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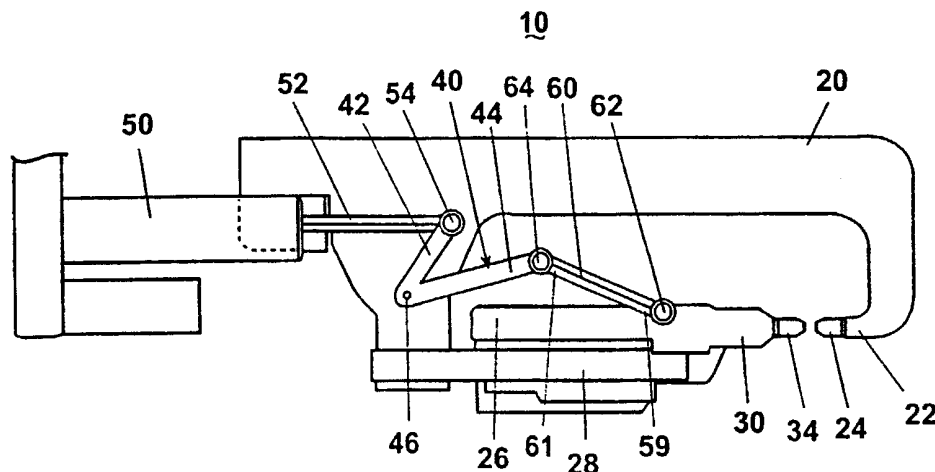
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(54) Title: TOGGLE LINK ACTUATED WELD GUN



(57) Abstract: A weld gun with a pair of jaws (20, 26) and a pivoting device (40, 161, 248) connected to one of the jaws is contemplated. A toggle link (60, 160, 250) connects the pivoting device to the second jaw such that when the pivoting member is rotated about its pivot, it moves the second jaw through the toggle link.

WO 01/36142 A1

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TOGGLE LINK ACTUATED WELD GUN**CROSS REFERENCE TO RELATED APPLICATIONS**

[01] This application claims benefit of U.S. Provisional Application Serial No. 60/166,511, filed November 19, 1999, the contents of which are incorporated in its entirety. Applicants also note the existence of U.S. Patent Application Serial No. 09/321,931, filed May 28, 1999, in turn claiming priority from U.S. Provisional Patent Application Serial No. 60/095,385 filed August 5, 1998, and now expired; U.S. Patent Application Serial No. 09/557,896, filed April 21, 2000, and claiming priority from U.S. Patent No. 5,742,022, filed April 19, 1995, and from U.S. Patent No. 6,066,824, filed April 20, 1998, all commonly owned with this application and incorporated herein by reference in their entirety.

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FIELD OF THE INVENTION

[02] The present invention relates to weld gun actuation. More particularly, the invention relates to a weld gun actuated by a combination of a toggle link and an actuator.

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BACKGROUND OF THE INVENTION

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[03] Resistance welding utilizes the flow of electricity to permanently join two or more overlapping metallic workpieces to one another. Typically, the metallic workpieces are placed between two opposing electrodes of an electric welding assembly. The electrodes are then forced together until their tips contact the outer surfaces of the workpieces at a pressure sufficient to sandwich the workpieces and ensure an adequate electrical contact between the electrodes and the workpieces. Then an electrical current is induced to flow from one electrode tip to the other electrode tip by way of the sandwiched workpieces. The workpieces act as conductors in the resulting electrical circuit, and resistance to the flow of electrical current at the interfaces between the metals generates heat. The affected metal of each workpiece selectively becomes molten, and interacts with

5 molten metal of an adjacent workpiece to form a weld nugget that permanently bonds the workpieces together at the point of electrode tip contact.

[04] A number of factors relate to the creation of a weld nugget, including the force and area of contact between the electrode tips and workpieces, the level of current flow, the length of time that the current flow lasts, degree of workpiece imperfection, and
10 even the condition of the electrode tips themselves.

[05] The prior art teaches the importance of creating an adequate weld nugget. Therefore, weld systems are over-configured to generate a weld nugget even if there are significant workpiece imperfections by having high force, current levels, and current application times. Yet, many resulting welds are still imperfect. Therefore, typically
15 approximately on the order of one quarter of all welds in a workpiece are added to insure adequate structural integrity.

[06] Further, such overcompensation for possible workpiece imperfection results in significantly higher deformation (mushrooming) of the electrode tips at the point of contact between the tips and the mating workpieces.

20 [07] Weld gun actuators have been linear devices that close the electrode tips on the workpiece and apply a compressive force to the electrode tips necessary to produce the weld nugget. Traditional linear actuators apply constant force over the full range of motion traversed by the electrode tips. However, there is an inverse proportional tradeoff with linear actuators between speed and force. As the force a linear actuator is capable of
25 delivering increases, the speed at which the actuator can move the electrode tips decreases. On the other hand, as the speed at which the linear actuator can move the electrode tips increases, the force that is capable of being delivered decreases.

[08] Moreover, the application of continuous significant electrode force upon the sandwiched workpieces requires the use of significant sources of compressed air in
30 traditional linear actuators. Further, as the required force increases, the required pressure necessary to achieve that force also increases.

