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(54) METHOD AND APPARATUS TO ADAPTIVELY COOL A WELDING-TYPE SYSTEM

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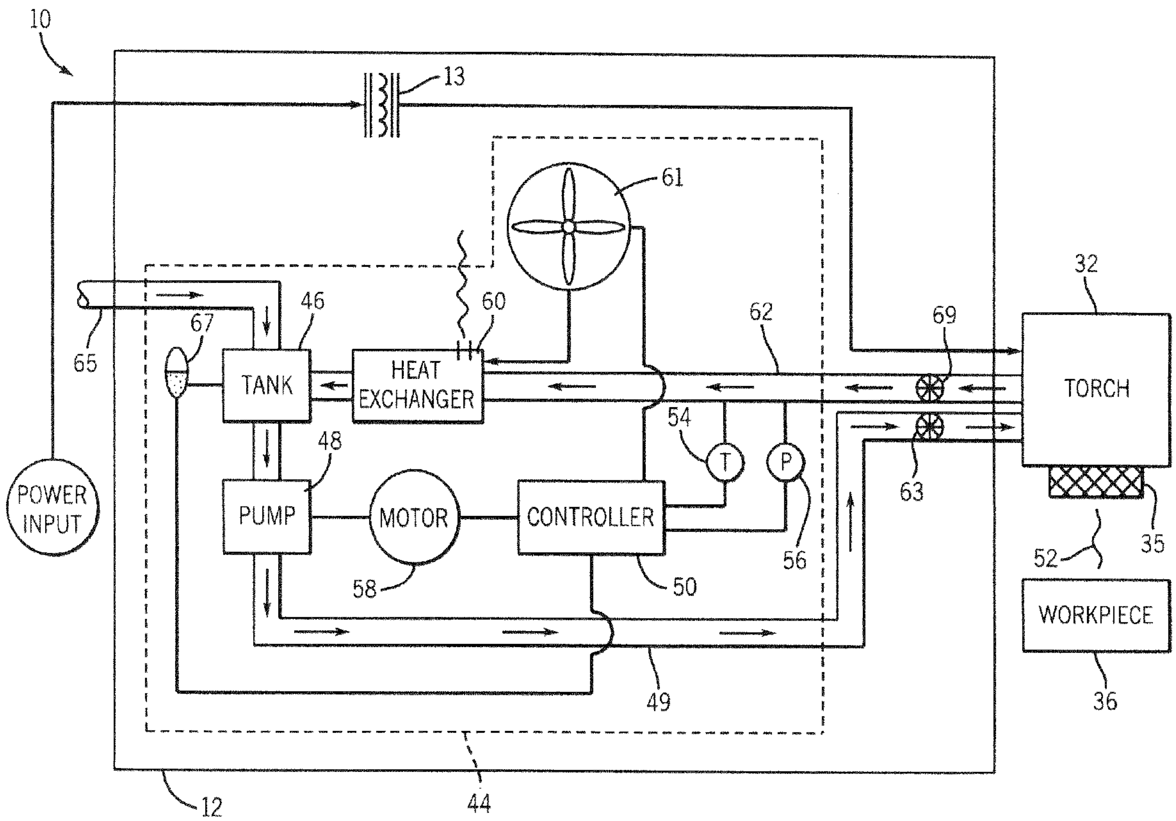
(57) **ABSTRACT**

A cooling system connected to provide coolant to a welding-type component automatically circulates coolant through the welding component upon activation of the welding component. A controller is configured to regulate the cooling system such that upon activation of the welding-type component coolant is caused to at least flow through the welding-type component and circulate after deactivation of the welding torch until a temperature of the coolant falls below a certain value or a specified time period has expired. The cooling system is constructed to be integrally disposed within a power source housing.



