ABSTRACT

A robotic end effector system and method having a plurality of end effectors which are selectively suitable for particular applications on a workpiece. The end effectors include a resident controller adapted to execute tasks specific to the end effector and are rapidly attachable and removable from the robot for easy changeover to different workpieces.
ROBOTIC END EFFECTOR SYSTEM AND METHOD

CROSS-REFERENCE TO RELATED APPLICATIONS


BACKGROUND

[0002] The use of automated robots in manufacturing and assembly facilities has become commonplace for the efficient assembly of large and small, simple and complex devices and machines. One example of an application which has become more complex is the use of the robot assembly and coordination of numerous robots is in the manufacture and assembly of automotive vehicles.

[0003] An assembly line in a manufacturing facility may include a fluid applying system for applying fluid, such as a bead of sealant or adhesive, to a workpiece. Other applications include clamping two or more pieces together to be transferred, welded or secured together. In a technologically advanced facility, one or more of these operations, and typically most of them, require the use of robots. In the past, such robots were typically set-up, tooled and programmed to carry out a specific task, for example, welding or adhering certain pieces together, application of fasteners used later in an assembly process or coating with paint or other material protectant. Once set-up and programmed, it was laborious and time consuming to change the robot tooling or programming to re-task the robot to function in a different capacity or application. This made it difficult, time consuming and costly to, for example, change from the manufacture and assembly of one vehicle type to another. Thus, one a robot was set-up and programmed, that robot was dedicated to that application and was not useful to use in other applications or tasks without substantial changeover time.

[0004] In one manufacturing and assembly application to provide fluid adhesive or sealant to a workpiece, for example a sheet metal vehicle body, typically such a fluid supply system includes a robot having a nozzle for applying fluid to the workpiece. The robot receives fluid from a fluid supply, such as one or more industrial sized drums of the fluid, disposed near the robot. A fluid supply line extends from at least one of the drums to the robot. The fluid supply line is often fixed to a ceiling or other support above the robot. An end of the fluid supply line coupled to the robot is typically a coiled line in order to prevent the fluid supply line from restricting movement of the robot, and the coiled line is in fluid communication with the robot. Such systems often required pumps and other capital equipment, sizable floor space and were very expensive. Further, changing from one fluid to another, for example to a different adhesive or sealant, required changing fluid lines and cleaning the existing line to comply with regulations and purity of the alternate fluid to be used. The robot can thus move the nozzle into an application position relative to the workpiece, and the nozzle can apply fluid to the workpiece. Additionally, other components, such as a pump and a control system, are typically necessary for operation of the system.

[0005] Similarly, other robotic applications such as metal-to-metal spot welding, application of weld studs, and automated clamping and component transferring systems suffered from the same disadvantages.

SUMMARY

[0006] A robotic end effector system and method is disclosed for use in the manufacturing and assembly of devices, for example, automotive sheet metal bodies and associated vehicle systems. The effector system allows a suitable robot to quickly change an end effector, for example an end effector used for applying an adhesive or sealant, to another end effector, for example a weld gun. The system and method substantially eliminates, or eliminates altogether, past restraints on dedicated robots for specific applications or tasks and provides for greatly increased flexibility of the robot to change tasks for more efficient use and efficient manufacturing and assembly as a whole.

[0007] The end effector system and method uses a connector and data communication links or means so that the end effector itself can include an on-board or on-effector controller to receive and/or execute programs specific to the type of effector in use by the robot. On a need to change the application of the robot, the end effector may be disconnected from the robot connector and a new or alternate effector or appliance can be picked-up or otherwise secured to the robot, communication re-established between the effector and the robot, or other communication equipment, and the robot is retasked to another application or use.

[0008] In an example of a fluid applying robot, for example the application of an adhesive or sealant, the end effector can include a receptacle for receiving and temporary holding of a canister of fluid. The robot, or preferably the end effector, can include a plunger or another structure for controlling the flow of fluid from the canister, and the robot can move the canister into a fluid applying position relative to the workpiece. With the canister in the fluid applying position, the plunger can be actuated to cause fluid to flow from the canister. When the canister is empty or a different fluid is required, the robot can maneuver to dispose of the canister and can obtain a new canister. In one example, the robot or end effector can include a blade or other cutting mechanism for removing a portion of an empty canister that contains any remaining fluid.

