



(51) International Patent Classification:

B23K 9/02 (2006.01) B23K 9/173 (2006.01)
B23K 9/025 (2006.01) B23K 9/23 (2006.01)
B23K 9/073 (2006.01) B23K 9/32 (2006.01)
B23K 9/08 (2006.01) B23K 101/00 (2006.01)
B23K 9/167 (2006.01) B23K 103/18 (2006.01)

(21) International Application Number:

PCT/US2018/064666

(22) International Filing Date:

10 December 2018 (10.12.2018)

(25) Filing Language:

English

(26) Publication Language:

English

(71) Applicant: SIEMENS ENERGY, INC. [US/US]; 4400 Alafaya Trail, Orlando, Florida 32826-2399 (US).

(72) Inventor: BRUCK, Gerald J.; 1282 Ficus Drive, Myrtle Beach, South Carolina 29579 (US).

(74) Agent: FIL, Michele S.; Siemens Corporation- Intellectual Property Dept., 3501 Quadrangle Blvd. Ste. 230, Orlando, Florida 32817 (US).

(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ,

OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

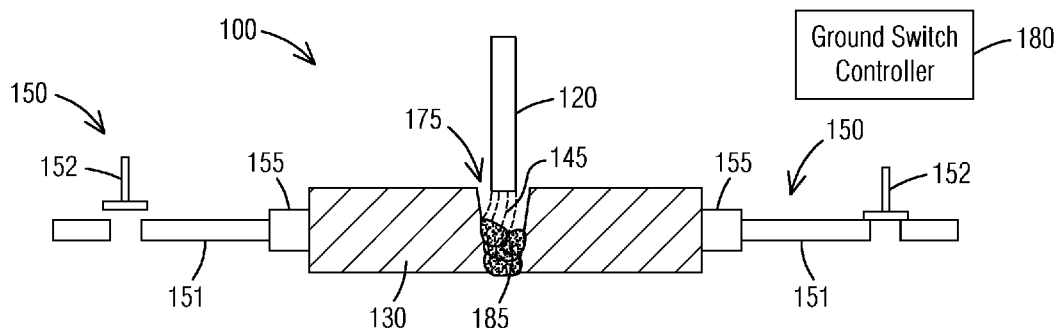
(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— with international search report (Art. 21(3))

(54) Title: METHOD OF AND AN ARC WELDING SYSTEM FOR WELDING ARC CONTROL BY GROUNDING MODULATION

FIG. 3



(57) Abstract: A method and a system (100) for improved control of arc position during an arc welding process are provided. A workpiece (130) is provided to be welded by an arc welding process. A pair of ground connections (155) are connected to the workpiece (130) on opposing sides of the weld location (175) and controlled to modulate which ground connection (155) is active. During the arc welding a weld torch is utilized to produce an arc (145) between an electrode (120) and the workpiece (130) to melt a weld material in order to form a weld bead (185) at a weld location (175) on the workpiece (130). By controlling the ground connections (155), the arc (145) is deflected away from a closed ground connection (155) so that the weld material is deposited in a desired weld location (175).



METHOD OF AND AN ARC WELDING SYSTEM FOR WELDING ARC CONTROL BY GROUNDING MODULATION

BACKGROUND

5 1. Field

[0001] The present application relates generally to welding, and more particularly to an improved method to control arc position during arc welding.

2. Description of the Related Art

10 [0002] Arc based welding involves utilizing an electric arc as a heat source to join two metallic materials together. A power source is used to create the electric arc which extends from an electrode to the base material. The arc quickly heats and melts metallic materials. A metallic wire may be used as a consumable electrode as in the case of Gas Metal Arc Welding (GMAW). Or, in contrast, a non-consumable
15 electrode such as a tungsten electrode may be used such as in Gas Tungsten Arc Welding (GTAW). With GTAW, the metallic wire is fed into a pool of molten metal created when the electrical arc extends from the tip of the tungsten electrode to the base materials forming the molten pool of molten metal. The melted areas of the metal, when cool, result in a binding of the metals.

20 [0003] Weld arc control is important for a variety of reasons. These include ensuring side wall fusion in weld grooves, avoiding arc drag in high travel speed welding, avoiding arc wander in magnetic materials, and managing grain orientation and shape in solidified weld deposits. Managing grain orientation is important when welding materials subject to weld solidification cracking, e.g. turbine blades and
25 vanes made from superalloy materials. In particular, it is widely known that transverse oscillation of the weld can help avoid weld solidification cracking.