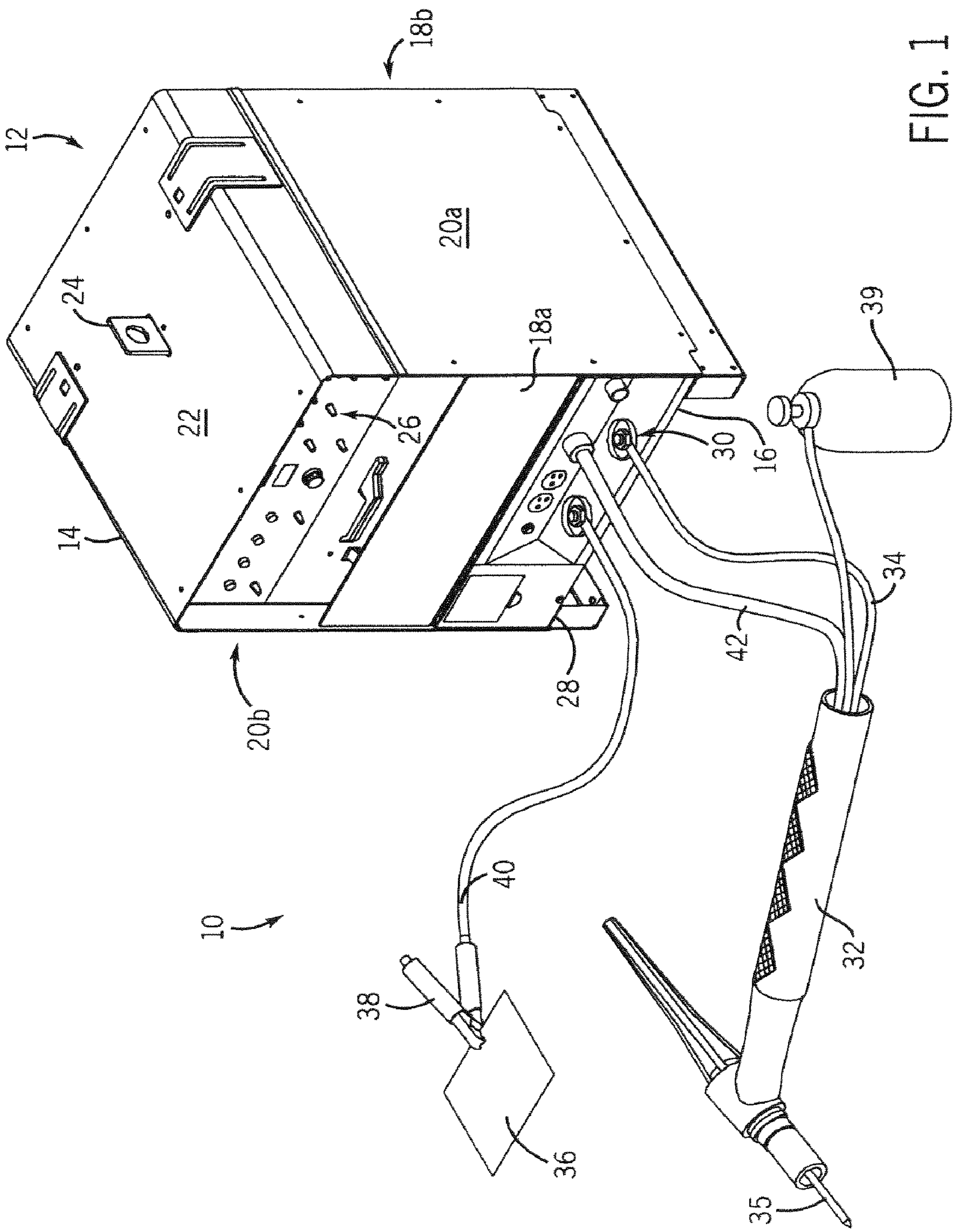
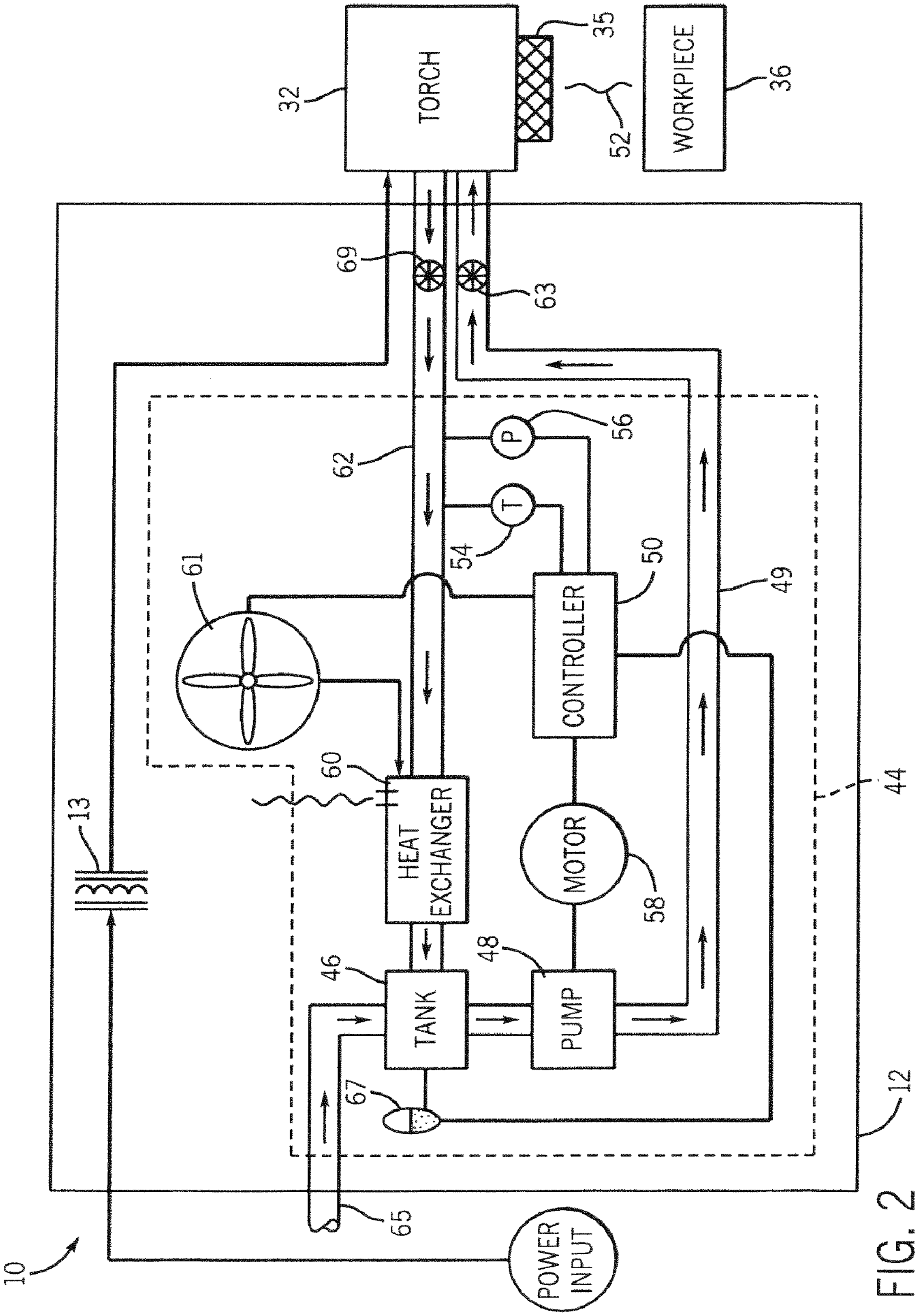