[0009] The example of an end effector described herein for applying a fluid applying robot as described herein can have many advantages over known fluid applying systems. For example, the fluid applying robot can cost an order of magnitude less than known fluid applying systems, at least in part because the fluid applying robot as described herein can be used without the complex fluid storage and transport components of known fluid applying systems. Further, the fluid applying robot can be much more versatile than known fluid applying systems, as the fluid applying robot can be more easily moved in order to reconfigure an assembly line since the fluid applying robot can be used without separate components, some of which may be fixed in place. Additionally, the fluid applying robot as described herein can also be more versatile than known fluid applying systems since changing the fluid applied by the fluid applying robot can be accomplished by the robot obtaining a new fluid canister. Finally, disposal of empty canisters can be less expensive than cleaning the fluid sources used by known fluid applying systems since the plunger of the fluid applying robot can remove
almost all of the fluid from the canister such that the only portion of the canister that should be cleaned is the portion removed by the blade.

[0010] These advantages are also achievable with many other robotic end effectors including welding, for example changing the particular spot welding gun end effector to access and weld in a different area or applying a different weld stud or in a different location. An end effector which provides a holding or clamping fixture or function, may be quickly changed to clamp alternate components or in different areas.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] The description herein makes reference to the accompanying drawings wherein like reference numerals refer to like parts throughout the several views, and wherein:

[0012] FIG. 1 is a simplified schematic plan view of a manufacturing or assembly line;

[0013] FIG. 2 is a perspective view of an example of the inventive end effector system in an exemplary application as a fluid applying robot at a workstation along the assembly line of FIG. 1;

[0014] FIG. 3 is a perspective view of an example of an adhesive applying end effector generally illustrated in FIG. 2;

[0015] FIG. 4 is a cross-section taken along line 4-4 in FIG. 3;

[0016] FIG. 5 is a schematic diagram of one example of a robotic and end effector control system for the exemplary application shown in FIG. 2;

[0017] FIG. 6 is a perspective view of the example system shown in FIG. 2 with an example of a fluid tray rack disposed adjacent to the robot;

[0018] FIG. 7 is a partial and alternate cross-section taken along line 4-4 in FIG. 3 showing the plunger in a fully extended position and an exemplary cutter in a first position and the cutter in phantom in a second position;

[0019] FIG. 8 is a schematic side view of an example of a robot having a stud welding end effector;

[0020] FIG. 9 is a perspective view of an example of a spot welding end effector useful with the robot shown in FIG. 2;

[0021] FIG. 10 is a perspective view of an example of a tooling fixture end effector utilizing exemplary clamps for use with the robot shown in FIG. 2;

[0022] FIG. 11 is a perspective view of an example showing two alternate end effectors temporarily stored on an automated guided vehicle along with the workpieces to be processed once positioned at a workstation;

[0023] FIG. 12 is a side view of an example of an end effector connector in an exemplary use with a weld gun end effector;

[0024] FIG. 13 is a perspective view of a portion of the end effector connector shown in FIG. 12 without the weld gun effector; and

[0025] FIG. 14 is a perspective view of the end effector connector shown in FIG. 12 with enlarged view of a portion of the connector.

DETAILED DESCRIPTION

[0026] Examples of a robotic end effector system 10 and method are shown in FIGS. 1-14. Referring to FIG. 1, the inventive system and method is generally useful in a manufacturing and assembly facility or plant having mechanical robots 16 (four shown) each having an end effector 10 positioned along a manufacturing and/or assembly line 20, and most useful positioned adjacent a workstation 24 where workpieces 30 are transferred to and positioned for further processing such as clamping, bonding, welding, sealing, painting or other processing known by those skilled in the art.