[0004] Arc position has previously been controlled, for example, by manipulation of the electrode position or by the use of magnetic arc oscillation equipment. Manipulation of the electrode position, however, requires significant welder skill and
30 attention is required to ensure consistent electrode positioning to accomplish base

metal and filler metal wetting, intended molten metal flow, and complete fusion without defects. Magnetic arc oscillation equipment is commercially available and comprises electromagnetics that can steer the arc over the surface of a plate but are too bulky to provide manipulation in narrow grooves or locations of limited access.

5 Additionally, the heat of welding can cause deterioration of the magnetic equipment that has to be close to the arc to be effective.

[0005] Consequently, a need exists for an improved method to manage the arc position during a welding process.

10

SUMMARY

[0006] Briefly described, aspects of the present disclosure relate to an improved method to control arc position and an arc welding system for improved control of the arc position during an arc weld process.

15

[0007] A first aspect provides an improved method to control arc position during an arc welding process. A workpiece for welding is provided where a pair of ground connections are connected to the workpiece. Each ground connection is controlled in order to modulate which ground connection is active. A weld torch produces an arc between an electrode and the workpiece to melt a weld material in order to form a weld bead at a weld location on the workpiece. The controlling deflects the arc away from a closed ground connection so the weld material is melted and deposited in a desired weld location.

20

25

[0008] A second aspect provides an arc welding system for improved control of the arc position during an arc weld process. The arc welding system includes a workpiece; the workpiece including a substrate to be welded, a welding torch including an electrode, and a power source configured to provide electrical power to the electrode so that an arc is produced between the electrode and the substrate to weld a weld material in order to form a weld bead at a weld location on the substrate. A pair of ground connections are connected to the substrate on opposing sides of the weld location. A ground switch controller controls the arc position by coordinated closing of the ground connections such that the arc is deflected away from a closed

30

ground connection with the result that a weld bead is deposited in a desired weld location.

BRIEF DESCRIPTION OF THE DRAWINGS

5 [0009] Fig. 1 illustrates a perspective view of a GTAW process,

[0010] Fig. 2 illustrates a side view of a workpiece undergoing a welding process that experiences the phenomenon of arc blow,

[0011] Fig. 3 illustrates a side view of a workpiece undergoing a welding process according to an embodiment of the described invention,

10 **[0012]** Fig. 4 illustrates a side view of a workpiece undergoing a welding process according a further embodiment of the described invention, and

[0013] Fig. 5 illustrates a top view of a workpiece comprising two plates undergoing a weld process according to an embodiment of the invention.

15 DETAILED DESCRIPTION

[0014] To facilitate an understanding of embodiments, principles, and features of the present disclosure, they are explained hereinafter with reference to implementation in illustrative embodiments. Embodiments of the present disclosure, however, are not limited to use in the described systems or methods.

20 **[0015]** The components and materials described hereinafter as making up the various embodiments are intended to be illustrative and not restrictive. Many suitable components and materials that would perform the same or a similar function as the materials described herein are intended to be embraced within the scope of embodiments of the present disclosure.

25 **[0016]** Referring now to the figures, Fig. 1 illustrates the tools required for Gas Tungsten Arc Welding (GTAW), which is also commonly known as Tungsten Inert

Gas (TIG) welding. A TIG arc weld system 100 includes a torch 110 that includes a gas cup 115 or nozzle and a tungsten electrode 120 positioned partially within the cup 115. A solid or metal cored or flux cored or flux coated weld wire 125 is used to add material during the welding process. Alternately, autogenous TIG welding may be performed (without filler metal addition). When TIG welding, a welder forms an electrical arc 145 that extends from the tip of the tungsten electrode 120 to a base material 130 in the location where the weld is being made. The arc 145 quickly heats and melts the base material 130 to form a melt pool 135 of molten metal. The welder manually feeds the weld wire 125 into the melt pool 135 where the wire 125 melts and forms part of the weld bead after the molten metal cools. Alternately, a wire feed device may be used to automatically feed the weld wire 125 into the melt pool 135. An inert gas 140 (e.g., argon) is discharged into the cup 115 and maintained around the arc and the weld pool 135 to protect the weld pool 135 from oxidation which can cause flaws in the weld and to protect the tungsten electrode from oxidation. TIG welding is well-known for the quality of welds that can be formed using the process and is well-suited to delicate work or welding of materials that have lower weldability. An alternate arc weld process, as discussed above, Gas Metal Arc Welding (GMAW) is a similar process to GTAW that utilizes the metal wire 125 as both the electrode and additive material. Additionally, other arc processes also exist that may benefit from the proposed method. These weld arc processes may include flux cored arc welding (FCAW), plasma arc welding (PAW), submerged arc welding (SAW), and shielded metal arc welding ((SMAW). Variations of basic processes such as TIP TIG (variation of GTAW) and CMT (variation of GMAW) are also envisioned to receive benefit.

