere, discontinuing said arc and inert gas direction, and then similarly directing a coaxial column of carbon dioxide gas against the molten metal with sufficient force to displace it through the sheet.

4. Apparatus for forming holes in sheet metal, comprising a generally pistol shaped body of electrically nonconductive material including a handle with a finger closable normally open switch mounted thereon, an electrode mounted in the body and projecting from the end thereof remote from the handle, a tubular head concentrically spaced about the projecting portion of the electrode and extending beyond the same to space the adjacent end of the electrode a predetermined distance from the work, a source of argon gas under pressure externally of the body, a source of carbon dioxide gas under pressure externally of the body, conduit means each including a normally closed valve connecting said argon and carbon dioxide sources respectively to the interior of said head for flow of said gases therethrough coaxially of the electrode and toward the work, a source of electricity, electrical circuit means including an arc current circuit for connecting said electricity source in series to the electrode and work and a control current circuit connectible in series with said electricity source by said finger closable switch, said arc circuit including a normally open switch, relay means energizable by current flow in said control circuit to simultaneously close said last named switch and open said valve in said argon conduit means, timer means responsive to energization of said relay means a predetermined period of time to simultaneously open said last named switch, close said argon valve and open said valve in said carbon dioxide conduit means.

5. Apparatus for forming holes in sheet metal, comprising an electrode, an electric current source for establishing an arc between the electrode and sheet metal of sufficient intensity to melt a section of the desired hole size in the sheet, a source of gas under sufficient pressure to force the molten metal through the sheet when directed thereagainst, means including selectively openable and closable switch means for electrically connecting said current source in series with the electrode and sheet metal, means defining a chamber extending substantially coaxially of the electrode, said chamber being open at its end adjacent the arc establishing end of the electrode, means for conducting gas from said gas source to said chamber including a chamber inlet, valve means controlling gas flow to said inlet, and means operatively connecting said valve means and switch means effective to open said valve means after a predetermined time in response to closing said switch means.

6. Apparatus for forming holes in sheet metal, comprising an electrode, an electric current source for establishing an arc between the electrode and sheet metal of sufficient intensity to melt a section of the desired hole size in the sheet, a source of gas under sufficient pressure to force the molten metal through the sheet when directed thereagainst, means including selectively openable and closable switch means for electrically connecting said current source in series with the electrode and sheet metal, means defining a chamber extending substantially coaxially of the electrode, said chamber being open at its

end adjacent the arc establishing end of the electrode, means for conducting gas from said gas source to said chamber including a chamber inlet, and a source of inert gas under pressure, means for conducting said inert gas from its source to the chamber for discharge through said chamber open end to form a shield about the arc, said last means including a valve between said chamber and the inert gas source, and means to open and close said valve simultaneously with closing and opening said switch means respectively.

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