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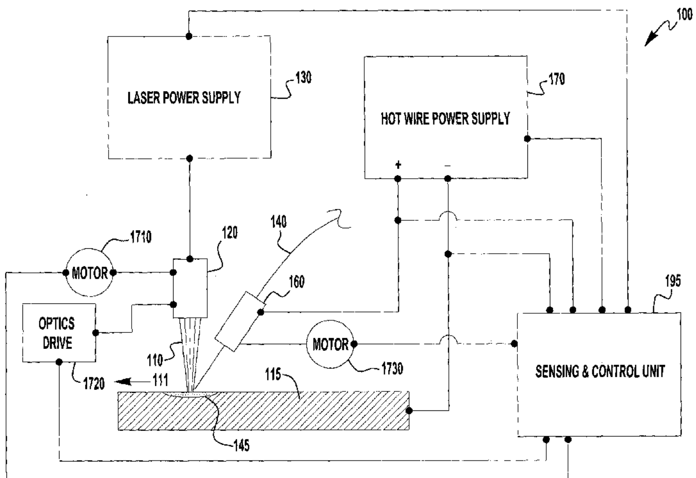

FIG. 1

(57) Abstract: A system (100) for and a method of controlling filler wire (140) are provided. The system (100) includes a high intensity energy source (130) configured to heat at least one workpiece (115) to create a molten puddle (145) on a surface of the at least one workpiece (115). A filler wire feeder (150) is configured to feed a filler wire (140) into said molten puddle (145), and a travel direction controller is configured to advance the high intensity energy source (130) and the filler wire (140) in a travel direction to deposit the filler wire (140) on the at least one workpiece (115). The system (100) also includes a filler wire (140) controller (195) configured to move the filler wire (140) in at least a first direction during the feeding and advancing of the filler wire (140). At least the first direction is controlled to obtain a desired shape, profile, height, size, or an admixture of a bead formed by the molten puddle (145).

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METHOD AND SYSTEM OF USING CONSUMABLE WITH WELD PUDDLE

[001] The present application claims priority to U.S. Provisional Patent Application No. 61/668,818, which is incorporated herein by reference in its entirety.

FIELD OF THE INVENTION

[002] The invention is related to a method of controlling filler wire according to claim 1 and to a system for controlling a filler wire according to claim 8. Certain embodiments relate to using filler wire in overlaying, welding and joining applications. More particularly, certain embodiments relate to controlling filler wire in a system and method for any of brazing, cladding, building up, filling, hard-facing overlaying, joining and welding applications.

TECHNICAL BACKGROUND

[003] The traditional filler wire method of welding (e.g., a gas-tungsten arc welding (GTAW) filler wire method) provides increased deposition rates and welding speeds over that of traditional arc welding alone. The filler wire, which leads a torch, is resistance-heated by a separate power supply. The wire is fed through a contact tube toward a workpiece and extends beyond the tube. The extension is resistance-heated such that the extension approaches or reaches the melting point and contacts the weld puddle. A tungsten electrode may be used to heat and melt

the workpiece to form the weld puddle. The power supply provides a large portion of the energy needed to resistance-melt the filler wire. In some cases, the wire feed may slip or falter and the current in the wire may cause an arc to occur between the tip of the wire and the workpiece. The extra heat of such an arc may cause burn through and spatter. In addition, because the traditional filler wire method uses an arc to transfer the filler material to the weld, it may be difficult to get the desired weld profile and/or control the cooling rate of the weld puddle.

[004] Further limitations and disadvantages of conventional, traditional, and proposed approaches will become apparent to one of skill in the art, through comparison of such approaches with embodiments of the present invention as set forth in the remainder of the present application with reference to the drawings.

DESCRIPTION

[005] The problem according to the invention is to overcome the limitations and disadvantages. This problem is solved by a method of controlling filler wire according to claim 1 and by a system for controlling a filler wire according to claim 8. Preferred embodiments of the invention are subject of the subclaims. Embodiments of the present invention comprise controlling filler wire in a system and method for any of brazing, cladding, building up, filling, hard-facing overlaying, welding, and joining applications. In some embodiments, the method includes heating at least one workpiece with a high energy heat source to create a molten puddle on a surface of the at least one workpiece and feeding a filler wire into the molten puddle.

The method also includes advancing each of the high energy heat source and the filler wire in a travel direction to deposit the filler wire on the at least one workpiece. The filler wire is moved in at least a first direction during the feeding and advancing of the filler wire, where the at least first direction is different from the travel direction. The method further includes controlling at least the movement of the filler wire in the at least first direction to obtain a desired shape, profile, height, size, or an admixture of a bead formed by the molten puddle.

[006] In some embodiments, the system includes a high intensity energy source configured to heat at least one workpiece to create a molten puddle on a surface of the at least one workpiece. A filler wire feeder is configured to feed a filler wire into the molten puddle. A travel direction controller is configured to advance each of the high intensity energy source and the filler wire in a travel direction to deposit the filler wire on the at least one workpiece. The system also includes a filler wire controller configured to move the filler wire in at least a first direction during the feeding and advancing of the filler wire, where the at least first direction is different from said travel direction. At least the movement of the filler wire in the at least first direction is controlled to obtain a desired shape, profile, height, size, or an admixture of a bead formed by the molten puddle.

[007] The method also includes applying energy from a high intensity energy source to the workpiece to heat the workpiece at least while applying the flow of heating current. The high intensity energy source may include at least one of a laser device, a plasma arc welding (PAW) device, a gas tungsten arc welding

(GTAW) device, a gas metal arc welding (GMAW) device, a flux cored arc welding (FCAW) device, and a submerged arc welding (SAW) device.