[0017] Arc blow, as is known to those skilled in the art, is the deflection of the arc during arc welding due to a build-up of magnetic flux surrounding the weld pool. Fig. 2 illustrates an example of arc blow caused by a ground effect. A side view of a workpiece 130 is shown during a welding process. The workpiece 130 includes a ground connection 150. The heavy line represents the path of the welding current 160 while a magnetic field 165 set up by the current may be seen circumferentially around the flow of the current 160. As the current 160 changes direction, or turns the corner from the arc 145 to the workpiece 130, a concentration of flux occurs at X, which

causes the arc to blow (deflect), as indicated by the arrow, away from the grounding connection 150. Typically, arc blow is an unwanted phenomenon as it may cause excessive spatter, incomplete fusion, porosity, and lower quality of the welded joint. However, in this disclosure, the inventor innovatively proposes a method and apparatus utilizing the phenomenon of arc blow to beneficially control the arc position during a weld process.

[0018] In an embodiment, an arc weld system 100 for improved control of the arc position during an arc weld process is shown with reference to *Figures 1-5*. The weld torch 110 is shown in detail in Fig. 1. For simplicity, *Figures 3-5* only show the electrode 120, however, the electrode 120 would necessarily be a part of the weld torch as shown in Fig. 1.

[0019] With reference now to Fig. 3, a side view of a workpiece 130 comprising a substrate, is shown undergoing a weld process. In the shown embodiment, a plurality of ground connections 150 are connected to the edges of the substrate 130. The ground connections 150 may comprise a grounding wire 151 including a switch 152 to control the ground connection. In the shown embodiment of Fig. 3, two ground connections 150 are connected to the substrate 130 on opposing sides of a weld location 175, however, two or more ground connections may be used to control the arc position during a weld process such that a pair of ground connections exist on opposing sides of the weld location. In the embodiment shown in Fig. 3, the switch 152 on the right side of the Fig. 3 is closed, closing the ground connection on the right side of the shown weld location 175. The switch 152 on the left side of the weld location 175 is open, disconnecting the ground connection 150 on the left. In an embodiment, the ground connections 150 may be joined to the edges of the substrate 130 by a sliding electrical connection 155 that moves in coordinated motion with the progression of the welding torch 110. The sliding functionality may be enabled by attaching the grounding wire 151 to a wheel or a roller.

[0020] The arc welding system 100 may also include a ground switch controller 180. The ground switch controller 180 provides the control of the switches 152 to modulate which ground connection is active at a given time. For example, in Fig. 3 the ground connections 150 are on opposing sides of the weld location 175. In this

embodiment, by closing one ground connection 150, for instance on the right as shown, the arc 145 is deflected to the opposing side of the weld location 175 (to the left as shown) without any further manipulation of the welding electrode 120. The next adjacent pass, which may be seen in Fig. 4, is accomplished by closing the
5 second ground connection 150 (on the left) and opening the first ground connection 150 to make a weld deposit 185 against the other wall of the weld location 175. Side wall fusion may thus be accomplished in a narrow groove as shown. In another embodiment, when centered deposition of the weld material is desired, such as for the root pass, both ground connections 150 can be connected simultaneously.

10 **[0021]** In an embodiment, the weld location 175 is a narrow groove. The width of a narrow groove 175 may be in the range of 8-15 mm, for example. The narrow groove 175 may also be deep, for example 5-51 mm deep. As mentioned above, a disadvantage of arc welding deep, narrow grooves is that the side wall fusion of the weld material may be poor. For instance, if the arc is projected straight down into the
15 groove there may not be enough arc concentration on the side of the weld location to ensure fusion to the side wall. Additionally, slight variations in wire position from center could result in arcing and fusion to the closest wall when, in practice, fusion to the opposite wall is needed and intended.

[0022] Referring to *Figures 1-5*, an improved method to control arc position
20 during an arc welding process is also provided. A workpiece 130 comprising a substrate is provided for welding and a plurality of ground connections 150 are connected to the substrate. The ground connections 150 are controlled to modulate which connection is active at any given time. A weld torch 110 is utilized to produce an arc 145 between an electrode 120 and the substrate 130 to melt a weld material 125
25 in order to form a weld bead 185 at a weld location 175 on the workpiece 130. The controlling of the ground connections 150 cause a deflection of the arc 145 away from a closed ground connection 150 so that the weld bead 185 is deposited in a desired weld location 175.

[0023] One solution to ensuring good side wall fusion of the weld material in a
30 deep narrow groove has previously been to use mechanical oscillators. The mechanical oscillators essentially rock the torch from side to side with the result that

the weld bead fuses well to the side wall. Alternately, however, controlling arc blow, as described by the presented method, may also be utilized to cause transverse arc oscillation in narrow grooves through the coordinated closing of the ground connections on opposing sides of a weld location.