[09] In the past, to overcome the limitations of the linear actuators, the primary means employed has been hydraulic intensification. When hydraulic intensification is used, a linear actuator closes the electrode tips about the workpiece, and a hydraulic device
35 provides significant additional force at the electrode tips. While this combination does somewhat alleviate the compromise between speed and force, another disadvantage arises

5 because of the use of the hydraulic device. Namely, a hydraulic device with an oil or fluid reservoir is required, thus adding to the costs of designing, building and maintaining the weld gun.

[10] There are additional costs to requiring complex hydraulic and air-actuated systems. Each electric welding system becomes unique. Each length of hose, each bend in
10 a pipe or conduit, and each selected placement for various fittings is necessarily tailored to the particular welding system. The kinematics of the host of hoses (pejoratively referred to as "spaghetti") cannot be accurately predicted or modeled. Accordingly, the robot movements in each work cell must be inputted on-site, step-by-step, to ensure that hoses do not become entangled. To further exacerbate the problem, the resulting "window" in
15 which a robot arm may move to reach, for example, a weld point, is significantly reduced, again due to the proliferation of hoses and associated components. Thus, the time to program a robot arm is extensive and the resulting process time to process workpieces is significantly increased.

[11] In a manufacturing plant having a large number of electric welding systems,
20 the aggregate cost of having to individually construct, install, and maintain each electric weld system is high. Accordingly, there is a need to provide an improved electric welding system that minimizes or eliminates one or more of the problems as set forth above.

SUMMARY OF THE INVENTION

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[12] In a first embodiment, a weld gun has a pair of jaws with a pivoting device connected to one of the jaws at a first fixed point. A first end of a toggle link is connected to the pivoting device at a second fixed point, while a second end of the toggle link is connected to the second jaw at a third fixed point. As a result of these interconnections,
30 movement of the pivoting device about the first fixed point causes the second jaw to move in a predetermined manner.

[13] In another embodiment, the weld gun has first and second jaws, wherein the first jaw is fixed while the second jaw is mounted on a track that allows only generally linear movement of the second jaw. The pivotable member is mounted on the fixed jaw at
35 a first pivot point, while the toggle link is mounted between the pivotable member and the movable jaw at second and third fixed points, respectively, such that pivotal movement of

5 the pivotable member about the first fixed point on the fixed jaw causes the link to pivot at second and third fixed points, forcing the movable jaw to move linearly along the track. In particular, pivotal movement of the pivotable member toward the movable jaw causes the jaw to move from a disengaged toward an engaged position. Moreover, the pivotable member is shaped so that it, in combination with the location of the first, second and third
10 fixed points, imparts a continuously variable force on the movable jaw through the toggle link. The location of the fixed points and the shape of the pivotable member preferably causes the force to increase as the movable jaw approaches the engaged position, and more preferably so that the force is maximized at the engaged position.

[14] In a further embodiment, a weld gun has first and second jaws
15 interconnected at a first fixed point to allow rotational movement of the jaws relative to each other from a disengaged to an engaged position. The jaws further include inwardly directed ends pointing toward the other arm, wherein the ends terminate in opposed electrode tips. A first pivotable member is connected to the first jaw at a second fixed point, while a second pivotable member is connected to the second jaw at a third fixed
20 point. The first and second pivotable members are connected to each other at a fourth fixed point. As a generally linear force is applied to the fourth fixed point to open the jaws, first and second pivotable members pivot and force second and third fixed points to diverge, causing the first and second jaws to pivot about the first fixed point and to close. As a result, a rotational movement is imparted to the jaws such that the opposed electrode
25 tips converge. Thus, a generally linear initial force is translated into a rotational force at the electrodes. As above, the location of the fixed points and the size and shape of the pivotable members preferably cause the force to increase as the jaws converge such that the force is maximized at the engaged position.

[15] Alternatively, instead of applying a linear force at the fourth fixed point, a
30 rotational force may be applied at one of the second and third fixed points to cause the first and second pivotable members to pivot about the fourth fixed point and cause the second and third fixed points to diverge. Thus, a rotational force applied at one end of a pivotable member imparts a rotational force on the jaws, causing the electrodes to converge with continuously variable force.

35 [16] Finally, a rotary actuator may be connected to one of the second and third fixed points such that the corresponding pivotable member is the crank of the rotary

5 actuator. The crank length is variable, which is accomplished by using a two-piece telescoping crank that self-adjusts to ensure that the second and third fixed points are separated sufficiently to ensure that the electrodes rotate to a fully engaged position.

[17] Thus, the present invention may be used to both move electrodes to an engaged position and to apply sufficient force to a work piece to achieve an improved
10 weld. Further, the present invention allows a simple linkage to translate a linear or a rotative force into linear and/or rotative motion of weld gun electrodes.

[18] The toggle link of the present invention is designed to provide high speed weld gun electrode tip closure at a cost savings over traditional weld guns, while also providing the necessary electrode tip force required to produce satisfactory weld nuggets.