[008] These and other features of the claimed invention, as well as details of illustrated embodiments thereof, will be more fully understood from the following description and drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[009] The above and/or other aspects of the invention will be more apparent by describing in detail exemplary embodiments of the invention with reference to the accompanying drawings, in which:

[0010] FIG. 1 illustrates a functional schematic block diagram of an exemplary embodiment of a combination filler wire feeder and energy source system for any of brazing, cladding, building up, filling, hard-facing overlaying, joining, and welding applications;

[0011] FIGS. 2A – 2C illustrate a method of controlling a filler wire that can be used by the system of FIG. 1;

[0012] FIGS. 3A and 3B illustrate a method of controlling a filler wire that can be used by the system of FIG. 1;and

[0013] FIGS. 4A and 4B illustrate a method of controlling filler wires that can be used by the system of FIG. 1.

DETAILED DESCRIPTION

[0014] Exemplary embodiments of the invention will now be described below by reference to the attached Figures. The described exemplary embodiments are intended to assist the understanding of the invention, and are not intended to limit the scope of the invention in any way. Like reference numerals refer to like elements throughout.

[0015] It is known that welding/joining operations typically join multiple workpieces together in a welding operation where a filler metal is combined with at least some of the workpiece metal to form a joint. Because of the desire to increase production throughput in welding operations, there is a constant need for faster welding operations, which do not result in welds which have a substandard quality. This is also true for cladding/surfacing operations, which use similar technology. It is noted that although much of the following discussions will reference "welding" operations and systems, embodiments of the present invention are not just limited to joining operations, but can similarly be used for cladding, brazing, overlaying, etc. –type operations. Furthermore, there is a need to provide systems that can weld quickly under adverse environmental conditions, such as in remote work sites. As described below, exemplary embodiments of the present invention provide significant advantages over existing welding technologies. Such advantages include, but are not limited to, using multiple filler wires, adjusting weld profiles, controlling the cooling rate of the weld puddle, reduced total heat input resulting in low distortion of the workpiece, very high welding travel speeds, very low spatter rates, welding with the absence of shielding, welding plated or coated materials at high speeds with little or no spatter, and welding complex materials at high speeds.

[0016] FIG. 1 illustrates a functional schematic block diagram of an exemplary embodiment of a combination filler wire feeder and energy source system **100** for performing any of brazing, cladding, building up, filling, hard-facing overlaying, and joining/welding applications. The system **100** includes a laser subsystem **130/120** capable of focusing a laser beam **110** onto a workpiece **115** to heat the workpiece **115** and form a weld puddle **145**. The laser subsystem is a high intensity energy source. The laser subsystem can be any type of high energy laser source, including but not limited to carbon dioxide, Nd:YAG, Yb-disk, YB-fiber, fiber delivered or direct diode laser systems. Further, even white light or quartz laser type systems can be used if they have sufficient energy. Other embodiments of the system may include at least one of an electron beam, a plasma arc welding subsystem, a gas tungsten arc welding subsystem, a gas metal arc welding subsystem, a flux cored arc welding subsystem, and a submerged arc welding subsystem serving as the high intensity energy source. The following specification will repeatedly refer to the laser system, beam and power supply, however, it should be understood that this reference is exemplary as any high intensity energy source may be used. For example, a high intensity energy source can provide at least 500 W/cm^2.

[0017] It should be noted that the high intensity energy sources, such as the laser devices **120** discussed herein, should be of a type having sufficient power to provide the necessary energy density for the desired welding operation. That is, the laser device **120** should have a power sufficient to create and maintain a stable weld puddle throughout the welding process, and also reach the desired weld penetration. For example, for some applications lasers should have the ability to "keyhole" the workpieces being welded. This means that the laser should have sufficient power to fully penetrate the workpiece, while maintaining that level of penetration as the laser travels along the workpiece. Exemplary lasers should have power capabilities in the range of 1 to 20kW, and may have a power capability in the range of 5 to 20kW. Higher power lasers can be utilized, but can become very costly.

[0018] The laser subsystem **130/120** includes a laser device **120** and a laser power supply **130** operatively connected to each other. The laser power supply **130** provides power to operate the laser device **120**. Laser device **120** allows for precise control of the size and depth of the weld puddle **145** as the laser beam **110** can be focused/de-focused easily or have its beam intensity changed very easily. Because of these abilities the heat distribution on the workpiece **115** can be precisely controlled. This control allows for the creation of a very narrow weld puddle for precise welding as well as minimizing the size of the weld zone on the workpiece **115**.

[0019] The system **100** also includes a filler wire feeder subsystem capable of providing at least one resistive filler wire **140** to make contact with the workpiece **115** in the vicinity of the laser beam **110**. Of course, it is understood that by reference to the workpiece **115** herein, the molten puddle, i.e., the weld puddle **145**, is considered part of the workpiece **115**, thus reference to contact with the workpiece **115** includes contact with the puddle **145**. The filler wire feeder subsystem includes a filler wire feeder **150**, a contact tube **160**, and a wire power supply **170**. During operation, the filler wire **140** is resistance-heated by electrical current from the power supply **170** which is operatively connected between the contact tube **160** and the workpiece **115**. In accordance with an embodiment of the present invention, the power supply **170** is a pulsed direct current (DC) power supply, although alternating current (AC) or other types of power supplies are possible as well. In some exemplary embodiments, the filler wire **140** is preheated by power supply **170** to at or near its melting point. Accordingly, its presence in the weld puddle **145** will not appreciably cool or solidify the puddle **145** and the filler wire **145** is quickly consumed into the weld puddle **145**.

[0020] The power supply **170**, filler wire feeder **150**, and laser power supply **130** may be operatively connected to sensing and control unit **195**. The control unit **195** can control the welding operations such as wire feed speed, wire temperatures, and weld puddle temperature – to name just a few. To accomplish this, the control unit **195** can receive inputs such as the power used by power supplies **130** and **170**, the voltage at contact tube **160**, the heating current(s) through the filler wire(s), the desired and actual temperature(s) for the filler wire(s), etc. US Patent Application No. 13/212,025, titled "Method And System To Start And Use Combination Filler Wire Feed And High Intensity Energy Source For Welding," filed August 17, 2011, is incorporated by reference in its entirety, describes exemplary sensing and control units, including exemplary monitoring and control methodologies, that may be incorporated in the present invention.