5 **[0024]** For example, Fig. 5 illustrates a series of ground connections 150 on opposing sides of a workpiece 130, in the form of two plates, to be welded. The plates 130 are separated by a gap 190 where the welding will occur. On the outer edge of each plate 130, a bar 200 may be disposed with conductive contacts 201 separated by insulators 202. Each conductive contact 201 may be connected to a grounding
10 connection 150. The ground connections 150 may be connected to the ground of the welding machine as shown. In the case of TIG welding, the ground of the welding machine may be the positive terminal for example. Each ground connection 150 may include a switch 152 to be controlled in order to cause arc deflection away from the closed grounding connection 150. In an embodiment, the series of switches may be
15 alternately closed, as shown by the sequence of numbers in Fig. 5, with the result that weld material is deposited in a pattern as shown. The frequency of such alternation may be slow to cause a weaved pattern, as shown. Alternately, the frequency may be modulated to be faster so that the weld pool is widened thereby achieving a weld deposit with good side wall fusion.

20 **[0025]** Various alloys may have different optimum frequencies and optimum amplitudes of arc deflection (which is also a function of other essential welding variables such as travel speed, amperage, and voltage). For example, optimum frequency reported for an aluminium alloy to minimize solidification cracking has been reported at about 1 Hz (for 54 amp, 11 volts, 2.54 mm/sec travel speed and at
25 both 1.9 mm and 1.1 mm amplitudes). For higher frequencies, cracking increased somewhat for the 1.9 mm amplitude, but increased by over an order of magnitude for the 1.1. mm amplitude. At ‘modest’ welding conditions (for example, 1-10 mm/sec, 40-150 amps, and 9-18 volts), it may be expected such optimum frequencies to be found in the range of 0.5 to 10 Hz and optimum amplitudes to be found in the range
30 of 0.5 to 3 mm. Amplitude may be adjusted by electrical characteristic, for example, by adjusting welding current.

[0026] In an embodiment, the arc welding system 100 may include a camera 210 for monitoring the condition of the weld bead 185 and providing feedback to the ground switch controller 180. The ground switch controller 180 may utilize the feedback to control the closing of the switches 152. In the embodiment of Fig. 5, the
5 ground switch controller 180 may utilize the feedback to control timing the sequence of switch closures to cause arc deflection.

[0027] Difficult to weld materials such as nickel-based superalloys may benefit from grounding oscillation. It is recognized that superalloy materials are among the most difficult materials to weld due to their susceptibility to weld solidification
10 cracking and strain age cracking. In an embodiment, the substrate 130 of the workpiece may be a nickel-based superalloy material. Additionally, the welding material 125 may also be a nickel-based superalloy material. It is advantageous to use matching filler wire so that properties of the weld are equivalent to the base metal.

[0028] It may be appreciated that the disclosed welding system and method utilizes
15 the phenomenon of arc blow to beneficially control the arc position during arc welding. The improved method avoids the need to manipulate the electrode and does not require equipment to be accessible near the arc, which equipment may be susceptible to overheating from the heat of the arc.

[0029] While embodiments of the present disclosure have been disclosed in
20 exemplary forms, it will be apparent to those skilled in the art that many modifications, additions, and deletions can be made therein without departing from the spirit and scope of the invention and its equivalents, as set forth in the following claims.

What is claimed is:

1. An improved method to control arc position during an arc welding process, the method comprising:

providing a workpiece 130 comprising a substrate for welding;

5 connecting a pair of ground connections 150 to the workpiece 130;

controlling each ground connection 150 by a switch 152 in order to close the ground connection 150;

10 producing, with a weld torch 110, an arc 145 between an electrode 120 and the workpiece 130 to melt a weld material 125 and/or a portion of the substrate 130 in order to form a weld bead 185 at a weld location 175 on the workpiece 130;

wherein the controlling deflects the arc 145 away from the closed ground connection 150 so that the weld material 125 is deposited in a desired weld location.

2. The method as claimed in claim 1, further comprising connecting a plurality of ground connections 150 on opposing sides of the weld location 175, and

15 controlling the plurality of ground connections 150 by alternately closing the ground connections 150 on opposing sides of the weld location 175 so that weld material 125 is alternately deposited on the opposite side of the weld location 175 from the closed ground connection.

3. The method as claimed in claim 1, further comprising connecting a plurality of ground connections 150 on opposing sides of the weld location 175, and

20 controlling the plurality of ground connections 150 by simultaneously closing the ground connections 150 on opposing sides of the weld location 175 so that weld material 125 is centrally deposited on the weld location 175.

