Nov. 3, 1970 G. A. KEMENY ET AL 3,538,378

ELECTRICAL CIRCUIT APPARATUS FOR DETECTING WHEN THE CURRENT WHICH NORMALLY PRODUCES AN ARC BETWEEN ELECTRODES TAKES A DIFFERENT PATH

Filed June 13, 1967

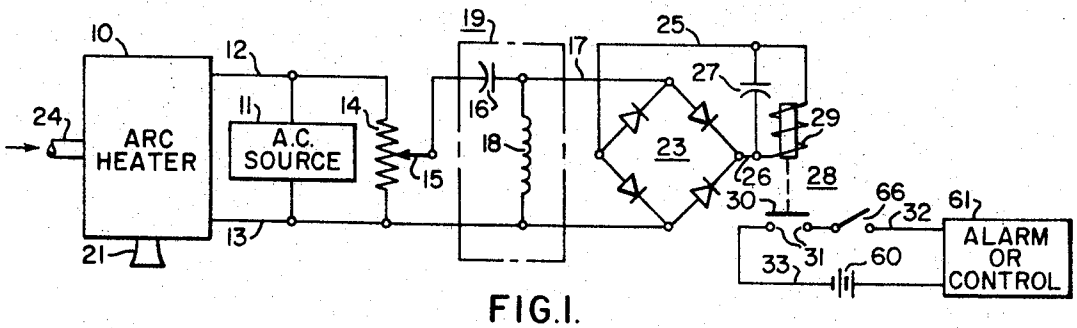



FIG. 1.

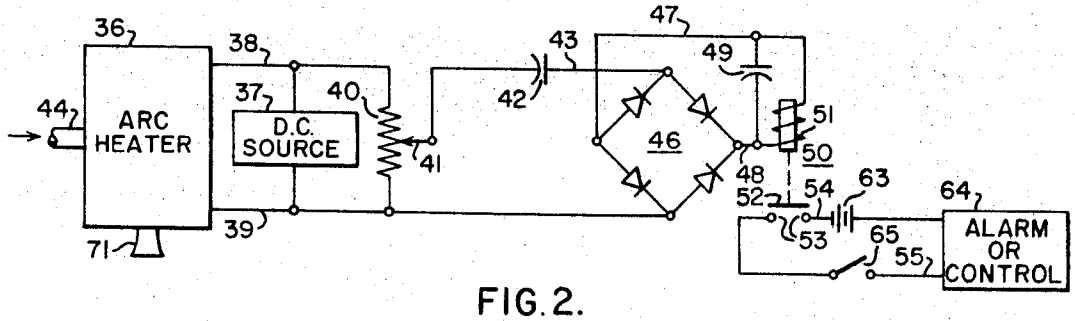



FIG. 2.

WITNESSES

Bernard R. Giegner

James F. Young

INVENTORS

George A. Kemeny and Armin M. Bruning.

BY Maury L. Hull

ATTORNEY

United States Patent Office

3,538,378
Patented Nov. 3, 1970



3,538,378

# ELECTRICAL CIRCUIT APPARATUS FOR DETECTING WHEN THE CURRENT WHICH NORMALLY PRODUCES AN ARC BETWEEN ELECTRODES TAKES A DIFFERENT PATH

George A. Kemeny and Armin M. Bruning, Export, Pa., assignors to Westinghouse Electric Corporation, Pittsburgh, Pa., a corporation of Pennsylvania

Filed June 13, 1967, Ser. No. 645,669
Int. Cl. H01j 7/24; H05b 31/26
U.S. Cl. 315—111 27 Claims

## ABSTRACT OF THE DISCLOSURE

In an arc heater the arc current normally produces an arc between electrodes. However, the arc current may suddenly take a path through deposited carbon or some other conductive material deposited on the wall or heat shield of the arc chamber resulting in an electrically conductive path between the arc heater electrodes. As a result the arc goes out. Furthermore, due to the failure of electrical insulation, the arc current may take a path through the arc heater structure. Electrical circuit means is provided, electrically connected across the electrodes and across the source of potential producing and sustaining the arc, for detecting the absence of high frequency voltage variations which are normally present while the arc is taking place between electrodes. These high frequency arc voltage variations occur whether the arc is sustained by direct or alternating current. We rectify the high frequency components and utilize the signal obtained by rectification to operate a warning relay or other warning device which may shut off the current when the high frequency component is absent. Where direct current sustains the arc we also provide relay circuit opening or warning means which operates when the high frequency voltage component stops. Where an alternating current source produces the arc, we employ a filter which substantially eliminates the power frequency.