[0021] In exemplary embodiments of the present invention, the weld profile, i.e., the shape and/or size of the weld puddle **145**, can be changed by controlling the movement of the wire **140** relative to the weld puddle 145. As illustrated in Figure 1, the impact location of the filler wire **140** in the weld puddle **145** may be controlled by filler wire motor **1730**, which controls contact tube **160**. The motor **1730** moves or translates the contact tube **160** such that the position of the wire **140** relative to the weld puddle **145** is moved during welding. In an exemplary embodiment, the filler wire **140** impacts the weld puddle **145** at the same location as the laser beam **110**. In such cases, the laser beam **110** may aid in melting the filler wire **140**. However, in other exemplary embodiments, the filler wire **140** can impact the same weld puddle **145** remotely from the laser beam **110**. Of course, when an arc-type heating subsystem is used instead of a laser subsystem, the filler wire **140** impacts the weld puddle **145** remotely from the arc. In some exemplary embodiments, the filler wire motor **1730** will control contact tube **160** such that the movement of wire **140** within the weld puddle **145** is coordinated with the movement of laser beam **110**. In this regard, the motor **1730** may be operatively connected to and communicate with the sensing and control unit **195** and/or directly with laser motion control subsystem **1710/1720**. The laser motion control subsystem **1710/1720** includes motor **1710** and optics drive unit **1720**. The motor **1710** moves or translates the laser **120** such that the position of the beam **110** relative to the weld puddle **145** is moved during welding. That is, while the laser beam **110** and wire **140** are moved relative to the workpiece **115** during the welding process (i.e., the direction of the weld (see arrow **111**)), the laser beam **110** can also be moved relative to the weld puddle **145**. For example, based on the welding parameters, the motor **1710** can translate the beam **110** back and forth in-line with the direction of the weld, back and forth along the width of the weld, in a circular pattern, in an elliptical pattern, etc. Alternatively, or in addition to moving the laser beam **110**, the optics drive unit **1720** can control the optics of the laser **120**, which control the shape and/or intensity of laser beam **110**. For example, the optics drive unit **1720** can cause the focal point of the beam **110** to move or change relative to the surface of the workpiece **115**, thus changing the penetration or depth of the weld puddle **145**. In some exemplary embodiments, the optics drive unit **1720** can cause the optics of the laser **120** to change the shape of the beam **110** and, thus the shape of weld puddle **145**. The operation of the laser motion control subsystem **1710/1720** is further discussed US Patent Application No. 13/212,025, titled "Method And System To Start And Use Combination Filler Wire Feed And High Intensity Energy Source For Welding," filed August 17, 2011, and incorporated by reference in its entirety.

[0022] By being able to move the wire **140** relative to the puddle, embodiments of the present invention are capable of adjusting the shape, profile and height of the puddle, as well as obtaining the desired weld puddle admixture during welding. For example, if the weld puddle **145** is relatively large due, the movement of the wire **140** will allow the wire **140** to be deposited and distributed relatively evenly throughout the puddle **145** during welding/cladding. Moreover, it may be desirable to deliver the **140** to certain portions of the puddle **145** at different times during the operation. Embodiments of the present invention allow this to occur by delivering the wire **140** to the proper location in the puddle **145** at the appropriate time. Further, mixing of the weld puddle can be enhanced by moving the wire **140** relative to the puddle during the operation.

[0023] In some exemplary embodiments, the sensing and control unit **195** may synchronize the movement of the wire **140** using the motor **1730** with that of laser beam **110**. In an exemplary embodiment, as illustrated in Figures 2A and 2B, the laser beam **110** and wire **140** are both moved in a circular pattern by motors **1710** and **1730**, respectively. The relative position of wire **140** with respect to beam **110** can be adjusted by motor **1730** to ensure that, as the beam **110** and wire **140** move forward in the direction of the weld (see arrow **111**), the wire **140** impinges the weld puddle **145** at a point where the puddle **145** is at its optimum temperature. For example, as shown in Figure 2B, the wire **140** will impinge point X on weld puddle **145** immediately after the beam **110** heats it. Thus, embodiments of the present invention can have the wire **140** follow the movement of the beam **110** (or other heat source) to optimize absorption of the wire **140** into the puddle **145**, which is generally shown in Figure 2C. Of course, the exact timing on the optimum impingement point may vary depending on the temperature of the weld puddle **145**, the intensity of laser beam **110**, the type of filler wire **140**, the feed speed of the filler wire **140**, etc.

[0024] In addition, the wire **140** and the laser beam **110** may follow other patterns and their movements need not be synchronized. For example, Figures 3A and 3B illustrates an embodiment in which the laser beam **110** and the filler wire **140** are translated back-and-forth along a single line. Depending on whether the beam **110** and wire **140** are translated across the width of the weld puddle **145** (Figure 3A) or in-line with the weld puddle (Figure 3B), these embodiments can be used to either elongate or widen the puddle **145** as needed depending on the desired shape of the weld. Of course numerous other patterns are possible. For example, the beam **110** and the wire **140** can be translated in an elliptical pattern in the weld puddle **145** rather than the circular pattern shown in Figures 2A and 2B. Of course, any combination of such patterns can be used to either elongate or widen the weld puddle **145** as needed to get the desired weld profile. In addition, US Patent Application No. 13/212,025, titled "Method And System To Start And Use Combination Filler Wire Feed And High Intensity Energy Source For Welding," filed August 17, 2011, and incorporated by reference in its entirety, provides additional patterns that may be used in the present invention.