[0027] In one example shown in FIG. 2, end effector 10 is in the form of an end effector for applying a fluid, for example an adhesive or sealant to a workpiece 30, for example automobile sheet metal body components using a robot 16. In the example, robot 16 includes a base 34, a body 38, an armature 42, a wrist 44, servo motors (not shown) and an exemplary end effector 10 in the form of an effector 60 for applying a fluid to workpiece 30 at a workstation 24. The robot 16, including base 34, body 38, armature 42 and wrist 44 is moveable in six degrees of freedom by servo motors and other devices and having other capabilities, movements and functions known by those skilled in the field. In the example shown, robot 16, and more specifically wrist 44 is connected to a connector face plate 50 typically attached to a robot wrist 44. Face plate 50 is used as a conduit and exit for service lines including electrical, water air and other service fluids and power for robot 16 to end effector 10 described in further detail below. Face plate 50 is useful to attach a selected end effector 10 for various manufacturing and assembly uses described in further detail below.

[0028] Referring again to FIG. 2, the robot 16 can additionally include a connector 50 for physical attachment to the end effector 10. The connector face plate 50 can also include a data connection for communication between robot 16 and the end effector 10, such as communication between the servos 46 and the controller 54. The connector 50 can receive end effectors 10 other than the adhesive applying end effector 60, such as a welding end effector 66 or clamping end effector 70.

Further, the robot 16 can be mounted on a movable platform 34 for mobility relative to the assembly line 20. As a result, the robot 16 can be easily moved to different positions and can be configured to perform different operations, both of which can increase the versatility of the assembly line 20.

[0029] Referring to FIG. 5, an exemplary end effector control system 52 for exemplary end effector 60 is shown. A controller 54 is in electronic communication with several components on-board the effector 60 as well as in communication with a separate controller on the robot 16 (not shown). In a preferred example, end effector 10 includes a separate control system that is integral or on-board the effector 10. See U.S. Provisional Application No. 61/160,893 filed Mar. 17, 2009, assigned to the same assignee herein, which is incorporated by reference in its entirety. In the example 52, a controller 54 may include a microprocessor and memory storage (not shown). Controller 54 may be in electronic communication with on-board effector 60 (or 10) components including one or more servo motors 132, a plunger 126 and first and second sensors 140 and 156 respectively described in more detail below. The use of a separate end effector control system 52 which is integral and dedicated to the particular end effector 10 allows the end effector 10 to communicate and carry-out end effector tasks or applications which are specifically designed or programmed for that particular end effector 10. On changing the end effector 10 by robot 16, the effector control system 52 is placed in communication with robot 16 control system (not shown) and/or local or remote serves which provide programs, instructions and/or downloads of information and instructions for the alternate and installed end effector 10 allowing robot 16 to be quickly
retasked, for example, a different vehicle body or other device to be manufactured and assembled.

[0030] An example of an end effector 10 in the form of an end effector 60 useful for applying a fluid, for example an adhesive or sealant, is shown in FIGS. 2, 3 and 4. In the example, adhesive end effector 60 may include a receptacle 80 having a longitudinal axis 82 sized to receive a fluid canister 90. The fluid canister 90 can enclose a chamber 94 which can contain an adhesive or another fluid (not shown) known by those skilled in the field. The canister 90 can include a nozzle 93 in fluid communication with the chamber 94. The canister 90 can also include a slidable backing plate 100. The backing plate 100 can have an outer diameter substantially the same as the inner diameter of the canister 90 such that the backing plate 100 seals the end of the chamber 94 opposite the nozzle 98. The backing plate 100 can include a needle 104 extending toward the nozzle 98 along the longitudinal axis. The needle 104 preferably includes an outer diameter slightly larger than an inner diameter of the nozzle 98, and the needle 104 can have a length slightly less than a length of the nozzle 98. Movement of the backing plate 100 toward the nozzle 98 reduces the volume of the chamber 94, thereby forcing fluid from the canister 90 via the nozzle 98 in the form of a fluid bead (not shown). The fluid bead may take the form of a thin, continuous cylinder or any other cross-sectional shape defined by the nozzle 98.

[0031] The fit between the backing plate 100 and interior diameter of the canister 90 can be sufficiently tight such that the backing plate 100 scrapes fluid from interior walls of the canister 90. As a result, only a small amount of fluid can remain in the canister 90 after the backing plate 100 is fully depressed, and the effort required to clean the canister 90 can be reduced. Further, the fit between the needle 104 and the nozzle 98 can be sufficiently tight such that the needle 104 scrapes fluid from interior walls of the nozzle 98. As a result, the effort required to clean the portion of the nozzle 98 scraped by the needle 104 can be greatly reduced.