FIG. 1



TORCH
WORKPIECE
35
32
52
36
69
63
62
P
56
T
54
50
61
CONTROLLER
49
60
HEAT EXCHANGER
44
13
MOTOR
58
46
48
TANK
PUMP
67
12
65
10
POWER INPUT

FIG. 2

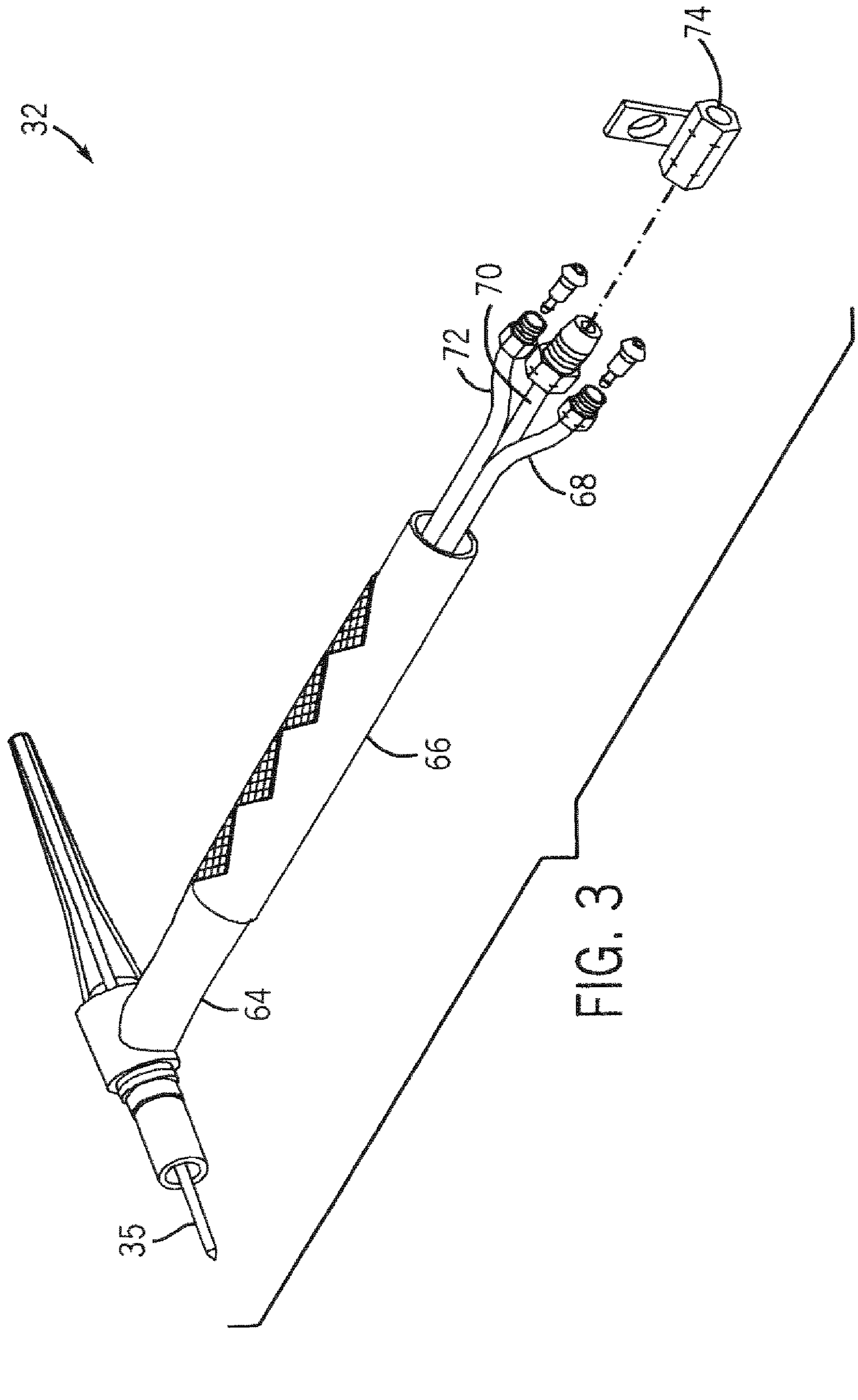


FIG. 3

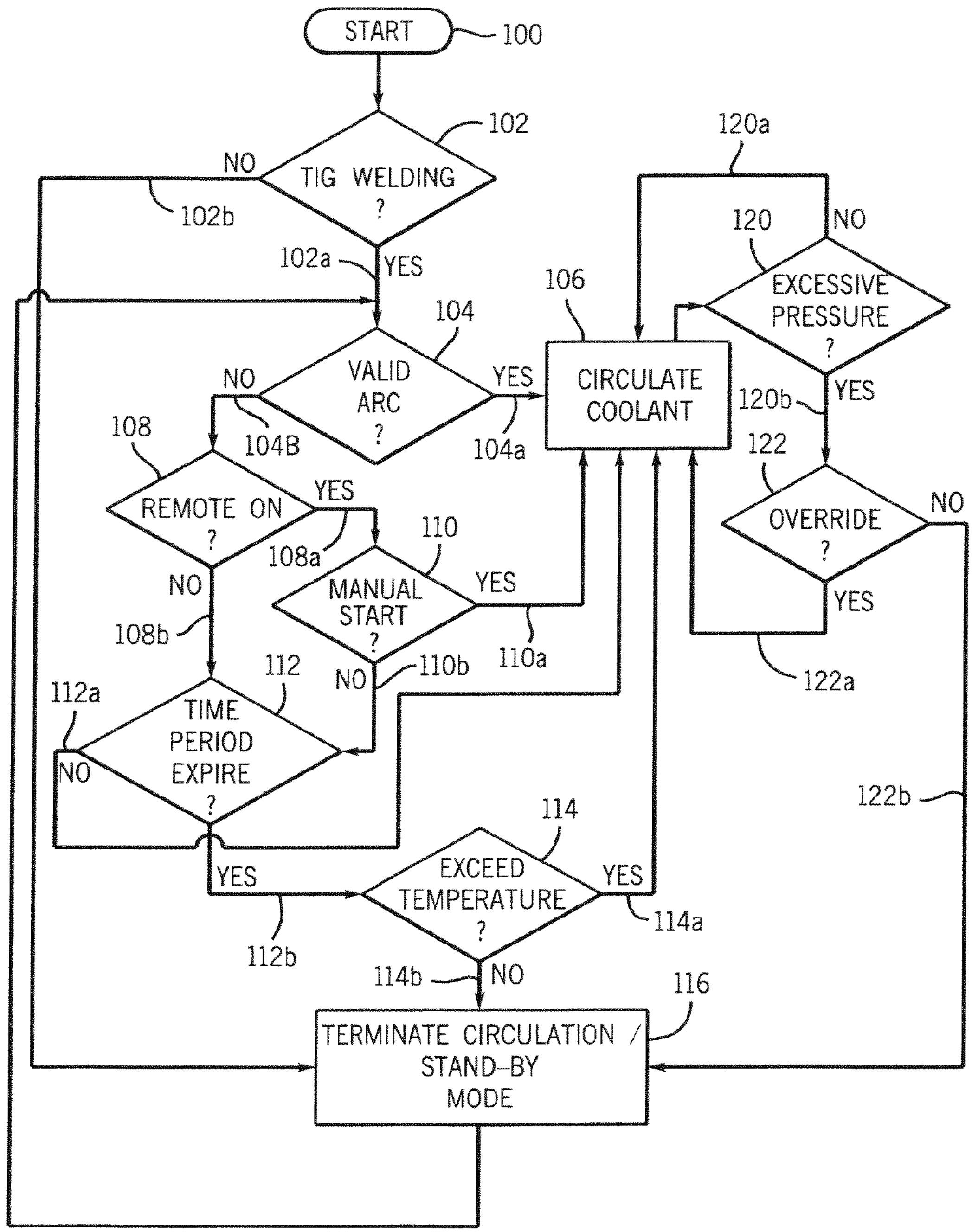

START
100
TIG WELDING ?
102
NO
102b
102a
YES
VALID ARC ?
104
NO
104B
YES
104a
CIRCULATE COOLANT
106
120a
NO
EXCESSIVE PRESSURE ?
120
120b
YES
OVERRIDE ?
122
NO
YES
122a
122b
REMOTE ON ?
108
YES
108a
NO
108b
MANUAL START ?
110
YES
110a
NO
110b
TIME PERIOD EXPIRE ?
112
112a
NO
YES
112b
EXCEED TEMPERATURE ?
114
YES
114a
NO
114b
TERMINATE CIRCULATION / STAND-BY MODE
116