15 [19] The toggle-link arrangement provides the advantage of being able to supply a smaller, lighter weight actuator in that the mechanical advantage of the toggle-link arrangement maximizes the closure speed of the electrode tips when the weld gun is in the widest open position and the required force is the lowest while maximizing the force exerted between the electrode tips as the weld gun is moved towards the closed position.
20 The closure speed of the weld gun slows as it moves towards the closed position, but this is also desirable to improve the controllability of the weld gun as it closes on the articles being permanently bonded.

BRIEF DESCRIPTION OF THE DRAWINGS

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[20] Figure 1 is a side view of a weld gun with toggle link actuation according to the invention;

[21] Figure 2 is a side view of a further embodiment of a weld gun with toggle link actuation according to the invention;

30 [22] Figure 3 is a side view of a further embodiment of a weld gun with toggle link actuation according to the invention; and

[23] Figure 4 is a side view of a rotary actuator with two-piece crank.

DETAILED DESCRIPTION OF THE INVENTION

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5 [24] Toggle links are pieces of generally rigid and often generally linear pieces that connect an actuator to a weld gun arm. The links further generally include openings at opposing ends adapted to receive fasteners so that the links may pivot about connecting fasteners. Alternatively, mating members may have complementary male and female components that allow for pivotal movement about a mated pivot point. Links and cranks
10 are examples of pivotable members in accordance with the teaching of the present invention. The toggle links may also indirectly connect an actuator in combination with an intermittently positioned crank to the weld gun arm. A crank may be connected to a mating member in the same manner as links, the actuator or weld gun arms. A pair of toggle links may be used to connect an actuator to opposing arms of a caliper type weld
15 gun. In combination with a pivot to which the weld gun arms are rotationally connected, the toggle links transfer a force generated by the actuator with a non-linear profile over the full range of motion provided by the actuator, as noted above.

 [25] In particular, a toggle link may be used to connect an actuator to a moveable jaw of a C-clamp weld gun by way of an intermediate pivotable crank rotationally
20 connected to a fixed jaw of a weld gun at a fixed pivot point. Preferably, the actuator travels an essentially linear path. However, at least the actuator travels a known, fixed path between retracted and extended positions. The toggle link may be rotationally connected at one end to a fixed point on a second jaw of the weld gun and at a second end to the pivotable crank at another fixed point. The combination of a pivotable crank fixed to one
25 jaw of a weld gun and a toggle link fixed to the second jaw of the weld gun and to the pivotable crank provides a force with a non-linear profile over the full range of motion induced by the actuator. The pivotable crank may have any shape, but as described below in a disclosed preferred embodiment, it includes two attached arms that pivot about a fixed point, where an angle between the arms may be adjusted to adjust the amount of toggle link
30 travel.

 [26] As shown in a first embodiment of the invention, a C-clamp type weld gun
10, illustrated in Figure 1, comprises a first jaw 20 having a first end 22 with an electrode tip 24 and a second jaw 26 comprising a linear guide 28. The second jaw 26 further comprises a first end 30 with an electrode tip 34, such that the electrode tips 24, 34 point
35 towards each other in an opposed orientation. The second jaw 26 is guided in a

5 longitudinal direction by the linear guide 28 and is restricted to movement along a fixed path, preferably linear.

[27] A crank 40 is pivotally mounted to the first jaw 20 at a first fixed pivot point 46. Mounting of the crank 40 may be accomplished by any conventional means, as long as crank 40 is able to pivot about first fixed pivot point 46. Similarly, a first end 59 of a
10 toggle link 60 is pivotally mounted to the second jaw 26 at a second fixed pivot point 62, again by conventional means. A second end 61 of link 60 is pivotally mounted to crank 40 at a first pivot point 64. While crank 40 may have any shape, the crank preferably is generally L-shaped, where one leg defines a crank actuator arm 42 and the other leg defines a crank toggle arm 44. In the preferred construction, second end 61 of link 60 is
15 pivotally connected to crank toggle arm 44 at first pivot point 64. As may be appreciated, as crank 40 pivots clockwise about first fixed point 46, the crank toggle arm 44 will push against second end 61 of link 60 at first pivot point 64. As a result, first end 59 of link 60 will push against second jaw 26 at second fixed pivot point 62 such that second jaw 26 will move along the fixed path from a disengaged position to an engaged position, thereby
20 moving electrode tip 34 towards electrode tip 24. In the preferred construction, at least two of the pivot points are fixed. More preferably, each jaw includes at least one fixed pivot point. Further, a minimum of four total pivot points are required in the present invention, with at least two of the four being fixed pivot points.