[0032] Referring to FIGS. 3 and 4, the receptacle 80 can have two opposing end-walls 108 and 114 spaced apart by the length of the canister 90. The length of receptacle 80 may be longer and in a preferred example, includes a semicircular or otherwise trough-shaped portion 118 between the end-walls 108 and 114. The end-wall 108 can define an aperture 110. The end-wall 114 can include a generally V-shaped cutout 116 through which the nozzle 98 of the canister 90 can project when the canister 90 is received in the receptacle 80. The trough-shaped portion 118 can have an inner circumference with a same or slightly larger diameter than an outer circumference of the canister 90. In an alternate example of a receptacle 80, the end effector 60 can include a different receptacle 80, such as a collar around the end-wall 114 and projecting toward end-wall 108 (not shown), or a pair of clamps (not shown) for engaging the canister 90. Other shapes and orientations of receptacle 80 for use in holding and securing a fluid canister 90 known by those skilled in the field may be used.

[0033] In the exemplary adhesive end effector 60, the end effector 60 can also include a plunger 126 and a servo motor 132 (shown schematically in FIG. 5), for actuating the plunger 126 for movement along the longitudinal axis 82. The plunger 126 can have a diameter smaller than the inner diameter of the canister 90, and the plunger 126 can extend through the aperture 110 in the end wall 108. The servo 132 can actuate the plunger 126 to forcibly move the plunger 126 axially along longitudinal axis 82 relative to the canister 90 in response to an instruction from the controller 54 as shown in FIG. 5. Also, the functions described herein as performed by the controller 54 can alternatively be performed by more than one controller packaged with the robot 16 and/or the selected end effector 10 to suit the application. For example, when the canister 90 is initially positioned in the receptacle 80, the servo 132 can move the plunger 126 to a starting position in which the plunger 126 exerts pressure on the backing plate 100 without moving the backing plate 100 by a large amount in order to aid retention of the canister 90 in the receptacle 80.

The servo 132 can additionally move the plunger 126 toward the end-wall 114, thereby moving the backing plate 100 toward the end-wall 100, reducing the size of the chamber 94, and causing fluid to flow from the nozzle 98. Also, instead of the servo 132, another device can move the plunger 126, such as another type of motor, pneumatic or hydraulic pistons or devices, motors and gears, or other devices (not shown) known by those skilled in the art.

[0034] As shown in FIGS. 2, 3 and 5, end effector 60 (or 10) can include one or more vision or other sensors, for example end effector 60 sensor 140. The sensor 140, in an exemplary use to monitor the existence and/or quality of the fluid bead extruded from nozzle 98, can be an ultrasonic sensor, a camera, or another type of sensor or vision system capable of detecting a bead of fluid exiting nozzle 98 onto work piece 30. The sensor 140 can be oriented to view a bead of fluid applied to the workpiece 30 from the nozzle 98 of the canister 90. For example, the sensor 140 can be coupled to the receptacle 80 and angled to face near the tip of the nozzle 98. The sensor 140 can detect, for example, the width, height, and/or continuity of the bead of fluid. As shown in FIG. 5, the sensor 140 can be in communication with the controller 54 as well as other controllers and onsite or remote controllers and servers. As a result, the sensor 140 can provide feedback as to the quality of the bead of fluid applied to the workpiece 80, and the controller 54 can instruct the servo 132 to control the plunger 126 and the servos 132 and 46 to control the robot 16 based on the bead quality.

[0035] The exemplary end effector 60 (or 10) can additionally include a second sensor 146, which can be a camera, an ultrasonic sensor, or another sensors known by those skilled in the field. As shown in FIG. 2, the sensor 146 can capture an image of an area 148 including the workpiece 30. The signal captured by the sensor 146 can be relayed to the controller 54 as shown in FIG. 5, and the controller 54 can analyze the signal to determine the presence and position of the workpiece 30 and/or the type of workpiece 30. The controller 54 can control the plunger servo 132 and the robot servos 46 based on the presence, position, and/or type of the workpiece 30. Thus, multiple different types of workpieces 30 requiring different types of adhesives and/or different patterns of adhesive application can be accommodated.