FIG. 4

METHOD AND APPARATUS TO ADAPTIVELY COOL A WELDING-TYPE SYSTEM

BACKGROUND OF INVENTION

[0001] The present invention relates generally to welding-type systems and, more particularly, to a method and apparatus of an automatically and conditionally cooling a welding-type system upon activation of the welding-type system. More particularly, the invention relates to circulating coolant automatically through a power source and a welding-type torch upon initiation of a welding-type process.

[0002] It is well known that certain welding processes such as heavy-duty TIG (tungsten inert gas) welding generate considerable amount of heat during the welding process. A welding component or welding torch is commonly used to hold a tungsten electrode that is heated to join metals through heat transfer. Because tungsten is a rare metallic element with an extremely high melting point (approximately 3410°), the electrode can withstand a tremendous heat load and use the heat to join metals with filler material. The heat generated, however, can cause the welding torch to become increasingly heated. A cooling system is typically required to prevent overheating of the torch. Generally, the welding torch is liquid-cooled with coolant, such as water, which is supplied from a coolant source remote from the power source. The welding torch may also be air cooled.

[0003] One of the drawbacks with these standard cooling systems is that the cooling system is manually operable. That is, a typical cooling system is equipped with an ON/OFF switch that requires an operator to manually turn on the cooling system at the commencement of the welding process. When the cooling system is activated, coolant is caused to circulate through the power source and the welding torch. It can therefore be problematic if the operator forgets to turn the cooling system on before commencing welding. As a result, the temperature of the torch quickly rises to maximum acceptable limits and if not immediately cooled, can cause the torch to break down and malfunction. It is also costly to interrupt the welding process and allow the torch to cool. Moreover, the operator may forget to turn off the cooling system during extended periods of downtime. As such, the cooling system continues to circulate coolant to the welding torch even when cooling is not needed which increases energy consumption.

[0004] Another disadvantage of manually actuated cooling system rests in that the operator may turn off the cooling system prematurely following completion of a welding session. It may take several minutes following welding termination for the temperature of the torch to drop below an acceptable set point. However, if the operator prematurely shuts down the cooling system, the temperature of the torch may actually increase for a short and potentially damaging period. These drawbacks can significantly reduce the life expectancy of the cooling system and/or torch and increase the overall energy consumption of the system. All of which increases the costs of the welding system.

[0005] Therefore, it would be desirable to design a cooling system that automatically circulates coolant through at least the welding torch upon activation of the torch or commencement of the welding process and maintains coolant flow until the temperature of the torch falls below a specified set point or expiration of a prescribed time period that is of sufficient length to allow the torch to cool to below the specified set point.

BRIEF DESCRIPTION OF INVENTION

[0006] The present invention solves the aforementioned problems by providing a cooling system with associated circuitry and sensory devices that causes coolant to flow in a torch of a welding system automatically upon activation of the torch or commencement of welding at a weld. Commencement of the welding process occurs when a welding arc is struck between an electrode and a workpiece. The cooling system is configured to circulate the coolant through the torch for a set period of time after deactivation of the torch or until temperature of the torch falls below a temperature set point.

[0007] There are a large number of welding processes available for use in industry. These welding processes include gas tungsten arc, oxygen gas welding, and shielded metal arc welding. The gas tungsten arc welding process is generally referred to as TIG (tungsten inert gas) welding. A typical TIG welding apparatus includes a welding component which is commonly referred to as welding torch and is designed to introduce a tungsten electrode to a weld. The welding torch holds the electrode which is heated to extremely high temperatures by electrical power received from the power source. The welding torch is designed to introduce the electrode to a weld such that the electrode "scratches" the workpiece and is removed therefrom. At appropriate voltage and current, a welding arc is created between the electrode and the workpiece. The torch typically includes a trigger mechanism for initiating the welding process, i.e., closing the circuit between the workpiece and the power source.

[0008] Accordingly, one aspect of the present invention includes a welding-type component configured to present an electrode to a weld. A cooling system is configured to automatically circulate liquid coolant through at least the welding-type component upon activation of the welding-type component.

[0009] In accordance with another aspect of the invention, a welding apparatus includes an enclosure having a power source and a cooling system disposed therein. A welding torch is connected to both the power source and the integrated cooling system. A controller is configured to regulate the integrated cooling system such that, upon activation of the welding torch, coolant is caused to at least flow through the welding torch and continue to circulate after deactivation of the welding torch until a temperature of the torch or coolant falls below a certain value.

[0010] In accordance with yet another aspect of the invention, a method for cooling a welding-type component includes the step of detecting activation of a welding-type component. The method further includes that the steps automatically circulating coolant through the welding-type component upon activation of the welding-type component and maintaining coolant circulation through the welding-type component for a limited period after the welding-type component is deactivated.