[0025] In some embodiments, the motion of the wire **140** is independent of the motion of the laser beam **110**. That is, the patterns of the laser beam **110** and the wire **140** need not be the same. For example, the laser beam **110** may have an elliptical pattern while the wire **140** has a circular or back-and-forth pattern. In still other embodiments, the laser beam **110** can remain stationary with respect to the weld puddle **145**, and only the wire **140** is moved or translated relative to the weld puddle **145**.

[0026] In some exemplary embodiments of the present invention, the filler wire **140** may be used to control the rate of cooling for the weld puddle **145**. For example, the filler wire **140** may be cooler than the weld puddle **145** in order to cool and solidify the weld. Such a welding system may be advantageous in out-of-position welding because the weld puddle **145** will start to cool and solidify before it can sag or spill out of the weld joint. However, to prevent undesirable localized (or uneven) cooling or solidification within the weld puddle **145**, motor **1730** can move the wire **140** as discussed above to ensure that the cooler filler wire **140** is spread evenly throughout the weld puddle **145**. Conversely, in some welding operations, it may be desirable to have the filler wire **140** hotter than the weld puddle **145** in order to prevent the weld puddle **145** from cooling or solidifying too quickly. Again, the filler wire **140** may be moved by motor **1730** to keep the temperature of weld puddle **145** uniform.

[0027] In the embodiment shown in Figures 2A-3B, the filler wire **140** trails the beam **110** during the welding operation. However, that is not necessary as the filler wire **140** can be positioned in the leading position. Further, it is not necessary to have the wire **140** in line with the beam **110** in the travel direction, but the wire can impinge the puddle from any direction so long as the filler wire **140** impacts the same weld puddle **145** as the beam **110**.

[0028] In the embodiments discussed above, only one filler wire was used. However, the present invention is not limited to directing a single filler wire to the weld puddle **145**. Unlike most welding processes the filler wire **140** makes contact and is plunged into the weld puddle **145** during the welding process. This is because this process does not use a welding arc to transfer the filler wire **140** but rather simply melts the filler wire **140** into the weld puddle **145**. Because no welding arc is generated in the welding process described herein, more than one filler wire can be directed to any one weld puddle, i.e. the feeder subsystem may be capable of simultaneously providing one or more filler wires. By increasing the number of filler wires to a given weld puddle the overall deposition rate of the weld process can be significantly increased without a significant increase in heat input. Thus, it is contemplated that open root weld joints can be filled in a single weld pass. In addition, along with the deposition rate of the filler wire, the shape and characteristics of the weld can be changed as desired by using additional filler wires. To the extent multiple filler wires are utilized, and both are heated as described herein, embodiments of the present invention can utilize a single power supply **170** for each wire.

[0029] In some exemplary embodiments, as illustrate in Figures 4A and 4B, two filler wires impinge weld puddle **145**. Embodiments where two or more filler wires are used are similar to the embodiments discussed above. Accordingly, for brevity, only the relevant differences will be discussed. As shown in Figures 4A and 4B, the second filler wire **140'** impinges the weld puddle **145** in-line with the wire **140** in the width direction. However, this configuration is not limiting and wire 140' may impinge the puddle **145** in-line with wire **140** in the direction of the weld (see arrow **111**). Of course, the wires **140** and **140'** need not be in the trailing position as shown in Figure 4A and 4B, and either wire **140'** or **140** or both may be in the leading position during welding operations. Wire **140'** may be composed of the same material as wire **140** or it may be composed of a different material depending on the desired weld. For example, wire **140'** may be used for hard-facing and/or providing corrosion resistance to the workpiece, and wire **140** may be used to add structure to the workpiece.

[0030] In some exemplary embodiments, wire **140'** may be controlled by a motor in a manner similar to wire **140** as discussed above. For example, as shown in Figures 4A and 4B, wire **140'** is being moved in a clockwise pattern by a motor (not shown) and wire **140** in a counter-clockwise pattern. The movements of wires **140** and **140'** can be controlled as discussed above to achieve the desired weld shape. Of course, the wires are not limited to circular patterns or to moving in opposite directions (i.e., clockwise and counter-clockwise). The wires **140** and **140'** can be controlled using any combination of the patterns discussed above to achieve the desired weld profile.

[0031] In some embodiments, the second filler wire may be used to control the temperature of the weld **145**. For example, the feed rate and/or the temperature of the second filler may be controlled based on the desired temperature of the weld puddle **145**. Similar to the exemplary embodiments discussed above, the second filler wire may be cooler or hotter than the weld puddle temperature and wire **140'** may be controlled to ensure that the temperature of weld **145** is uniform.

[0032] In Figure 1, the laser power supply **130**, hot wire power supply **170** and sensing and control unit **195** are shown separately for clarity. However, in embodiments of the invention these components can be made integral into a single welding system. Aspects of the present invention do not require the individually discussed components above to be maintained as separately physical units or stand alone structures.

[0033] While the invention has been described with reference to certain embodiments, it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted without departing from the scope of the invention. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the invention without departing from its scope. Therefore, it is intended that the invention not be limited to the particular embodiments disclosed, but that the invention will include all embodiments falling within the scope of the appended claims.

REFERENCE NUMBERS

100	system
110	laser beam
111	arrow
115	workpiece
120	laser device
130	power supply
140	filler wire
140`	wire
145	weld puddle
150	wire feeder
160	contact tube
170	power supply
195	control unit
1710	motor
1720	optics drive unit
1730	wire motor

CLAIMS

1. A method of controlling filler wire, the method comprising:

heating at least one workpiece with a high energy heat source to create a molten puddle on a surface of said at least one workpiece;

feeding a filler wire into said molten puddle;

advancing each of said high energy heat source and said filler wire in a travel direction to deposit said filler wire on said at least one workpiece;

moving said filler wire in at least a first direction during said feeding of said filler wire and said advancing of said filler wire where said at least first direction is different from said travel direction; and

controlling at least said movement of said filler wire in said at least first direction to obtain a desired shape, profile, height, size, or an admixture of a bead formed by said molten puddle.