## FIELD OF THE INVENTION

The invention relates to apparatus for shutting off the current to an arc heater or giving a warning when the arc current, normally between electrodes, takes a current path through carbon or other electricity conducting material deposited on the walls or heat shields of the arc heater as a result of pyrolysis of a hydrocarbon gas or other cause, or takes a path through the arc heater structure because of the failure of electrical insulation.

## DESCRIPTION OF THE PRIOR ART

Heretofore it is believed the only known way of ascertaining when the current which normally produces an arc between electrodes took a path through a carbon deposit was by monitoring the temperature of gas obtained from the arc heater or by continuous observation of the arc voltage trace on an oscillograph instrument. The prior art methods are entirely unsatisfactory because a current path between electrodes through a carbon deposit or deposit of other conductive material can cause serious electrode damage in a very short interval of time.

## SUMMARY OF THE INVENTION

Where alternating current is used to sustain an arc between electrodes in an arc heater, a high-pass filter is electrically connected either directly across the source or the electrodes or across a portion of a voltage divider connected across the alternating current source or the electrodes. The output of the high-pass filter is applied to a rectifier, the rectified output of which is applied to a normally energized relay winding while the arc is taking place



between electrodes and high frequency arc voltage variations occur. Should the arc current cease to produce an arc and take any other path between electrodes, the high frequency voltage variations cease, and the relay winding becomes deenergized thereby closing an alarm or control circuit.

Where a direct current source supplies the arc current, a rectifier is coupled, for example capacitor coupled, to the source of direct current or across the electrodes or to a tap on a voltage divider and the output of the rectifier applied to a normally energized relay which remains energized while the high frequency voltage variations are present, the relay becoming deenergized and the contacts thereof closing an alarm or shut-down circuit when the high frequency voltage variations present during normal operation cease.

## BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is an electrical schematic circuit diagram of the apparatus of the invention as used with an alternating current arc current source, and

FIG. 2 is an electrical schematic circuit diagram of the invention used with a direct current arc power source.

## DESCRIPTION OF THE PREFERRED EMBODIMENTS

In FIG. 1 an arc heater **10** which it is understood has a pair of spaced electrodes, not shown, electrically insulated from each other between which the arc takes place, is connected to an alternating current source by leads **12** and **13**. The alternating current source **11** has a relatively low impedance; for example, the arc voltage may be 400 volts and the arc current may be 5000 amperes. Connected across leads **12** and **13** and accordingly connected across the electrodes is a voltage divider **14** having a tap thereon connected by way of lead **15**, and also by way of lead **13**, to supply an input to a high pass filter generally designated **19** including the capacitor **16** and inductor **18**. The high pass filter **19** has the values of capacitance and inductance chosen whereby the filter passes only frequencies above 60 cycles per second, the frequency of source **11**, or substantially eliminates the 60 cycle component or attenuates it to a very low percentage of its original value. The output of the high pass filter is applied by way of leads **13** and **17** to a rectifier **23** shown as full wave but which could be half wave of conventional design and employing any suitable rectifiers, the full wave rectifier **23** supplying its output by leads **25** and **26** to the winding **29** of a relay generally designated **28**. Preferrably the winding **29** has capacitor **27** connected thereacross to prevent the relay from being responsive to momentary variations in voltage having no significance as far as the circuit is concerned, the charge on capacitor **27** also preventing winding **29** from becoming deenergized during the intervals between high frequency impulses. Relay **28** has a movable armature **30** and fixed contacts **31**, these being connected by way of switch **66**, leads **32** and **33** and energizing source **60** to device **61** which may give an alarm or be a relay operating suitable circuit interrupting means in one of the leads **12** and **13** for opening the circuit to the arc heater **10**. It will be noted that winding **29** is normally energized as a result of a rectified signal obtained from normal high frequency components or variations in the arc voltage, these being passed by the high-pass filter **19** and rectified by the full wave rectifier **23** and energizing winding **29** to maintain the relay armature **30** out of contact with the contacts **31**. Should the current between electrodes in arc heater **10**, which normally produces an arc between the electrodes, suddenly begin to follow a path through a conductive deposit on the walls and/or heat shields of the arc heater or through the arc heater structure as a result of the breakdown of electrical insula-