[0011] Various other features, objects and advantages of the present invention will be made apparent from the following detailed description and the drawings.

BRIEF DESCRIPTION OF DRAWINGS

[0012] The drawings illustrate one preferred embodiment presently contemplated for carrying out the invention.

[0013] In the drawings:

[0014] **FIG. 1** is a perspective view of a welding-type system incorporating the present invention.

[0015] **FIG. 2** is a block diagram of a welding system in accordance with one aspect of the present invention.

[0016] **FIG. 3** is a perspective view of a welding torch for use with the present invention.

[0017] **FIG. 4** is a flow chart setting forth the steps of a control algorithm for on-demand coolant circulation through components of a welding system in accordance with the present invention.

DETAILED DESCRIPTION

[0018] **FIG. 1** is a perspective view of a welding-type system **10** suitable for a number of welding processes including tungsten inert gas (TIG) welding and stick welding. The welding-type system **10** includes a power source **12** disposed within an enclosure **14**. Enclosure **14** is defined by a base **16**, front and back panels **18***a*, **18***b*, and a pair of side panels **20***a*, **20***b* attached to the base **12**. A top cover **22** having a handle **24** is secured to the pair of side panels **20***a*, **20***b* to form enclosure **14**. The front panel includes control knobs **26** and outlets and receptacles **28** to facilitate connection of welding accessories to the enclosure. For example, an electrode weld output terminal **30** is used to connect a torch or other welding-type component **32** to the power source via cable **34**. The torch is designed to hold a tungsten electrode **35**. To complete a welding circuit, a workpiece **36** is introduced to a weld by a clamp **38** that is also connected to the power source by cable **40**. A gas cylinder **39** is used to store shielding gas which is delivered to the torch during the welding process.

[0019] Enclosed in the enclosure **14** are the welding-type power source and a cooling system. The power source is constructed to condition raw power from a power supply into a power suitable for welding. In the preferred embodiment, the welding-type power supply and cooling system are disposed within the common enclosure **14**. The cooling system is designed to circulate coolant through the torch **32** via coolant conduit **42**. The coolant system is designed such that coolant automatically flows into the torch when the welding process begins, i.e., the torch is activated or an arc is stuck. Alternately, the integrated cooling system may be remote from the power source.

[0020] **FIG. 2** is a block diagram of a welding system **10** designed to condition raw power from a raw power input **11** into a form usable in a welding-type process. The system includes power source **12**, a power conditioning or transformer assembly **13**, a TIG torch **32**, a work piece **36**, and a cooling system **44**. The cooling system **44** includes a coolant tank **46** and pump assembly **48** designed to pump fluid from the tank to heat zones in the welding system, such as the electrode holder or torch **32**, in response to control signals from controller **50**. Alternately, pump **48** or other circulation powering device may re-circulate fluid contained in fluid path **49** rather than pulling coolant from tank **46**. The cooling system **44** is configured to adaptively circulate coolant to and from torch **32** upon activation. For example, coolant circulation automatically begins when a welding arc **52** is struck between the tungsten electrode **35** and the workpiece **36**.

[0021] Controller **50** is adapted to electronically communicate with the cooling system to effectuate automatic commencement of coolant circulation to torch **32** when the welding process begins. The controller **50** is also connected to a temperature sensor **54** designed to provide feedback as to the temperature of the torch and/or the coolant within the torch as well as a pressure sensor or flow meter **56** to provide feedback regarding coolant pressure in the system. In this regard, controller can regulate pump **48** to increase or decrease the pressure or flow of coolant to and from the torch. The temperature sensor **54** provides temperature feedback to the controller such that circulation is maintained after a welding process is complete if the temperature exceeds a specified set point. Controller **50** may also include a timer that regulates or maintains coolant circulation for a specified period. The timer is designed to define a cool-down period of sufficient duration to allow the torch to cool.

[0022] Cooling system also includes a motor assembly **58** to drive pump **48** and a heat exchanger **60** and fan assembly **61** operationally connected to one another to remove the heat carried by the coolant from the torch. During one operational embodiment, the pump **48** draws coolant from tank **46** and delivers the coolant to torch **32** through coolant path **49**. The coolant absorbs heat from the torch and carries the heated coolant to heat exchanger via path **62**. The heat exchanger **60** may include a coiled radiator to remove the heat from the coolant to the surrounding atmosphere and dissipated by fan **61**. The cooled coolant is then re-deposited in tank **46** and further allowed to cool before re-circulated back to torch **32**. As illustrated, cooling system **44** is integrated within the welder or power source **12**. However, the cooling system **44** may be a modular or portable unit separately mounted to the power source or other welding or transport equipment.