2. The method of claim 1, wherein said movement of said filler wire in said at least first direction includes at least one of a back and forth motion that is in-line with said travel direction, a back and forth motion that is transverse to said travel direction, a circular motion, and an elliptical motion.

3. The method of claim 1 or 2, further comprising:

preheating said filler wire to at or near a melting temperature of said filler wire prior to said filler wire entering said molten puddle.

4. The method of any of the claims 1 to 3, wherein said high energy heat source comprises a laser which directs a laser beam onto said at least one workpiece to create said molten puddle, and said method further comprises:
moving said laser beam in at least a second direction during said advancing of said high energy heat source where said at least second direction is different from said travel direction,
wherein said controlling to obtain said desired shape, profile, height, size, or admixture of said bead formed by said molten puddle further comprises controlling said movement of said laser beam in said at least second direction, and
wherein said movement of said laser beam in said at least second direction includes at least one of a back and forth motion that is in-line with said travel direction, a back and forth motion that is transverse to said travel direction, a circular motion, and an elliptical motion.

5. The method of any of the claims 1 to 4, further comprising:
feeding a second filler wire into said molten puddle; and
advancing said second filler wire in said travel direction to deposit said second filler wire on said at least one workpiece,
moving said second filler wire in at least a third direction during said feeding of said second filler wire and said advancing of said second filler wire where said at least third direction is different from said travel direction,
wherein said controlling to obtain said desired shape, profile, height, size, or admixture of said bead formed by said molten puddle further comprises con-

trolling said movement of said second filler wire in said at least third direction, and

wherein said movement of said second filler wire in said at least third direction includes at least one of a back and forth motion that is in-line with said travel direction, a back and forth motion that is transverse to said travel direction, a circular motion, and an elliptical motion.

6. The method of any of the claims 1 to 5, wherein said controlling of said movement of said laser beam and/or of said second filler wire in said at least second direction and/or in said at least third direction is synchronized with said controlling of said movement of said filler wire in said at least first direction, or wherein said controlling of said movement of said laser beam and/or of said second filler wire in said at least second direction and/or in said at least third direction is independent of said controlling of said movement of said filler wire in said at least first direction.

7. The method of any of the claims 1 to 6, wherein said at least first direction is a direction that is opposite that of said at least third direction.

8. A system (100) for controlling a filler wire (140, 140′), the system (100) comprising:

a high intensity energy source which heats at least one workpiece (115) to create a molten puddle on a surface of said at least one workpiece (115);

a filler wire feeder (150) which feeds a filler wire (140, 140′) into said molten puddle;

a travel direction controller which advances each of said high intensity energy source and said filler wire (140, 140′) in a travel direction to deposit said filler wire (140, 140′) on said at least one workpiece (115); and

a filler wire controller which moves said filler wire (140, 140′) in at least a first direction during said feeding of said filler wire (140, 140′) and said advancing of said filler wire (140, 140′), where said at least first direction is different from said travel direction,

wherein at least said movement of said filler wire (140, 140′) in said at least first direction is controlled to obtain a desired shape, profile, height, size, or an admixture of a bead formed by said molten puddle.

9. The system (100) of claim 8, wherein said movement of said filler wire (140, 140′) in said at least first direction includes at least one of a back and forth motion that is in-line with said travel direction, a back and forth motion that is transverse to said travel direction, a circular motion, and an elliptical motion.

10. The system (100) of claim 8 or 9, further comprising:

a wire power supply which preheats said filler wire (140, 140′) to at or near a melting temperature of said filler wire (140, 140′) prior to said filler wire (140, 140′) entering said molten puddle.

11. The system (100) of any of the claims 8 to 10, wherein said high intensity energy source comprises a laser (120) which directs a laser beam (110) onto said at least one workpiece (115) to create said molten puddle, and the system (100) further comprises:

a laser beam controller which moves said laser beam (110) in at least a second direction during said advancing of said high intensity energy source where said at least second direction is different from said travel direction,

wherein said controlling to obtain said desired shape, profile, height, size, or admixture of said bead formed by said molten puddle further comprises controlling said movement of said laser beam in said at least second direction, and

wherein said movement of said laser beam in said at least second direction includes at least one of a back and forth motion that is in-line with said travel direction, a back and forth motion that is transverse to said travel direction, a circular motion, and an elliptical motion.

12. The system (100) of any of the claims 8 to 11, wherein said controlling of said movement of said laser beam (110) in said at least second direction is synchronized with said controlling of said movement of said filler wire (140, 140′) in said at least first direction, and/or wherein said controlling said movement of said laser beam (110) in said at least second direction is independent of said controlling said movement of said filler wire (140, 140′) in said at least first direction.

13. The system (100) of any of the claims 8 to 12, further comprising:

a second filler wire feeder which feeds a second filler wire (140´) to said molten puddle, said travel direction controller further configured to advance said second filler wire (140´) in said travel direction to deposit said second filler wire (140´) on said at least one workpiece (115); and

a second filler wire controller which moves said second filler wire in at least a third direction during said feeding of said second filler wire and said advancing of said second filler wire (140´), where said at least third direction is different from said travel direction,

wherein said controlling to obtain said desired shape, profile, height, size, or admixture of said bead formed by said molten puddle further comprises controlling said movement of said second filler wire (140´) in said at least third direction, and

wherein said movement of said second filler wire (140´) in said at least third direction includes at least one of a back and forth motion that is in-line with said travel direction, a back and forth motion that is transverse to said travel direction, a circular motion, and an elliptical motion.