tion, then the high frequency variations in the arc voltage or power supply voltage across electrodes will cease, winding **29** will become deenergized and armature **30** and contacts **31** will close a circuit therebetween. The device **61** connected to leads **32** and **33** will be energized by the energizing source means **60**.

It will be understood that upon starting up the arc heater, switch **66** is open, and is not closed until the arc between electrodes is established and has been running for perhaps two seconds.

It has been found in practice that the voltage between electrodes can be about the same in magnitude for an arc heater condition in which normal arcing takes place between the electrodes and for a condition where current conduction is through a carbon deposit or some other deposited conductive material. One the other hand, while the arc is taking place between electrodes, there are normally high frequency variations in the arc voltage and these normal high frequency variations in arc voltage are continually present while the arc is operating normally.

Particular reference is made now to FIG. 2. In FIG. 2 the arc heater **36** has a pair of spaced electrodes, not shown, and a wall and/or heat shield portion between electrodes, not shown, on which carbon or some other conductive material may be deposited. Arc heater **36** is connected to direct current source **37** by way of leads **38** and **39**. Leads **38** and **39** are also being connected across a voltage divider **40** having a tap connected by way of lead **41** to a coupling capacitor **42** which is connected by way of lead **43** to rectifier **46**, and together with lead **39** supplies an input to the rectifier **46** shown as full wave but which may be half wave. The full wave rectifier **46** supplies its output by way of leads **47** and **48** to the winding **51** of a relay designated generally **50** having armature **52** and stationary contacts **53**. Preferably winding **51** has capacitor **49** connected thereacross. Relay **50** is normally energized while the arc in arc heater **36** is operating properly and normally, there being high frequency voltage variations in the arc voltage, these being coupled by capacitor **42** to the full wave rectifier **46** which supplies an output signal which maintains winding **51** energized while the arc heater is operating normally. In normal operation, armature **52** is not in contact with contacts **53**. Should the arc current suddenly take a path through carbon or other deposited conductive material, deposited on the wall and/or heat shield of the arc heater between electrodes, or through the structure of the arc heater because of the failure of electrical insulation, winding **51** becomes deenergized and an electrical circuit is completed through **52–53** to alarm or control means **64** connected by way of power source **63** and switch **65** to leads **54** and **55**. In starting up the arc heater **36**, switch **65** is open, and is closed after, for example, two seconds.

Where the sources of current **11** or **37** for the arcs are of relatively low voltage, it will be understood that the voltage dividers **14** and **40** respectively may be dispensed with.

It will further be understood that the circuitry can be utilized for detecting shorting of the arc through any other electricity conducting deposits and not only for detecting shorting through carbon deposits.

It will be further understood that the circuit will also detect shorting of the arc current by any other means such as accidental shorting through any electricity conducting structural members.

It should also be noted that other means not illustrated may be provided for temporarily deenergizing alarm or control **61** and **64** during the starting of the arc heater and reenergizing these circuits a short time after arc start when steady state operation of the arc heater has been attained. Such circuitry may be required as otherwise, controls **61** and **64** may prevent arc start.

It should further be noted that even though arc heaters with two electrodes have been illustrated, the circuitry can as well be utilized between electrodes of opposing polarity of arc heaters using more than two electrodes.