[0023] Cooling system **44** further includes a check valve **63** in coolant supply path **49** that is biased such that coolant is prevented from flowing out of the system when torch **32** is not connected to the power source. Additionally, the system may be constructed with additional multiple check valves, i.e. check valve **69** in the coolant return path **62**, to further regulate coolant flow. The check valves are designed to prevent coolant flow when the torch is not connected or when the power source is being serviced and the like. Limiting coolant flow is advantageous under certain situations because of the high voltage characteristics of the power source as well as limiting exposure to the internal electronic components of the power source.

[0024] Cooling system **44** is designed such that coolant is supplied to tank **46** through a spout **65** that extends externally of the power source **12**. Having spout **65** extending outside the power source frame reduces and, preferably, eliminates accidental coolant and internal power source component contact. Tank **46** is preferably constructed to hold approximately two gallons of coolant, such as water.

[0025] A coolant level indicator **67** is provided for real-time status of coolant level in the tank. Indicator **67** is preferably mounted externally to the frame of the power source. Additionally, controller **50** may be connected to level indicator **67** such that warnings (audio and visual) may be activated if the coolant falls below acceptable levels.

[**0026**] **FIG. 3** illustrates torch **32** as having an elongated tubular body **64** connected to a handle **66**. The handle **66** is relatively hollow which allows for extension of a water hose **68**, power cable **70**, and a gas hose **72**. Hose **68** provides a coolant jacket that facilitates the ingress and egress of coolant to and from the torch. Alternately, torch **32** may be constructed to have an input hose and an output hose for carrying coolant to and from the torch. As such, heat generated within the torch is carried away to prevent overheating of the torch. Gas hose **72** facilitates the flow of shielding gas to the weld. Power cable **70** includes an adapter **76** to connect the weld cable from the power source to the torch.

[**0027**] Referring now to **FIG. 4**, the steps of a control algorithm to adaptively regulate cooling of a torch are set forth. The process begins at START **100** with powering-up of the power source, the coolant assembly, and other components of the welding process are likewise powered. Once the user identifies the welding process to be used through appropriate switches on the power source, a determination is made at **102** whether a TIG welding process is to be carried out. Since some welding processes do not require coolant circulation and power sources are capable of carrying out more than one process, the aforementioned determination is preferred and reduces the likelihood that an operator would forget to activate the cooling system for a TIG welding session. If a TIG welding process is not selected, the cooling system is placed in a stand-by mode **116**. The controller **50** then detects whether a valid arc **104** is present at the weld. That is, the controller determines if a welding arc **40** has been struck between the welding torch **30** and the work piece **32** indicative of welding commencement. The controller **50** transmits a circulation commencement signal to the cooling system **28** to activate motor **58** and pump **48** at **106** such that coolant is circulated through the welding torch. If a valid arc is not detected **104***b*, the controller determines if remote operation has been activated **108**. If so **108***a*, coolant is caused to circulate upon manual start-up of the welding power source **26** at step **110**, **110***a*. The controller then transmits a circulation commencement signal to activate the solenoid pump **62** and cause coolant flow through the torch at step **106**. If the controller does not detect a manual start **110***b* or remote operation **108***b*, the controller determines if a specified time period has expired after termination of the arc at **112**. If the time period has not expired **112***a*, coolant circulation is maintained at **106**. If not **112***b*, the algorithm proceeds to step **114**. The controller is configured to regulate the integrated cooling system such that coolant flow is maintained after deactivation of the welding torch until a temperature of the liquid coolant or torch falls below a certain value. The controller **50** compares temperature feedback from a sensor with a first set point temperature to determine if circulation should be maintained. In this regard, if the temperature of the liquid coolant does not exceed the temperature set point, then the integrated cooling system **28** is placed in stand-by mode **116**. That is, the controller **50** is configured to repeatedly detect a coolant temperature signal from one or more temperature sensors and if coolant temperature exceeds a threshold, circulation continues independent of welding torch activation status.

[**0028**] The algorithm also instructs the controller to regulate coolant flow based on coolant pressure in the system. As such, break-down in coolant lines or other failures in the cooling system that affect the amount and force of coolant flow are readily identified. An excessive flow condition may indicate that coolant supply pressure has exceeded a maximum level signaling malfunction of the pump and/or motor. Similarly, an insufficient flow condition may indicate a failure of the coolant supply or a general blockage of the coolant supply or return lines. Therefore, the controller **50** detects at step **120** whether coolant pressure is within acceptable limits. If so **120***a*, circulation continues at **106**. If not **120***b*, the controller determines whether a pressure override has been selected at step **122**. If so **122**, **122***a*, coolant flow continues despite the pressure being outside acceptable limits. If not **122**, **122***b*, coolant circulation ceases and the cooling system is returned to stand-by state at **116**.

[**0029**] The heretofore described steps are to be repeatedly executed by one or more processors. For example, the steps of the algorithm are carried out repeatedly every 10 ms by a microprocessor in the power source or cooling system. As such, once the cooling system is placed in stand-by mode, the controller switch confirms that a valid arc has been struck or other indicators that welding has recommenced such as a manual start before recommencement of coolant circulation.