[0036] In a further example of adhesive end effector 60, FIG. 6 shows an exemplary tray or carousel 156 can be disposed adjacent the robot 16. The tray 150 can include canister receiving slots 154, some or all of which can be loaded with additional or alternate canisters 90 containing fluid and some or all of which can be available to receive the canister 90 from the end effector 60. The tray 150 can be mounted on an automation guided vehicle (AGV) (not shown), which can transport the tray 150 between robots 16 and other areas in a manufacturing plant. The controller 54 can determine if a new canister 90 should be loaded into the receptacle 80 in response to, as examples, a low amount of
fluid in the canister 90 or the need for another canister 90 containing a different type of fluid. The controller 54 can determine the amount of fluid remaining in the canister 90 held by the receptacle 80 based on, for example, the position of the plunger 126. The controller 54 can instruct the servos 46 and/or 132 to move the robot 16 such that the second sensor 146 is positioned to sense the tray 150. The second sensor 146 can detect the position of canisters 90 on the tray 150 and/or the availability of canister receiving slots 154. The robot 16 can then move the end effector 160 (or 10) to deposit the canister 90 in one of the canister receiving slots 154 and to obtain another canister 90. Fluid canisters 90 can be disposable, one-time use devices, or may be refillable through a refilling station (not shown) for further use. The robot 16 may also be involved in such disposal, refilling and/or cleaning of the canisters 90 and effector 10 as the application may require.

As an example of interaction between the end effector 60 and tray 150, each canister receiving slot 154 can include a hole sized to receive the nozzle 98 of one of the canisters 90. The controller 54 can instruct the servos 46 to move the robot 16 such that the end effector 60 is in a position to move vertically to insert the nozzle 98 into the canister receiver slot 154, and the end effector 60 can be controlled to at least partially insert the nozzle 98 into the slot 154. Once the nozzle 98 is at least partially in the slot 154, the controller 54 can instruct the servos 132 to disengage the plunger 126 from the canister 90, and the robot 16 can move the end effector 60 laterally relative to the canister receiving slot 154. Engagement between the nozzle 98 and canister receiving slot 154 can retain the canister 90 in position relative to the canister receiving slot 154 while the receptacle 80 is moved laterally away from the canister receiving slot 150, thereby disengaging the receptacle 80 and canister 90. The canister 90 can then be propelled by gravity into the canister receiving slot 154. The robot 16 can move the empty receptacle 80 into position to engage another canister 90 by laterally moving the receptacle 80 to engage one of the canisters 90 by sliding between the canister 90 and tray 150, then vertically lifting the canister 90 from the tray 150.

Alternatively, new canisters 90 can be loaded into the receptacle 80 in different ways known by those skilled in the field. For example, the end effector 60 can include a canister hopper (not shown) containing a stack of canisters 90. A new canister 90 from the hopper can be released into the receptacle after disposing of the canister 90 previously in the receptacle 80. As another example, canisters 90 can be loaded or unloaded by hand or by use of another robot.

In another example, one of the robot 16 and end effector 60 can also include a cutter 156 as shown in FIG. 7. The cutter 156 can be positioned to remove a tip of the nozzle 98 of the canister 90 in the receptacle 80. For example, the cutter 156 can depend from the end-wall 118 of the receptacle 80. Alternatively, cutter 156 could be a stand along device proximate robot 16, tray 150, delivered by an AGV or positioned elsewhere known by those skilled in the art. The cutter 156 can include, for example, a blade 158 movable radially relative to the nozzle 90. Additionally, the cutter 156 can be movable between two positions, a first position in which the cutter 156 is positioned to remove a small portion of the nozzle 98 to create a path for fluid to flow from the nozzle 98 (shown in phantom in FIG. 7) and a second position in which the cutter 156 is positioned to remove a portion 160 of the nozzle 98 not occupied by the needle 104 when the backing plate 100 is fully depressed as shown in FIG. 7. By removing the portion 160 of the nozzle 98 not occupied by the needle 104, the cutter 156 can separate the canister 90 such that the removed portion 160 of the nozzle 98 can be cleaned if necessary to comply with, for example, environmental regulations. The remainder of the canister 90 (i.e., the canister 90 other than the portion 160) can be disposed of without additional cleaning if sufficiently cleaned by the backing plate 100 and its needle 104 as described above. Instead of the cutter 156 being movable, more than one cutter can be included (e.g., a first cutter at the first position and a second cutter at the second position). Other cutting devices other than 156 including an exposed blade, and in different locations and orientations known by those skilled in the art may be used.