4. The method as claimed in claim 1, wherein the weld location 175 is a

25 narrow groove.

5. The method as claimed in claim 4, wherein the narrow groove includes a width in a range of 8-15 mm.

6. The method as claimed in claim 5, wherein the narrow groove includes a depth in a range of 5 to 51 mm.

7. The method as claimed in claim 2, further comprising modulating the frequency of the alternation in a range of 0.5 to 10 Hz and an amplitude of alternation
5 in a range of 0.5 to 3 mm in order to create a weaving of the microstructure of the weld deposit.

8. The method as claimed in claim 2, further comprising modulating the frequency of the alternation in order to cause weaving of the solidification grain structure for improved crack resistance or widening of the deposited metal to ensure
10 fusion with side walls.

9. The method as claimed in claim 1, further comprising monitoring the condition of the weld bead utilizing a camera and communicating the condition of the weld bead to a ground switch controller 180 for controlling the closing of the ground connections.

10. The method as claimed in claim 8, wherein the workpiece 130
15 comprises a nickel-based superalloy material.

11. An arc welding system 100 for improved control of an arc position during an arc welding process, comprising:

a workpiece 130 comprising a substrate 130;
20 a welding torch 110 comprising an electrode 120;
a pair of ground connections 150 connected to the substrate 130;
a power source configured to provide electrical power to the electrode 120 so that an arc 145 is produced between the electrode 120 and the substrate 130 to melt a weld material 125 and portion of the substrate 130 in order to form a weld bead 185 at
25 a weld location 175 on the substrate 130; and

a ground switch controller 180 controlling the arc position by coordinated closing of the pair of grounding connections 150 such that the arc 145 is deflected away from the closed grounding connection 150 with the result that the weld bead 185 is deposited in a desired weld location.

12. The arc welding system 100 as claimed in claim 11, wherein the ground connections 150 each comprise a grounding wire 151 and a switch 152 for opening and closing the ground connection.

13. The arc welding system 100 as claimed in claim 11, further comprising
5 a plurality of ground connections 150,
wherein pairs of ground connections 150 of the plurality of ground connections 150 are disposed on opposite sides of the weld location 175.

14. The arc welding system 100 as claimed in claim 11, wherein each ground connection 150 comprises a sliding ground connection 155, the sliding ground
10 connection 155 including a roller connected to the grounding wire 151 so that the sliding ground connection 155 moves in coordinated motion with the welding torch 110.

15. The arc welding system 100 as claimed in claim 11, further comprising a camera for monitoring the condition of the weld bead 185 and providing feedback to
15 the ground switch controller 180 for timing of the closing of the switch 152.

16. The arc welding system 100 as claimed in claim 11, wherein the workpiece 130 comprises a nickel-based superalloy material.

17. The arc welding system 100 as claimed in claim 16, wherein the weld bead is controlled to reduce solidification cracking of the weld bead.