Our invention is particularly useful with arc heaters used in chemical processing. Where a feed stock hydrocarbon, for example methane, $CH_4$, is pyrolyzed, carbon is deposited in an amount depending upon operating conditions, upon the wall or heat shield of the arc chamber. Ultimately, this carbon deposit becomes sufficient to form a conductive path for arc current.

Whereas relays **28** and **50** are shown as direct current relays, suitable alternating current relays could be employed and rectifiers **23** and **46** respectively dispensed with.

It will be understood that other relay contact arrangements may be employed if desired.

It will be understood that both arc heaters **10** and **36** have means symbolized by inlets **24** and **44** respectively, for admitting gas to be heated into the arc chamber thereof.

Nozzles **21** and **71** are symbolical; arc heaters **10** and **36** could have exhaust nozzles for heated gas located between electrodes if desired.

The circuits of both FIGS. 1 and 2 may include any convenient means, not shown, for adjusting the sensitivity of the circuits.

Whereas source **11** has been described as a 60 cycle source, other power frequencies could be used and the L-C values of **18–16** accordingly changed.

The above-described drawing and the aforegoing written description are illustrative and exemplary only and are not to be interpreted in a limiting sense.

We claim as our invention:

**1.** Current path indicating apparatus for use with arc heater apparatus including an arc heater having at least a pair of spaced electrodes, means for admitting fluid to be heated to the arc chamber, means for exhausting heated fluid from the arc chamber, and a source of potential connected to the electrodes for normally producing and sustaining an arc between electrodes, the current path indicating apparatus including means for obtaining a signal while high frequency voltage variations are present in the voltage across the arc heater, said high frequency voltage variations resulting from the dynamic nature of the arc and not depending on material lost from an electrode producing a temporary path of less resistance and being present during normal operation while an arc is occurring between electrodes and ceasing when the arc current takes a path through any material and other than the normal arc-producing path, and signal utilization means connected to the signal obtaining means.

**2.** Apparatus according to claim **1** in which the current path other than the normal arc-producing path is provided by deposited conductive material on the inside wall of the arc chamber.

**3.** Apparatus according to claim **1** in which the current path other than the normal arc-producing path is provided by deposited carbon on the inside wall of the arc chamber.

**4.** Apparatus according to claim **1** in which the current path other than the normal arc-producing path is through inadequately electrically insulated structure of the arc heater.

**5.** In combination, an arc heater having at least a pair of spaced electrodes, means for admitting fluid into the arc chamber to be heated, and means for exhausting heated fluid from the chamber, the electrodes of said arc heater being adapted to be connected to a source of potential for producing and sustaining an arc between electrodes, said arc heater being characterized by fluctuations in the range of several hundred to a thousand times per second resulting from normal arc instability and the dynamic nature of the arc, said fluctuations occurring while the arc heater is operating normally and an arc is occurring between electrodes, and means operatively connected to the arc heater for utilizing the fluctuations in voltage for indicating whether the current from the source is pro-

ducing an arc between electrodes and whether the current from the source is following some other path between electrodes.

6. Apparatus according to claim 5 in which the other current path between electrodes is provided by deposited conductive material on the inside wall of the arc chamber.

7. Apparatus according to claim 5 in which the other current path between electrodes is provided by deposited carbon on the inside wall of the arc chamber.

8. Apparatus according to claim 5 in which the other current path between electrodes is through inadequately electrically insulated structure of the arc heater.

9. In arc heater apparatus according to claim 5 of the type employed in chemical processing where a deposit of conductive material may be formed in the arc heater and provide a path for current between electrodes, the arc heater having an alternating current source of predetermined power frequency not greater than several hundred cycles per second, the indicating means including high-pass filter means operatively connected across the electrodes of the arc heater for passing frequencies greater than the power frequency of the source, rectifier means operatively connected to the filter means for rectifying the signal from the filter means, and relay means having a winding operatively connected to receive the output of the rectifier means, voltage fluctuations resulting from arc instability and the dynamic nature of the arc being passed by the filter means and rectified by the rectifier means and used to maintain the relay winding normally energized, the relay winding becoming deenergized when the arc current takes a path through the deposited conductive material.

10. Indicating means according to claim 9 including in addition voltage divider means between the filter means and the arc heater.