[28] An actuator 50 may be used to cause crank 40 to pivot about first fixed
25 point 46. Preferably, actuator 50 is restricted to movement along a predetermined path, and more preferably, along a linear path between a retracted and an extended position. As shown in Figure 1, actuator 50 comprises an actuator shaft 52 that is pivotally connected to crank actuator arm 42 at a second pivot point 54. Shaft 52 is restricted to only a linear path parallel to the restricted path of second jaw 26. In operation, shaft 52 exerts a linear force
30 on second pivot point 54, imparting a pivotal or rotational movement to crank 40 so that it pivots about first fixed point 46. Crank 40 imparts pivotal or rotational force on link 60, which in turn is limited to exerting movement upon second jaw 26 along its fixed path, causing the gap between electrode tips 24, 34 to close. Due to the mechanical relationship between toggle arm 44 and link 60, a given extension of shaft 52 will result in a variable
35 displacement of second jaw 26, dependent upon the initial position of crank 40. As toggle arm 44 approaches the horizontal, as seen in Figure 1, a larger portion of the linear force

5 exerted by shaft 52 on crank 40 is transferred through link 60 to second jaw 26 to exert the force on the articles held between electrode tips 24, 34 as the rate of displacement decreases in the engaged direction. At the fully extended position of shaft 52, the movement of the second jaw 26 is small compared to the movement of the shaft 52. At the same time, the force exerted by the electrode tips 24, 34 is maximized at the fully extended position or engaged position.

10 [29] Similarly, the operation may proceed in reverse. As actuator 50 withdraws shaft 52, crank 40 rotates or pivots in a counterclockwise direction about first fixed pivot point 46, thereby causing second jaw 26 to move away from the first end 22 of first jaw 20. At the same time, the angle of link 60 with respect to the direction of movement of second jaw 26 increases, reducing the effective horizontal force exerted between the electrode tips 24, 34 and increasing the speed of the second jaw 26 as it moves away from first end 22. The crank-link arrangement therefore allows the second jaw 26 to be moved toward the first end 22 more rapidly while exerting less force on end 30, but as the electrode tips 24, 34 approach the articles enclosed therebetween, the speed decreases, increasing

15 20 controllability, and the force increases, providing better contact between the electrode tips 24, 34 and the material placed therebetween, and further compressing the materials against each other for the formation of a better fusion bond.

[30] While compressed air linear actuators have traditionally been used to close the electrode tips of a weld gun about a workpiece and provide the necessary compressive force, two alternate linear actuators are also suitable for use in the present invention. First, in addition to a programmable logic controller controlling the actuator, a manual actuator may be used. A manual actuator may be preferable in situations where the availability of compressed air is limited or the use of compressed air is not feasible, as, for example, in situations where the weld gun is portable or otherwise designed to be used outside the traditional factory setting. Second, a two stage linear actuator may be used. As the name suggests, a first stage closes the electrodes, while the second stage applies additional pressure in the form of force per unit area. While similar to hydraulic intensification, a two stage linear actuator has the benefit of not requiring the use of a hydraulic device. Preferably, the two stages may be accomplished through the use of a linear motor with a two stage core. In addition, other linear force actuators that do not use compressed air may also be suitable for use in the present invention.

25 30 35

5 [31] Referring now to Figure 2, in a different embodiment of the invention, a caliper type weld gun 110 includes two generally identical jaws 120, 121 having a first inwardly directed ends 122, 123, respectively, that point towards each other in an opposed orientation, second ends 126, 127, and inwardly directed pivot extensions 128, 129 that overlap inwardly of the first and second jaws 120. The jaws 120 are rotatably connected to each other along the pivot extension overlap and to a mounting bracket 130 by a rotative fixed connection 132. Fixed connection 132 may be of any conventional type, as long as the jaws 120 are rotatably interconnected such that rotational movement about fixed connection 132 allows the inwardly directed ends 122, 123 to move either toward or away from each other. An electrode tip 124, 125 is affixed to each respective inwardly directed tip 122, 123 of jaws 120, 121. An actuator 150 having an actuator shaft 152 may also be affixed to the mounting bracket 130.

 [32] First and second links 160, 161 include respective first ends 170, 172 and second ends 174, 176. First end 170 is pivotally attached to upper jaw 120 at a first fixed pivot point 162, while first end 172 is pivotally attached to lower jaw 121 at a second fixed pivot point 163. Additionally, second ends 174, 176 are pivotally attached to each other and to the actuator shaft 152 at a first pivot 154. Thus, a fixed pivot point is associated with each of jaws 120, 121, and only first pivot 154 is disposed between them in this embodiment. Further, actuator shaft 152 is preferably allowed to move only along a fixed path, and more preferably, linearly with respect to the central axis A defined between opposing jaws 120, 121 that intersects fixed connection 132 and first pivot 154. The central axis should also ideally intersect the point of ultimate contact between electrode tips 124, 125.

 [33] As actuator shaft 152 extends from actuator 150, first pivot point 154 is pushed toward will move toward fixed connection 132, thereby also moving second ends 174, 176 of links 160, 161, respectively, toward fixed connection 132. As second ends 174, 176 move toward fixed connection 132, second ends 170, 172 of the links 160, 161 pivot about their respective fixed pivot points 162, 163, and the resulting force exerted at first pivot point 154 forces the fixed pivot points 162, 163 to diverge, thereby causing jaws 120, 121 to rotate about fixed connection 132. In this way, electrodes tips 124, 125 are forced towards each other with gradually increasing pressure until articles to be fused together are clamped between the electrode tips 124.