14. The system (100) of any of the claims 8 to 13, wherein said controlling of said movement of said second filler wire (140´) in said at least third direction is synchronized with said controlling of said movement of said filler wire (140) in said at least first direction, and/or wherein said controlling of said movement of said second filler wire (140´) in said at least third direction is inde-

pendent of said controlling of said movement of said filler wire (140′) in said at least first direction.

15. The system (100) of any of the claims 8 to 14, wherein said at least first direction is a direction that is opposite that of said at least third direction.

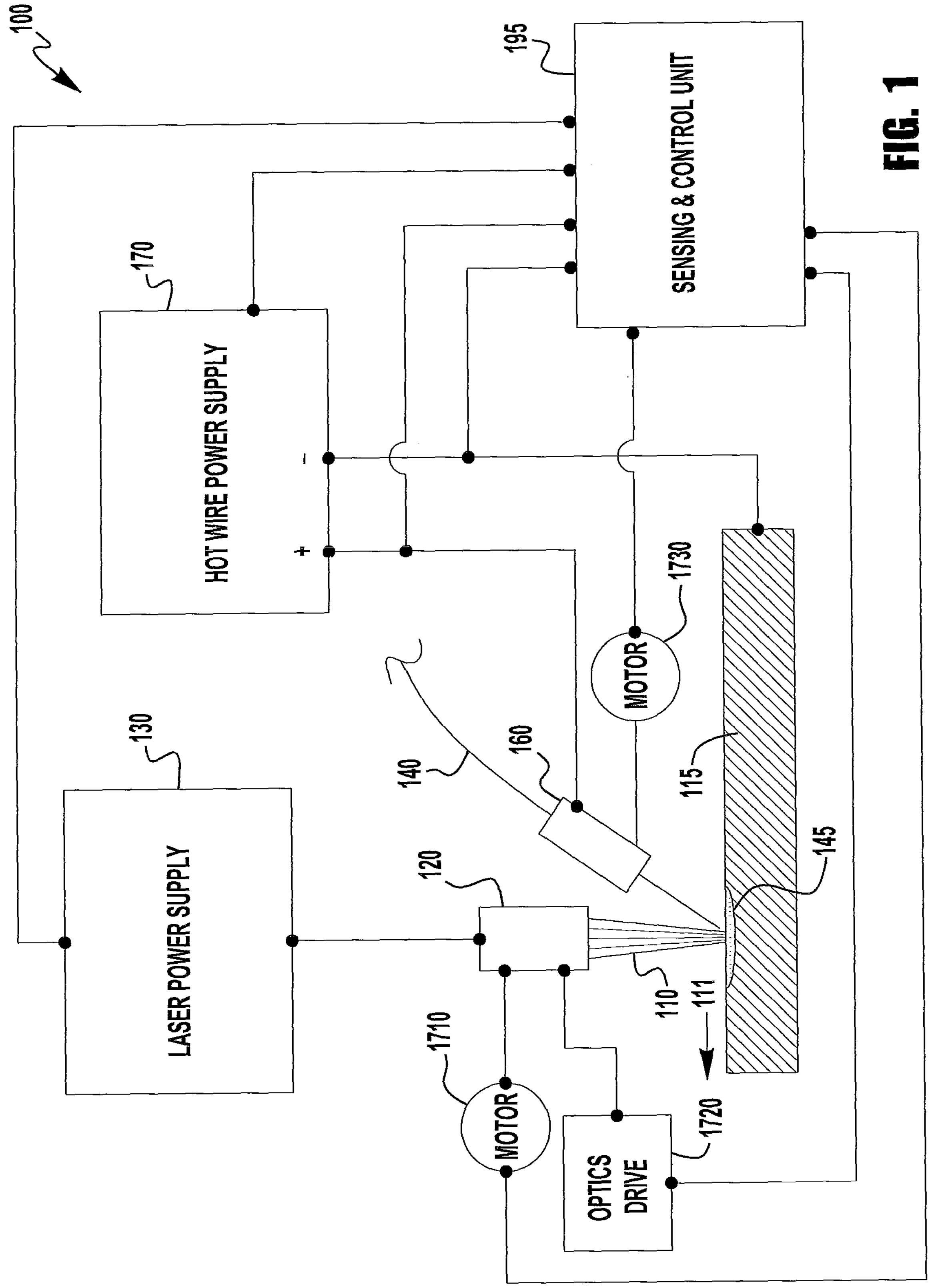
100
195
SENSING & CONTROL UNIT
170
HOT WIRE POWER SUPPLY
-
+
130
LASER POWER SUPPLY
1730
MOTOR
140
160
115
145
120
110
111
1710
MOTOR
OPTICS DRIVE
1720