[**0030**] Accordingly, one embodiment of the present invention includes a welding-type component configured to present an electrode to a weld. A cooling system is configured to automatically circulate liquid coolant through at least the welding-type component upon activation of the welding-type component.

[**0031**] In accordance with another embodiment of the invention, a welding apparatus includes an enclosure having a power source and a cooling system disposed therein. A welding torch is connected to both the power source and the integrated cooling system. A controller is configured to regulate the integrated cooling system such that, upon activation of the welding torch, coolant is caused to at least flow through the welding torch and continue to circulate after deactivation of the welding torch until a temperature of the torch or coolant falls below a certain value.

[**0032**] In accordance with yet another embodiment of the invention, a method for cooling a welding-type component includes the step of detecting activation of a welding-type component. The method further includes that the steps automatically circulating coolant through the welding-type component upon activation of the welding-type component and maintaining coolant circulation through the welding-type component for a limited period after the welding-type component is deactivated.

[**0033**] As one skilled in the art will fully appreciate, the heretofore description of welding devices not only includes welders, but also includes any system that requires high power outputs, such as heating and cutting systems. Therefore, the present invention is equivalently applicable with any device requiring high power output, including welders, plasma cutters, induction heaters, and the like. Reference to welding power, welding-type power, or welders generally, includes welding, cutting, or heating power. Description of a welding apparatus illustrates just one embodiment in which the present invention may be implemented. The present invention is equivalently applicable with many high power systems, such as cutting and induction heating systems, or any similar systems.

[0034] The present invention has been described in terms of the preferred embodiment, and it is recognized that equivalents, alternatives, and modifications, aside from those expressly stated, are possible and within the scope of the appending claims.

1-23. (canceled)

24. A welder comprising:

a welding torch configured to present an electrode to a weld;

an enclosure defined by a base plate, a pair of side plates, a pair of end plates, and a top cover;

a power conditioner disposed within the enclosure and configured to condition raw power into a form usable in a welding process; and

a cooling system disposed within the enclosure and designed to circulate coolant through the welding torch connected to the enclosure.

25. The welder of claim 24 wherein the cooling system is further configured to automatically commence coolant circulation through the torch when the electrode is presented to the weld.

26. The welder of claim 25 wherein the cooling system is further configured to maintain coolant flow though the welding torch until a temperature of the welding torch falls below a temperature set point.

27. The welder of claim 25 wherein the cooling system is further configured to maintain coolant flow through the welding torch until expiration of a time period following removal of the electrode from the weld.

28. The welder of claim 24 further comprising at least one coolant hose connecting the cooling system and the welding torch.

29. The welder of claim 24 further comprising a controller configured to control the cooling system and the power conditioner.

30. The welder of claim 24 wherein the cooling system includes a heat exchanger, a water pump, and a coolant tank.

31. The welder of claim 30 wherein the cooling system further includes a check valve biased to prevent coolant flow when the welder torch is disconnected from the enclosure.

32. The welder of claim 24 wherein the cooling system further includes a coolant level indicator mounted to one of the end plates or one of the side plates.

33. The welder of claim 24 wherein the cooling system further includes a coolant tank and a spout extending exteriorly of the enclosure, and a coolant passage connecting the spout and the tank.

34. A welding-type power source comprising:

an enclosure;

a power supply circuit disposed in the enclosure and configured to receive a raw power input and provide a power output usable by a welding-type process; and

a cooling system disposed in the enclosure and configured to circulate coolant to regulate a temperature in at least the enclosure.

35. The welding-type power source of claim 34 further comprising an outlet configured to receive a hose of a welding-type component.

36. The welding-type power source of claim 35 wherein the cooling system is further configured to circulate coolant to the welding-type component via the hose.

37. The welding-type power source of claim 36 further comprising a check valve configured to prevent outflow of coolant through the outlet when the hose is disconnected form the outlet.

38. The welding-type power source of claim 34 further comprising a controller configured to regulate the cooling system to automatically at least circulate coolant at start-up of the welding-type process.

39. The welding-type power source of claim 38 wherein the controller is further configured to maintain coolant circulation after termination of the welding-type process if a temperature in a welding-type torch connected to the enclosure exceeds a threshold.

40. A welding system comprising:

a power source connectable to a coolant-cooled welding torch;

a cooling system disposed in the power source and configured to circulate coolant to at least the welding torch during a welding process; and

at least one check valve integrated with the cooling system and biased to prevent coolant leakage from the power source when the welding torch is disconnected from the power source.

41. The system of claim 40 further comprising a controller operationally connected to the cooling system such that coolant is automatically circulated upon commencement of welding.

42. The system of claim 40 wherein the cooling system further includes:

a coolant tank;

a pump assembly configured to draw coolant from the coolant tank and deliver coolant to the welding torch; and

a heat exchanger configured to lower a temperature of coolant being reclaimed from the welding torch.

43. The system of claim 42 wherein the coolant includes water and further comprising a supply path from the tank to the welding torch and a return path from the welding torch to the tank.

* * * * *