5 [34] As in the first embodiment, as the electrode tips 124, 125 approach a fully engaged position, the closure speed reaches a minimum while the force exerted is maximized due to the mechanical advantage of the link arrangement, working to create a solid electrical connection between the electrode tips 124, 125 and the material to be welded, and a firm connection between the materials to be welded. As the actuator shaft
10 152 is withdrawn into the actuator 150, first pivot 154 is drawn away from fixed connection 132, thereby pulling first and second fixed pivot points 162, 163 toward each other, causing jaws 120, 121 to rotate about fixed connection 132, thereby forcing the first ends 122, 123 of the jaws 120, 121 away from each other. As the electrode tips 124, 125 pull away from one another, the rate of divergence between the electrode tips 124,
15 125 rapidly increases rate for a given constant retraction speed of actuator shaft 152, and the force between electrode tips 124, 125 decreases.

 [35] Rotary actuators may also be used in the present invention to eliminate the linear actuator 150 and its connection to first pivot 154. As seen in Figure 3, a caliper weld gun 210 includes two generally identical upper and lower jaws 220, 222, having a first
20 ends 224, 226 inwardly directed toward each other, second ends 228, 230 and inwardly directed pivot extensions 232, 234 that overlap and interconnect at a connection point 240. Electrode tips 236, 238 are affixed to respective inwardly directed ends 224, 226 of each of the jaws 220, 222. If necessary, the second end 230 of lower jaw 222 is connected to a mounting bracket 242. As in Figure 2 above, first and second links 248, 250 are attached
25 at first ends to first and second fixed pivot points 254, 246 located respectively on upper and lower jaws 220, 222, and are also interconnected with each other at a first pivot point 252. A rotary actuator 244 is connected to one of the second ends of the one of the jaws (in Figure 3, to second end 230 of lower jaw 222), and second fixed pivot point is located on rotary actuator 244. Thus, link 248 is pivotally attached at one end directly to the rotary
30 actuator 244 such that link 248 acts as a crank arm for the rotary actuator. Preferably, connection point 240, first pivot point 252 and the point of ultimate contact between electrode tips 236, 238 lie on an axis A' defined between jaws 220 and 222.

 [36] As may be appreciated from Figure 3, clockwise rotary motion of the rotary actuator about fixed pivot 246 causes fixed pivot points 254, 246 to diverge, thereby
35 forcing rotational motion of jaws 220, 222 about fixed connection 240, which in turn moves electrodes 236, 238 toward each other. Likewise, counterclockwise rotary motion

5 about fixed pivot 246 causes the fixed pivot points 254, 246 to converge, thereby moving electrode tips 236, 238 away from each other. As in the other embodiments, as the electrode tips 236, 238 approach the fully closed position, the closure speed reaches a minimum while the force exerted at electrode tips 236, 238 is maximized due to the mechanical advantage of the link arrangement, working to create a solid electrical and material connection between the electrode tips 236, 238 and the material to be welded.

10 [37] In certain situations, the condition of electrode tips 236, 238 may degrade such that the amount of rotation about fixed connection 240 required to move the electrodes to an engaged position increases over the life of the electrodes. Additionally, as the electrode tips degrade, the compressive pressure applied by the tips decreases. To address this problem, a two-piece link may be substituted for the one-piece link 248 in Figure 3, or may be fixedly attached to the first end of link 248 at a fixed pivot point. The two piece link is thus used in combination with a rotary actuator to compensate for tip wear by providing a constant force over a limited distance independent of the electrode tip length. The utilization of a two piece link also offers extended lifetime for the electrode tips.

20 [38] A closer view of a rotary actuator 300 is shown in Figure 4. For purposes of the following discussion, actuator 300 is shown as a separate device from any links shown in either Figures 2 or 3. The rotary actuator 300 includes a two piece crank 310 comprising an inner crank 312 and an outer crank 314 connected to a fixed pivot point 316. The inner crank 312 is slidably attached to the outer crank 314 along its longitudinal length. A first end 330 of the inner crank 312 includes a fixed attachment point 318 to allow for a first end of a link to be rigidly attached thereto. A cam follower 320 is affixed along the longitudinal length of the inner crank 312, which is slidably engaged in a cam track 322 that includes a predetermined cam surface along which cam follow 320 slides. As a rotative force is applied at fixed pivot point 316, the two piece crank 310 rotates about fixed pivot point 316. As crank 310 rotates, cam follower 320 slides within cam track 322. In response to variations in the cam track 322 pattern, inner crank 312 is slidably drawn out of or pushed into outer crank 314.

35 [39] In general, the cam track 322 contains two portions, but any conventional design may be employed. The first portion 324 of the cam track 322 is preferably arcuate and is preferably a single radius from the fixed pivot point 316. The second portion 326 of

5 the cam track 322 is shaped such that the inner crank 312 preferably slides away from the fixed pivot point 316. To accomplish this, in a preferred embodiment, the second portion 326 of the cam track 322 is generally straight or may be curved so that the second portion 326 is generally convex with respect to the fixed pivot point 316. Preferably, the second portion 326 of the cam track 322 begins approximately about five to ten degrees (5 to 10°) above the axis defined by the fixed pivot point 316. More preferably, the second portion 326 of the cam track 322 begins approximately seven degrees (7°) above the axis. The sliding of the inner crank 312 away from the fixed pivot point 316 provides a constant force over a limited distance at the electrode tips, thus compensating for electrode tip wear, thereby eliminating complex controls by using the constant torque input provided by the rotary drive to create a constant force output.