11. Indicating means according to claim 9 including in addition normally open contacts for the relay means, said contacts being closed when the winding is deenergized as a result of current in the arc heater taking a path through the deposited conductive material, an alarm and control device electrically connected to the relay contacts, and source means for energizing the alarm and control device when the relay winding is deenergized and a circuit through the contacts is completed.

12. Apparatus according to claim 9 in which the alternating current source is additionally characterized as having a very low internal impedance compared to the open circuit impedance between electrodes of the arc heater.

13. In combination, an arc heater adapted for chemical processing, the arc heater being subject to the deposit of carbon on the wall thereof between electrodes, the arc heater being adapted to have a source of potential connected to the electrodes of the arc heater, the arc heater producing high frequency variations in the range of several hundred to a thousand times per second in the voltage applied thereto while the arc current is producing an arc path between electrodes, said high frequency voltage variations ceasing when the arc current takes a path through the deposit of carbon, and means connected to the arc heater for utilizing the high frequency voltage variations to give an indication of which path the current between electrodes is taking.

14. Apparatus according to claim 13 in which the means for utilizing the high frequency variations includes means for rectifying the high frequency variations to obtain a control signal, and signal responsive means having the control signal applied thereto.

15. Apparatus according to claim 13 including in addition means connected to the arc heater and normally energized by the high frequency voltage variations, said last-named means becoming deenergized when the arc current takes a path through the carbon deposit and the high frequency variations cease.

16. In an arc heater apparatus according to claim 5, a direct current source normally sustaining the arc between the electrodes.

17. In arc heater apparatus according to claim 5, an alternating current source having a frequency lower than the frequency of voltage fluctuations resulting from arc instability and the dynamic nature of the arc.

18. Apparatus according to claim 16 wherein the indicating means includes rectifier means coupled to the arc heater for rectifying the high frequency voltage variations to obtain a direct current, and relay means having said last-named direct current applied thereto to maintain the relay means normally energized while the arc is operating normally.

19. Apparatus according to claim 18 including in addition alarm and control means electrically connected to the contacts of the relay means.

20. Apparatus according to claim 18 including voltage divider means operatively connected between the arc heater and the rectifier means.

21. Apparatus according to claim 18 including in addition capacitor means connected in shunt with the winding of the relay means.

22. Current path indicating apparatus according to claim 1 wherein the source of potential is an alternating current source of predetermined power frequency, and the signal obtaining means includes a high-pass filter for passing only frequencies higher than the power frequency.

23. Current path indicating apparatus according to claim 1 wherein the source of potential is a direct current source, and the signal obtaining means includes rectifier means coupled to the arc heater for rectifying the high frequency voltage variations.

24. Current path indicating apparatus according to claim 22 including in addition rectifier means connected to the high-pass filter means to receive the output thereof.

25. The method of monitoring an arc produced by an alternating current of power frequency which comprises obtaining from the electrode terminals an alternating current signal having a frequency within the range of several hundred to a thousand cycles per second resulting from normal voltage fluctuations caused by the dynamic instability of the arc and in the absence of any material transfer between electrodes, separating from the signal the component of power frequency, and utilizing the remaining signal representing only the dynamic instability of the arc in normal operation to indicate proper arc operation.

26. The method according to claim 25 wherein a high-pass filter is connected across the electrodes and the signal representing the dynamic nature of the arc is obtained as an output from the high-pass filter.

27. The method according to claim 26 including the step of rectifying the output of the high-pass filter to obtain a direct current indicating signal.

**References Cited**

UNITED STATES PATENTS

| | | | |
|---|---|---|---|
| 2,027,224 | 1/1936 | David | 315—135 X |
| 2,858,411 | 10/1958 | Gage | 219—75 |
| 3,121,675 | 2/1964 | Case | 260—679 X |
| 3,318,791 | 5/1967 | Harris et al. | 260—679 X |


JOHN W. HUCKERT, Primary Examiner

B. ESTRIN, Assistant Examiner

U.S. Cl. X.R.

315—135; 219—169; 313—231