18. The arc welding system 100 as claimed in claim 11, wherein the weld
20 location is a narrow groove.

19. The arc welding system 100 as claimed in claim 18, wherein the width of the narrow groove is in a range of 8-15 mm.

20. The arc welding system 100, as claimed in claim 19, wherein the depth
25 of the groove is 5 to 51 mm.

1/3

FIG. 1

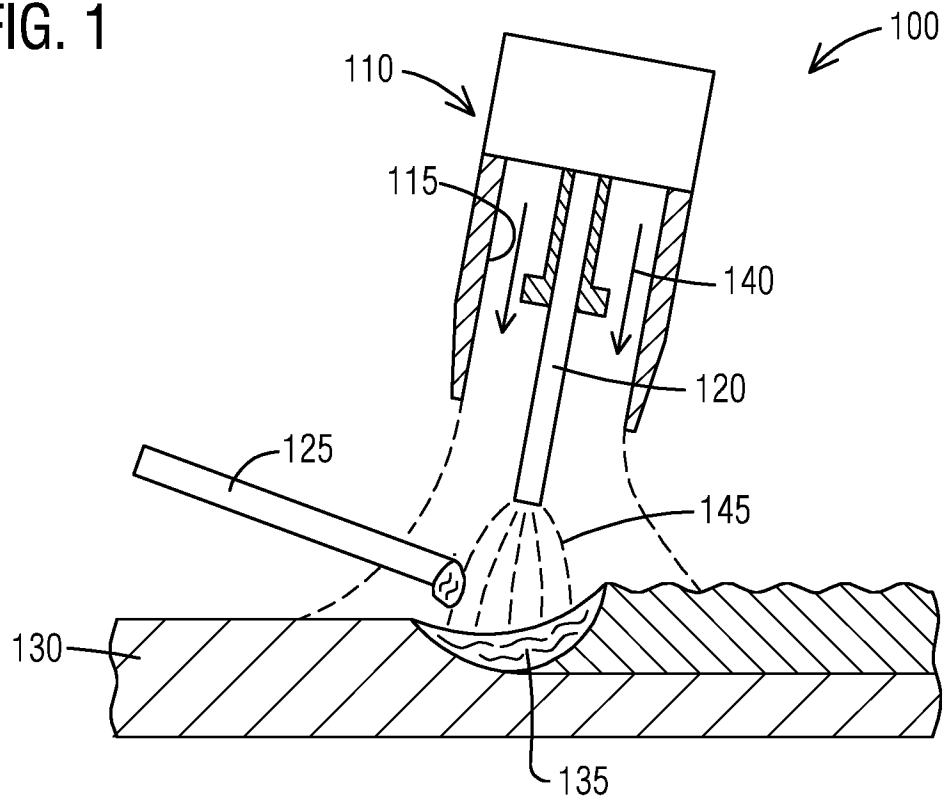
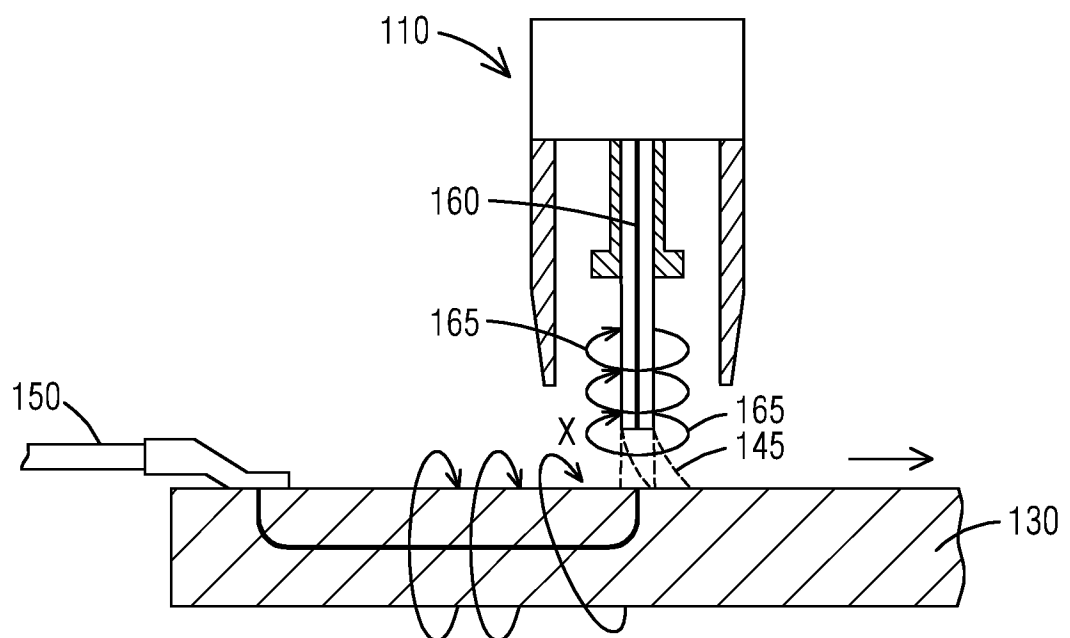