[40] Although certain preferred embodiment of the present invention have been described, the invention is not limited to the illustration described and shown herein, which are deemed to be merely illustrative of the best modes of carrying out the invention. A person of ordinary skill in the art will realize that certain modifications and variation will come within the teachings of this invention and that such modifications and variations will come within its spirit and the scope as defined by the claims.

5 We claim:

1. A weld gun comprising:

first and second jaws;

a first pivotable member connected to said first jaw at a first fixed pivot point; and

a second pivotable member disposed between said pivotable member and said

10 second jaw, a first end of said second pivotable member connected to said second jaw at a second fixed pivot point, and a second end of said second pivotable member pivotally connected to said first pivotable member at a first pivot point, such that pivotal movement of said first pivotable member about said first fixed pivot point results in pivotal movement of said second pivotable member about said second fixed pivot point and a motion of said
15 second jaw between disengaged and engaged positions along a fixed, preset path.

2. The weld gun of claim 1, wherein said fixed, preset path is one of generally linear or rotational.

20 3. The weld gun of claim 1, further comprising a linear actuator pivotally connected to said first pivotable member at a second pivot point, wherein said pivotal movement of said pivotable member is provided by movement of said linear actuator.

25 4. The weld gun of claim 3, wherein the gun includes a minimum of two fixed pivot points.

5. The weld gun of claim 4, wherein the gun further includes a minimum of two pivot points.

30 6. The weld gun of claim 3, wherein said fixed, preset path is in the same direction as said movement of said linear actuator.

7. The weld gun of claim 3, wherein said fixed, preset path is in a direction transverse to said linear movement.

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5 8. The weld gun of claim 4, wherein said second pivotable member is a toggle link, said toggle link is attached to said first pivotable member at a toggle pivot, and said linear actuator is also connect to said toggle pivot.

9. The weld gun of claim 1, further comprising a rotary actuator pivotally connected
10 to said first pivotable member wherein said pivotal movement of said first pivotable member is provided by movement of said rotary actuator.

10. The weld gun of claim 1, wherein said second jaw motion is continuously variable from a low force at a disengaged position to a high force at an engaged weld inducement
15 position such that force is maximized at said engaged position.

11. The weld gun of claim 1, wherein said second jaw motion is continuously variable from a low speed to a high speed such that speed is minimized at said engaged position.

20 12. The weld gun of claim 1, wherein said pivotable member is generally L-shaped.

13. The weld gun of claim 1, wherein the actuator is a manual actuator.

14. A weld gun comprising:
25 first and second jaws;
 a pivotable member pivotally connected to said first jaw at a first fixed pivot point, said pivotable member being generally L-shaped having first and second legs, said first pivot point located at the intersection of said first and second legs;
 a link having first and second ends, said first end pivotally connected to said second
30 jaw at a second fixed pivot point, said second end pivotally connected to said pivotable member at a first pivot point on said second leg, such that pivotal movement of said pivotable member about said first fixed pivot point results in pivotal movement of said link about said second fixed pivot point and a motion of said second jaw from disengaged to engaged positions along a fixed, preset path.

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5 15. The weld gun of claim 14, wherein said fixed, preset path is one of generally linear or rotational.

16. The weld gun of claim 15, further comprising a linear actuator pivotally connected to said pivotable member at a second pivot point on said first leg, wherein said pivotal
10 movement of said pivotable member is provided by movement of said linear actuator.

17. The weld gun of claim 16, wherein said fixed, preset path is in the same direction as said movement of said linear actuator.

15 18. The weld gun of claim 14, wherein the gun includes a minimum of two fixed pivot points.

19. The weld gun of claim 14, wherein the gun further includes a minimum of two pivot points.
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20. The weld gun of claim 14, wherein said second jaw motion is continuously variable from a low force to a high force such that force is maximized at said engaged position.

21. A weld gun comprising:

25 upper and lower jaws each with first and second ends, each said first end pointing inwardly towards the other in an opposed orientation and terminating in an electrode tip, said jaws further including inwardly directed pivot extensions that overlap and are rotatably connected inwardly of the first and second jaws by a fixed connection;

a first link having first and second ends, said first link first end pivotally connected
30 to said upper jaw second end at a first fixed pivot point;

a second link having first and second ends, said second link second end pivotally connected to said lower jaw second end at a second fixed pivot point;

said first link second end pivotally connected to said second link second end at a first pivot point such that pivotal movement of said first and second links about said first
35 pivot point results in rotational movement of said upper and lower jaws about said fixed

5 connection and a motion of said second jaws from disengaged to engaged positions along a fixed, preset path.