In an example of an alternate end effector 10, an effector useful for positioning and securing a weld stud to a workpiece 30 is generally illustrated in FIG. 8. As shown, a robot 16 can include a stud welding end effector 74. In one example shown, the end effector 74 can carry a part reservoir 164 and a welding head 106. The part reservoir 164 can be coupled to the welding head 166 via a conduit 170. The part reservoir 164 can be loaded with parts, and the part reservoir can transmit parts to the welding head 166. The studs could be gravity fed or forced down conduit 170 by a vibratory device (not shown) or by other part transfer mechanisms known by those skilled in the art. By carrying the part reservoir 164 on the robot 16, inexpensive and versatile stud welding can be provided. Alternatively, a robot can carry an integral part reservoir.

In an alternate example of an end effector 10 useful with a robot 16 in the herein described end effector system described is illustrated in FIG. 9. An end effector 66 useful to spot weld two or more sheet metal components is shown. The effector 66 is connectable to a robot 16 or wrist 44 through a robot wrist connector face plate 50 and end effector or appliance connector 220 as further described below.

In the example shown in FIG. 9, weld end effector 66 includes sideplates 180, a first weld arm 184, a second weld arm 186 opposing spot welding tips 190 and a power supply 194 to provide electricity to flow through the weld tips. Depending on the particular spot welding application, one or more displacement devices 186 used to move the arms 184 and 186 may be used. Additional components typically used in weld guns, for example a coolant system and other controls (not shown) may be included in the end effector. As described, end effector preferably includes its own on-board control system in communication with other controllers and servers as previously described. Other forms and configurations of weld gun effector 66 known by those skilled in the art may be used.

In an alternate example of an end effector 10 useful with robot 16 in the herein described end effector system is illustrated in FIG. 10. An end effector 70 used as a positional and clamping fixture or tool is illustrated. In the example, end effector 70 includes a support or rail 200, several pedestals connected to support 200, and clamps or clamping fixtures 208 connected to the pedestals to position the clamps 208 in the desired position so as to properly position the workpieces 30 (not shown) in the desired location. Other devices commonly used with clamping tooling or fixtures such as pneumatic or hydraulic actuators (not shown) to open and close the clamps 208, as well as other components known by those skilled in the art may be used.
Although several alternate examples of end effectors 10 have been illustrated and described, other end effectors 10 known by those skilled in the art are useful in the inventive system and method. For example, instead of spot weld gun effector 66, a laser or other seam or bead welding device may be used. As an alternate to an alternate adhesive or sealant effector 60, a paint or other surface coating, or part cleaning fluid applying effectors may be used. Alternate fluids, for example compressed air or lubricating oils or fluids may be used.

Referring to FIG. 11, an example of a use of the inventive end effector system is illustrated. Since the particular end effector 10 may be quickly changed and/or installed on any common robot with the appropriate connectors 50 and/or 300, the particular end effectors 10 that are needed for particular parts or operations may travel or be transferred along with the components themselves as they travel down an assembly line 20 to a workstation 24 where the components are to be processed. FIG. 11 illustrates two alternate effectors temporarily stored or attached to a transfer pallet 210 or other support for transferring workpiece 30 between workstations. The pallet 210 can be supported and transferred by an automated guided vehicle (AGV) or other transfer device such as a conveyor, overhead gantry conveyor and other such systems known by those skilled in the art. When the workpieces 30 arrive at the workstation 24 for processing, one or more robots 16 can pick up the applicable end effector 10, establish electronic communication with its on-board controller 54 with the robot and/or other controllers, receive or execute instructions by its controller 54 and carryout the particular and required processing step or operation, for example, applying adhesive, welding or clamping one or more workpieces 30 together for additional processing.

Referring to FIGS. 12-14 an example of an end effector or appliance connector 220 is illustrated. The appliance connector 220 is shown in an exemplary use in connecting a weld gun effector 66 as described above and the connection detailed below. Other end effectors 10 may be operably connected to robot 16 through connector 220.