FIG. 2



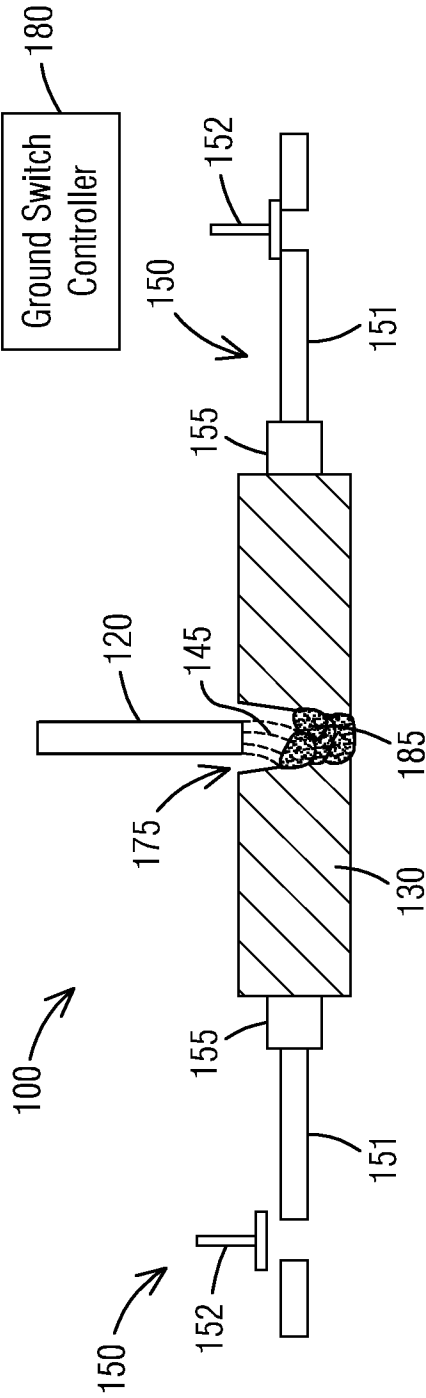


FIG. 3

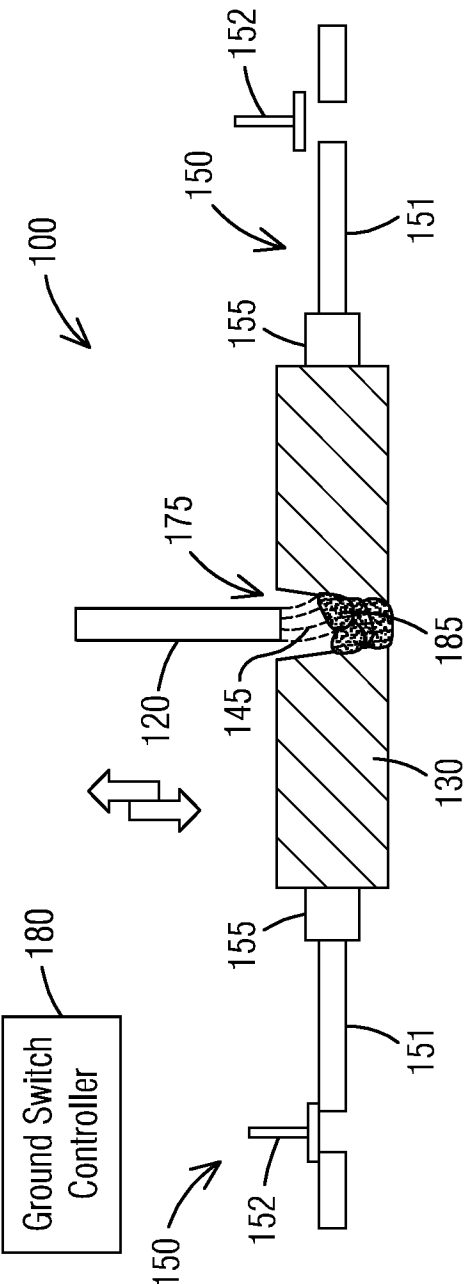
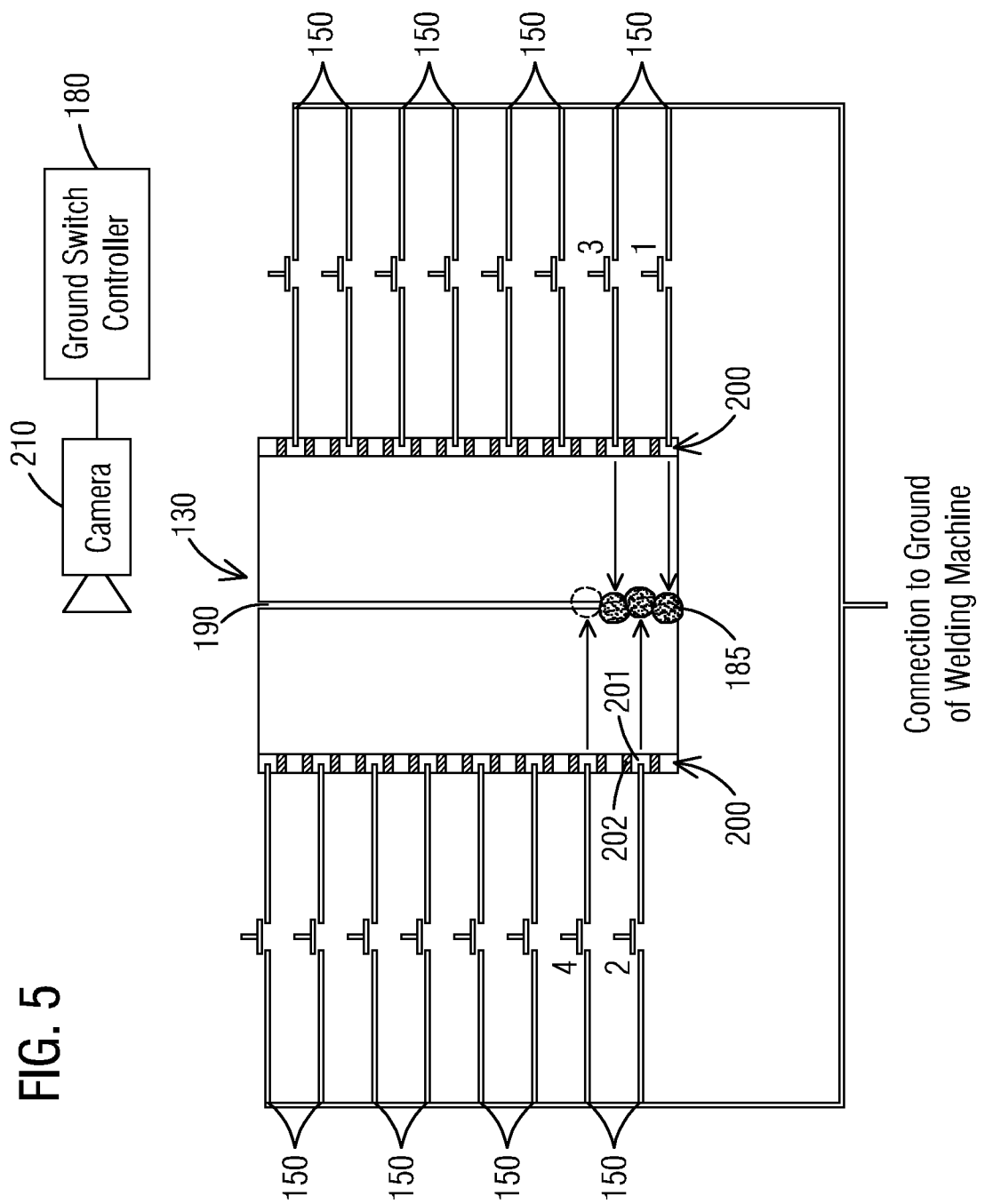