22. The weld gun of claim 21, further comprising a linear actuator pivotally connected to said first and second links at said first pivot point, wherein said pivotal movement of
10 said first and second links is provided by movement of said linear actuator.

23. The weld gun of claim 21, further comprising a rotary actuator pivotally connected to said second link second end at said second fixed pivot point, wherein said pivotal movement of the pivotable member is provided by movement of said rotary actuator.
15

24. The weld gun of claim 23, wherein said rotary actuator includes a dual arm crank.

25. The weld gun of claim 23, wherein said dual arm crank comprises
an inner crank with a cam follower affixed thereto slidably engaged to an outer
20 crank and rigidly connected at a first end to said second link second end, said outer crank pivotally connected to a drive center; and
a cam track, wherein said cam follower is slidably engaged to said cam track.

26. The weld gun of claim 25, wherein said cam track is shaped such that movement of
25 said rotary actuator provides a constant force over a predetermined distance to said electrode tips and accommodates variation in electrode tip sizes.

27. The weld gun of claim 21, wherein said fixed connection, said first pivot point, and a point of ultimate contact between said electrode tips lie on an axis.

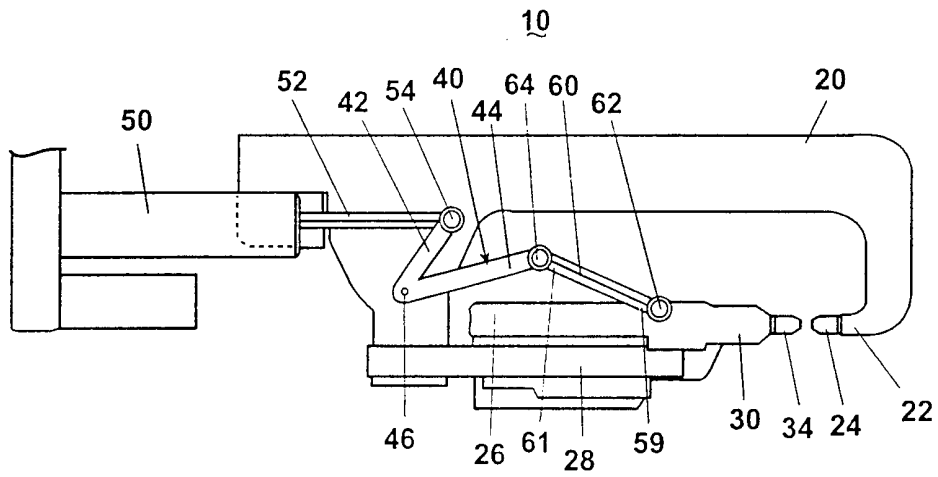


Fig. 1

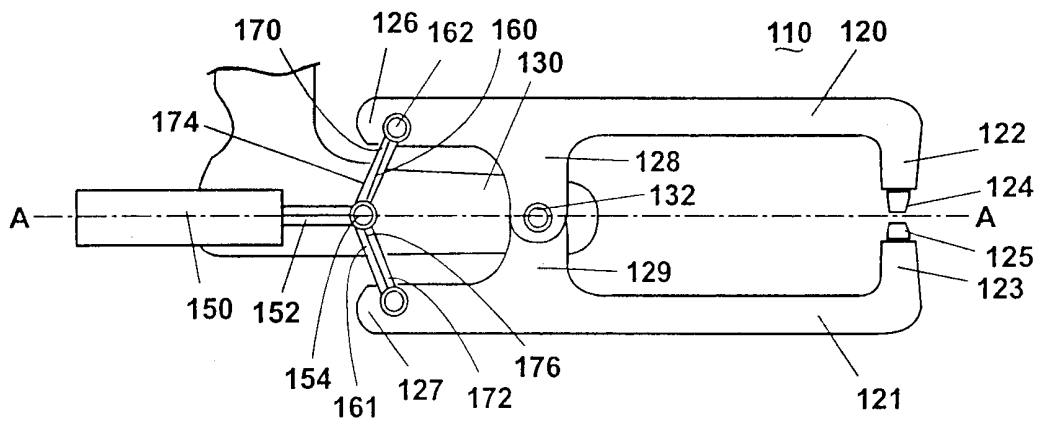


Fig. 2