As best seen in FIG. 13, connector 220 may include a plate 224 that is rigidly connected to robot wrist face plate 50 though mechanical fasteners or other means known by those skilled in the field. In the example, plate 224 includes a first end 228 and a second end 230. Each end includes several brackets 240 (four shown) rigidly connected to plate 226. Each bracket defines a slot 246 all opening to the same direction (to the right as shown in FIG. 13).

In the example, connector 220 may further include an angle bracket 250 that connects to one end of plate 224 (to first end 228 in the example). Attached to bracket 250 is socket 256 which, as best seen in FIG. 14, receives service lines 270 from the robot 16 through wrist 44 and plate 50. Service lines 270 may include hoses or rigid lines to transfer or communicate services, for example electric power, data communication, water or other conditioning fluid, compressed air and other services needed by the end effector 10 to function for the particular application. In a preferred example, a protective cover 260 is used to cover the socket 250 and service lines as they enter the socket 250.

In the example illustrated, connector system 220 further includes a plug 266 preferably affixed to the appliance or end effector 10, a welding gun end effector 66 in the illustrations. Plug 266 provides the appropriate service lines (not shown) needed into the end effector 10 (shown as 66 for illustrative purposes only). As best seen in FIG. 13 (although shown detached from end effector 66), plug 266 includes corresponding male prongs (not shown) or other communication plugs or ports that coincide with the plugs or ports in socket 256 for the effective transfer of the service lines 270 from the robot 16 to the end effector 10 to suit the particular application.

An advantage of connector 220 over prior designs is its ability to substantially maintain or only minimally alter the center of gravity (CG) and tool center point (TCP) of an end effector 10 (illustrated as effector 66) while permitting all of the advantages described herein and as known by those skilled in the art. This is advantageous as relatively little or no reprogramming, readjustment or other modifications is required to change end effector 10 as described herein.

It is understood that connector 220 may be attached to other parts of end effector 66 (or 10) other than in the position shown in FIG. 12 (to the top of effector 66). Other connection points to the effector 10 to suit the particular application may be used. It is also understood that different components and configurations of the connection and interface points between the connector 224 and end effector 66 other than the specific plug and socket arrangements may be used without deviating from the present invention.

Although connector 220 is shown with a weld gun end effector 66, connector 220 is useable with other end effectors 10 described herein and known by those skilled in the field. Further, connection schemes other than studs 274 into bracket slots 246 may be used as known by those skilled in the field. For example, other quick connect fasteners or temporary locking systems may be used to securely attach end effector 10 to robot 16 while allowing relatively quick release to change the end effector.

In operation to connect an appliance or end effector 10 to robot 16, an appliance or end effector 10 is selected to suit the particular process or operation needed on work pieces 30 in a workstation 24. The end effector, for example weld gun effector 66 includes studs 274 protruding outwardly and oriented so as to slide into slots 246 in brackets 240 as best seen in FIGS. 12 and 14. Socket 256 and coinciding plug 266 are oriented so as to engage on seating of the studs 274 into slots 246 for a positive locking engagement between the robot 16 and the end effector 10 thereby establishing communication of service lines between the robot 16 and end effector 10.

The end effector controller 54 is then placed in electronic and data communication with one or more controllers on the robot or other local or remote servers to receive additional programming or instructions, or is simply activated through on-board sensors and/or programs resident in its controller to begin the operation. As each end effector preferably includes its own controller, relatively little or no reprogramming, adjustment or other modifications are typically needed. When a change of end effector 10 is desired, the end effector 10 may be readily removed from connector 220 thereby sealingly severing the service lines 270 and terminating communication of controller 54 with the other controllers or servers. This allows robot 16 for greater versatility over prior end effector designs and connector systems which in effect, dedicated a robot to a specific task unless significant time and investment were expended to reconfigure, reprogram and re-equip the robot to serve an alternate task.

The above-described examples have been described in order to allow easy understanding of the invention and do not limit the invention. On the contrary, the invention is
intended to cover various modifications and equivalent arrangements, whose scope is to be accorded the broadest interpretation so as to encompass all such modifications and equivalent structure as is permitted under the law.