FIG. 1

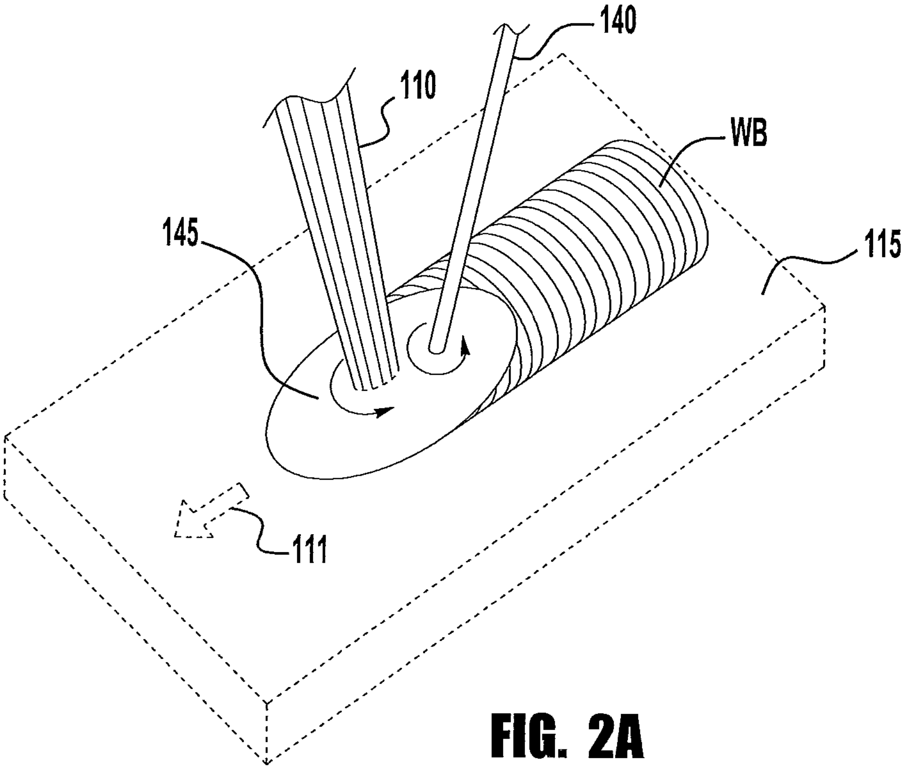

FIG. 2A

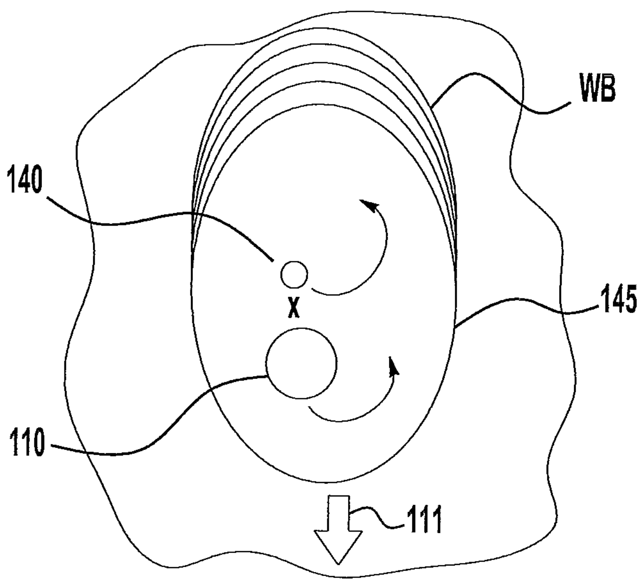

FIG. 2B

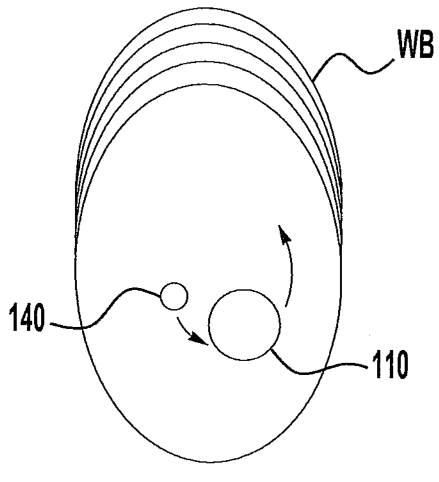

FIG. 2C

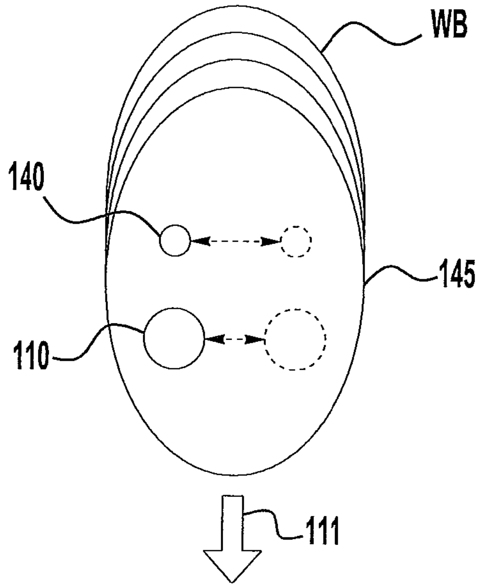

FIG. 3A

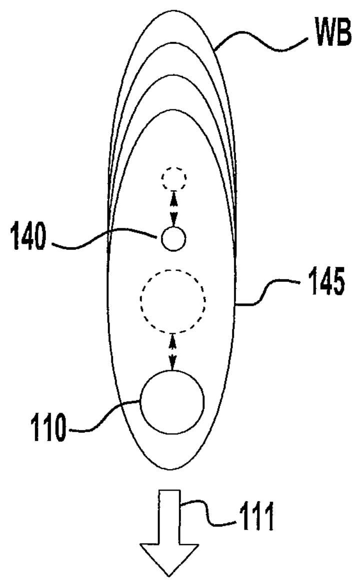

FIG. 3B

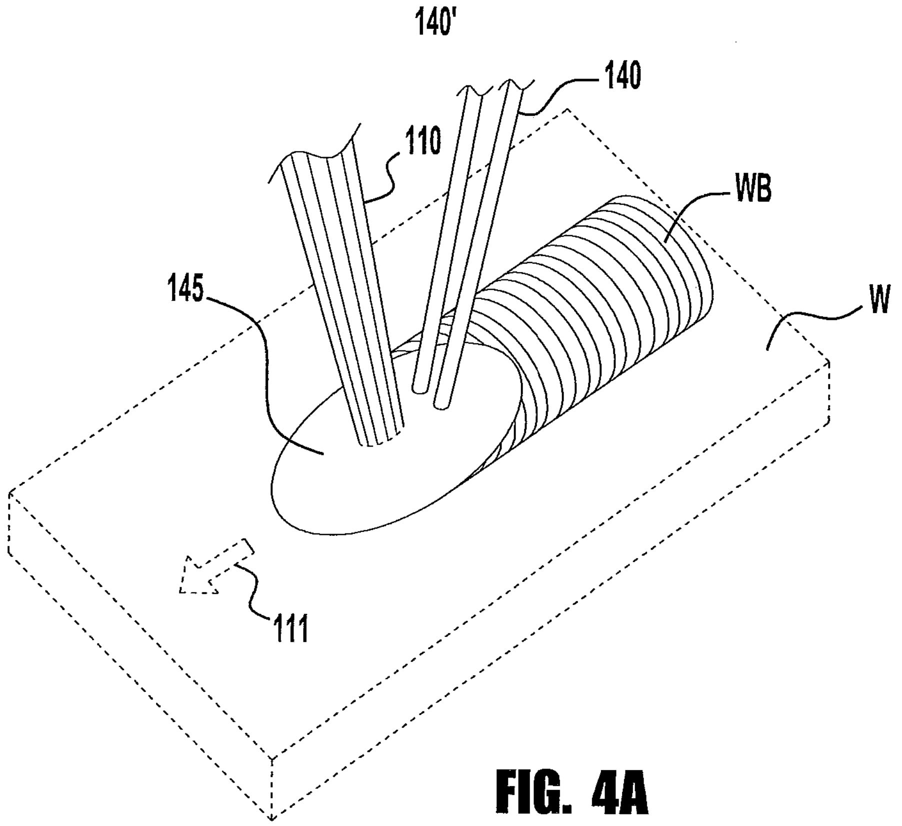

FIG. 4A

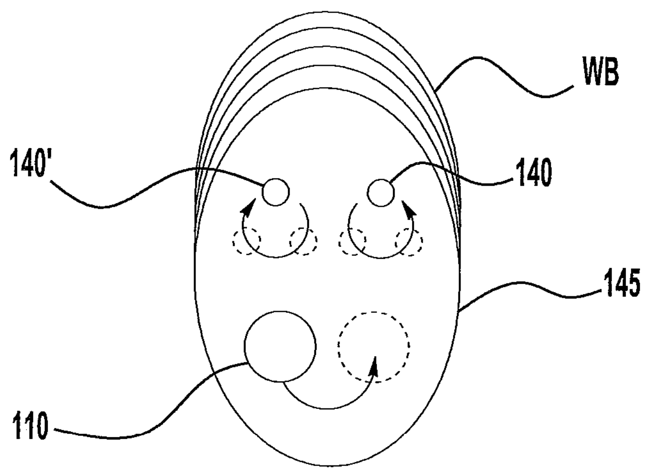

FIG. 4B

PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference T 113 0189 WO	**FOR FURTHER ACTION**	see Form PCT/ISA/220 as well as, where applicable, item 5 below.
International application No. PCT/IB2013/001464	International filing date *(day/month/year)* 5 July 2013 (05-07-2013)	(Earliest) Priority Date *(day/month/year)* 6 July 2012 (06-07-2012)
Applicant LINCOLN GLOBAL, INC.		

This international search report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This international search report consists of a total of 5 sheets.

[X] It is also accompanied by a copy of each prior art document cited in this report.

1. **Basis of the report**
   a. With regard to the **language,** the international search was carried out on the basis of:
      - [X] the international application in the language in which it was filed
      - [ ] a translation of the international application into ______________________ , which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1(b))

   b. [ ] This international search report has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 43.6*bis*(a)).

   c. [ ] With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, see Box No. I.

2. [ ] **Certain claims were found unsearchable** (See Box No. II)

3. [ ] **Unity of invention is lacking** (see Box No III)

4. With regard to the **title,**
   - [ ] the text is approved as submitted by the applicant
   - [X] the text has been established by this Authority to read as follows:

   METHOD OF AND SYSTEM FOR USING MOVING CONSUMABLE WIRE WITH WELD PUDDLE

5. With regard to the **abstract,**
   - [ ] the text is approved as submitted by the applicant