FIG. 4

FIG. 5



INTERNATIONAL SEARCH REPORT

International application No
PCT/US2018/064666

A. CLASSIFICATION OF SUBJECT MATTER		
INV.	B23K9/02	B23K9/025
	B23K9/173	B23K9/23
ADD.	B23K101/00	B23K103/18
	B23K9/073	B23K9/32
	B23K9/08	B23K9/167
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) 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 practicable, search terms used) EPO-Internal, WPI Data		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2013/228558 A1 (J. A. DANIEL) 5 September 2013 (2013-09-05)	1-4,7,8, 11-14
Y	paragraphs [0031], [0038]; figures 3,6	5,6,9, 10,15-20
Y	----- JP H02 89575 A (MITSUBISHI HEAVY IND LTD) 29 March 1990 (1990-03-29)	5,6,10, 16-20
A	abstract; figures 1-4	4
Y	----- EP 3 315 237 A1 (SIEMENS AG) 2 May 2018 (2018-05-02)	9,15
	abstract; claims; figures	
X	----- US 2016/082539 A1 (M. S. FLAGG) 24 March 2016 (2016-03-24)	1,2,4,7, 8,11,13
	paragraphs [0035], [0048], [0049], [0052]; figures	
	----- -/-	
☒ Further documents are listed in the continuation of Box C. ☒ See patent family annex.		
* Special categories of cited documents : "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier application or patent but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family		
Date of the actual completion of the international search 28 August 2019		Date of mailing of the international search report 09/09/2019
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016		Authorized officer Jeggy, Thierry

INTERNATIONAL SEARCH REPORT

International application No

PCT/US2018/064666

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP H01 148468 A (MITSUBISHI MOTORS CORP) 9 June 1989 (1989-06-09) abstract; figures -----	1-3, 11-13
A	US 4 455 471 A (G. M. ECER ET AL) 19 June 1984 (1984-06-19) column 1, lines 42-52; figures -----	1-20

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2018/064666

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2013228558	A1	05-09-2013	CN 104203473 A 10-12-2014
			DE 212013000077 U1 21-11-2014
			JP 3196142 U 26-02-2015
			KR 20140132757 A 18-11-2014
			US 2013228558 A1 05-09-2013
			WO 2013128263 A1 06-09-2013

JP H0289575	A	29-03-1990	NONE

EP 3315237	A1	02-05-2018	CN 109937111 A 25-06-2019
			EP 3315237 A1 02-05-2018
			EP 3507048 A1 10-07-2019
			WO 2018077572 A1 03-05-2018

US 2016082539	A1	24-03-2016	NONE

JP H01148468	A	09-06-1989	NONE

US 4455471	A	19-06-1984	JP S58125372 A 26-07-1983
			US 4455471 A 19-06-1984