What is claimed is:

1. A robotic end effector apparatus for use with a multi-axis robot having a movable wrist, the apparatus comprising:
   a connector removably attached to the robot wrist; and
   an end effector removably engageable with the connector,
   the end effector having a tool operable on a work piece.
2. The device of claim 1 wherein the effector further comprises a controller mounted to the effector and a motor in electronic communication with the controller for imparting movement of at least one component of the tool for use on the workpiece.
3. The device of claim 1 wherein the controller includes a microprocessor and memory storage, the controller is in electronic communication with at least one other controller for the electronic receipt by the effector controller of data specific to the effector.
4. The apparatus of claim 2 wherein the end effector further comprises:
   a fluid applicator comprising:
   a replaceable canister defining a chamber at least partially containing fluid and having a nozzle in fluid communication with the chamber,
   a receptacle adapted to receive the canister; and
   a plunger operable to force fluid from the chamber.
5. The apparatus of claim 4 wherein the controller is in electronic communication with a motor in driving engagement with the plunger, wherein on a selective activation signal from the controller, the motor drives the plunger to force fluid from the canister chamber through the nozzle.
6. The apparatus of claim 4 wherein the receptacle includes an open trough defining a cavity for receipt of the canister in the cavity, the receptacle further defining an end wall having an aperture for through receipt of the canister nozzle for orientation of the nozzle in a direction toward the workpiece.
7. The apparatus of claim 4 further comprising at least one sensor in electronic communication with the effector controller for active monitoring a fluid bead exiting the canister nozzle.
8. The apparatus of claim 4 wherein the canister further comprises a backplate in communication with the chamber, the backplate further having a needle extending into the chamber oriented toward the nozzle, wherein on movement of the backplate toward the needle, the needle enters at least a portion of the nozzle to force additional fluid from the chamber through the nozzle.
9. The apparatus of claim 4 further comprising a tray for holding a plurality of canisters proximate the end effector, the tray adapted to release the canisters through engagement of the end effector with at least one of the canisters.
10. The apparatus of claim 4 further comprising a cutter positioned proximate the end effector, the cutter operable to remove a selected portion of the canister nozzle.
11. The apparatus of claim 1 wherein the end effector tool is one of a welding gun and a clamping fixture.
12. The apparatus of claim 1 wherein the connector further comprises:
   a plate connected to the robot wrist;
   a socket connected to the plate, the socket in communication with at least one service line from the robot wrist;
   a plug connected to the end effector in communication with at least one service line of the end effector, wherein on engagement of the end effector to the plate, the effector plug engages the socket for communication of the at least one service line from the robot wrist to the service line of the end effector.
13. The connector of claim 12 wherein the plate further comprises at least one bracket having a slot for adapted sliding receipt of a stud connected to the end effector for removable engagement of the end effector with the plate.
14. The connector of claim 13 wherein engagement of the end effector to the connector does not substantially alter at least one of the center of gravity or the tool center point of the end effector.
15. A quick-release connector for use in connecting a robot having a movable wrist to a selected end effector, the connector comprising:
   a plate connected to the robot wrist;
   a socket connected to the plate, the socket in communication with at least one service line from the robot wrist;
   a plug connected to the end effector in communication with at least one service line of the end effector, wherein on engagement of the end effector to the plate, the effector plug engages the socket for communication of the at least one service line from the robot wrist to the service line of the end effector.
16. The connector of claim 15 wherein the plate further comprises at least one bracket having a slot for adapted sliding receipt of a stud connected to the end effector for removable engagement of the end effector with the plate.
17. The connector of claim 16 wherein engagement of the end effector to the connector does not substantially alter at least one of the center of gravity or the tool center point of the end effector.
18. A method of rapidly attaching an end effector useful on a workpiece from operable engagement with a robot having a movable wrist and at least one service line extending from the wrist, the method comprising the steps of:
   identifying the work to be done on the workpiece;
   selecting one of a plurality of end effectors having at least one service line;
   engaging the end effector to the robot wrist such that the service line of the robot wrist is in communication with the end effector service line.
19. The method of claim 18 further comprising the step of establishing electronic communication between a controller mounted on the end effector with at least one controller not mounted to the end effector.
20. The method of claim 19 further comprising the step of actuating electronic instructions specific to the selected end effector for use on the workpiece.

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