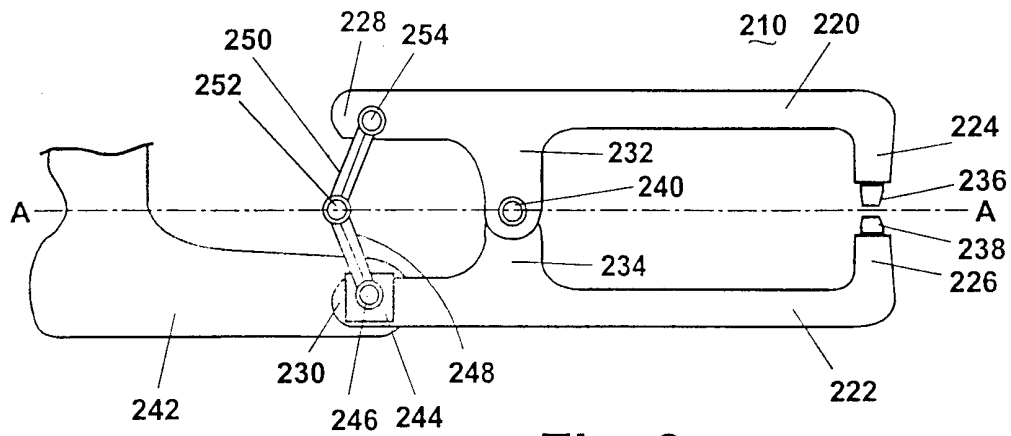


Fig. 3

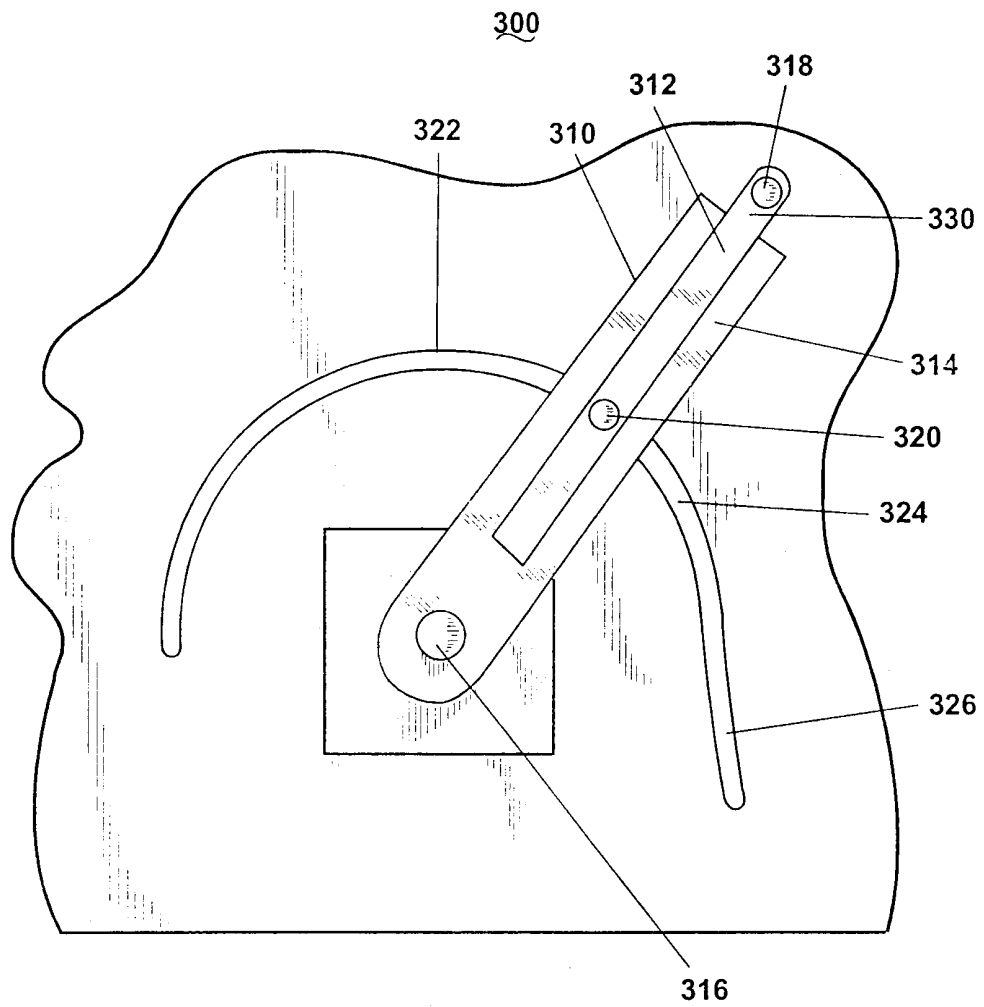


Fig. 4

INTERNATIONAL SEARCH REPORT

International Application No

PCT/US 00/31768

A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 B23K11/31

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 B23K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DE 39 37 643 A (BAYERISCHE MOTOREN WERKE AG) 16 May 1991 (1991-05-16)	1-5, 7, 10-12, 14-16, 18-21 22
Y	figure 1	
X	DE 41 37 574 A (AUDI NSU AUTO UNION AG) 19 May 1993 (1993-05-19) figure 1	1-5, 7, 10-12, 21
X	US 4 656 327 A (WILCOX PAUL A) 7 April 1987 (1987-04-07) figures 2, 3	1, 4, 5, 7, 8, 10, 11, 13
X	EP 0 133 929 A (BAYERISCHE MOTOREN WERKE AG) 13 March 1985 (1985-03-13) page 3, line 25 -page 7, line 35	1, 3, 6
	-/--	

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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Date of the actual completion of the international search

14 February 2001

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INTERNATIONAL SEARCH REPORT

International Application No

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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Y	US 4 728 137 A (HAMED NIHAD ET AL) 1 March 1988 (1988-03-01) figure 4 -----	22

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Information on patent family members

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PCT/US 00/31768

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