   - [X] the text has been established, according to Rule 38.2, by this Authority as it appears in Box No. IV. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority

6. With regard to the **drawings,**
   a. the figure of the **drawings** to be published with the abstract is Figure No. 1
      - [X] as suggested by the applicant
      - [ ] as selected by this Authority, because the applicant failed to suggest a figure
      - [ ] as selected by this Authority, because this figure better characterizes the invention

   b. [ ] none of the figures is to be published with the abstract

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2013/001464

A. CLASSIFICATION OF SUBJECT MATTER
INV. B23K26/20 B23K26/32 B23K26/34
ADD.

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 Y	JP 2004 330299 A (NIPPON STEEL CORP) 25 November 2004 (2004-11-25) abstract; figures	1,2,8,9 3-7, 10-15
Y	US 2002/117485 A1 (M. G. JONES ET AL) 29 August 2002 (2002-08-29) paragraphs [0030] - [0033], [0045]; figures 1,3	3,10
Y	US 2010/326969 A1 (T. TSUKAMOTO ET AL) 30 December 2010 (2010-12-30) paragraphs [0037] - [0038]; figures 1,3	4,11
Y	US 2011/132878 A1 (J. WANG ET AL) 9 June 2011 (2011-06-09) paragraphs [0070] - [0076]; figures	5-7, 12-15

-/--

[X] Further documents are listed in the continuation of Box C.

[X] 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	Date of mailing of the international search report
27 November 2013	05/12/2013

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Jeggy, Thierry

1

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 H02 99286 A (MAZDA MOTOR CORP) 11 April 1990 (1990-04-11) abstract; figures -----	1,2,8,9

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/IB2013/001464

Patent document cited in search report		Publication date	Patent family member(s)			Publication date
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			JP	5136521	B2	06-02-2013
			JP	2011005533	A	13-01-2011
			US	2010326969	A1	30-12-2010
US 2011132878	A1	09-06-2011	JP	5278426	B2	04-09-2013
			US	2011132878	A1	09-06-2011
			WO	2010021094	A1	25-02-2010
JP H0299286	A	11-04-1990	NONE			