July 16, 1968 T. S. BURKHALTER ETAL 3,393,038

IGNITION SYSTEMS

Filed Nov. 8, 1965 3 Sheets-Sheet 1

FIG. 1.

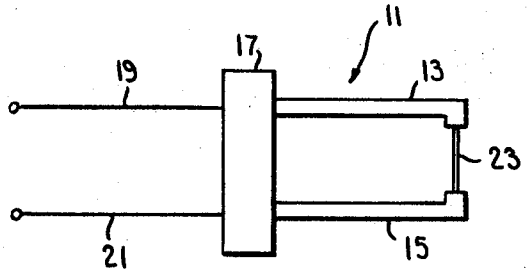


FIG. 2.

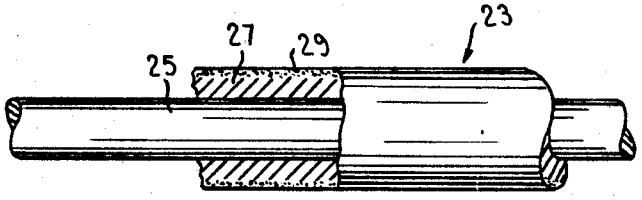
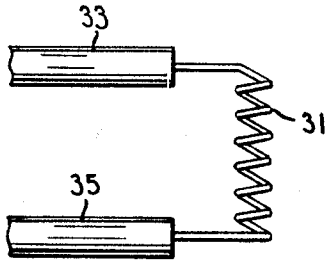


FIG. 3.



Thomas S. Burkhalter,
Joseph W. Waseleski, Jr., and
Francis P. Buiting,
Inventors.
Koenig, Senniger, Powers and Leavitt,
Attorneys.

FIG. 4.

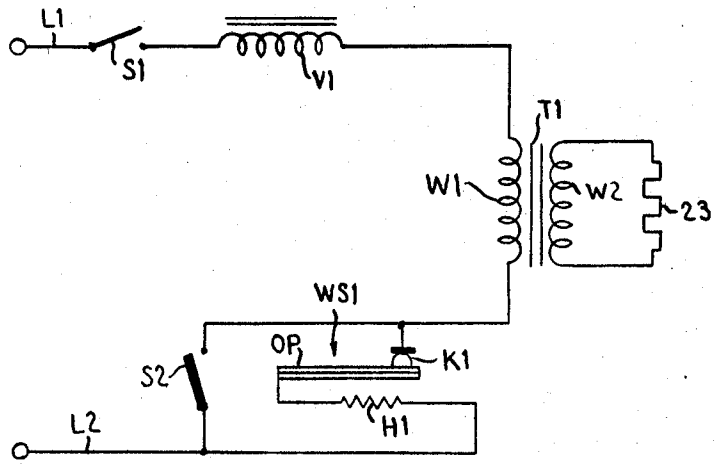

L1
S1
V1
T1
W1
W2
23
WS1
OP
K1
S2
H1
L2

FIG. 5.

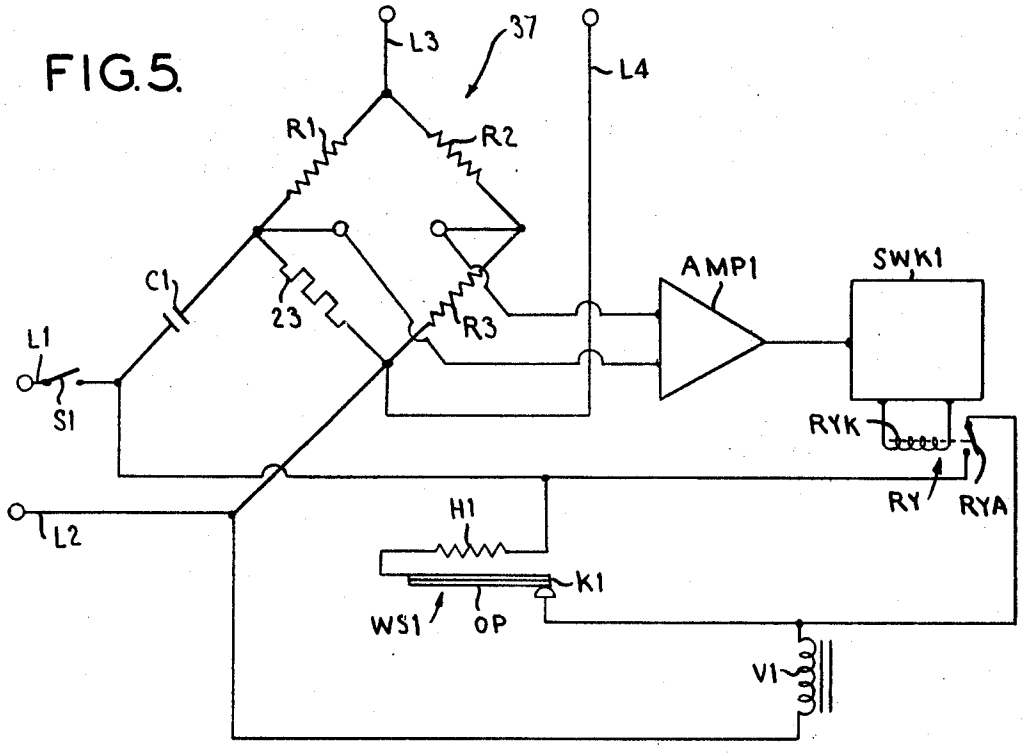

L3
37
L4
R1
R2
C1
23
R3
AMP1
SWK1
L1
S1
RYK
RY
RYA
H1
L2
K1
WS1
OP
V1

FIG. 7.

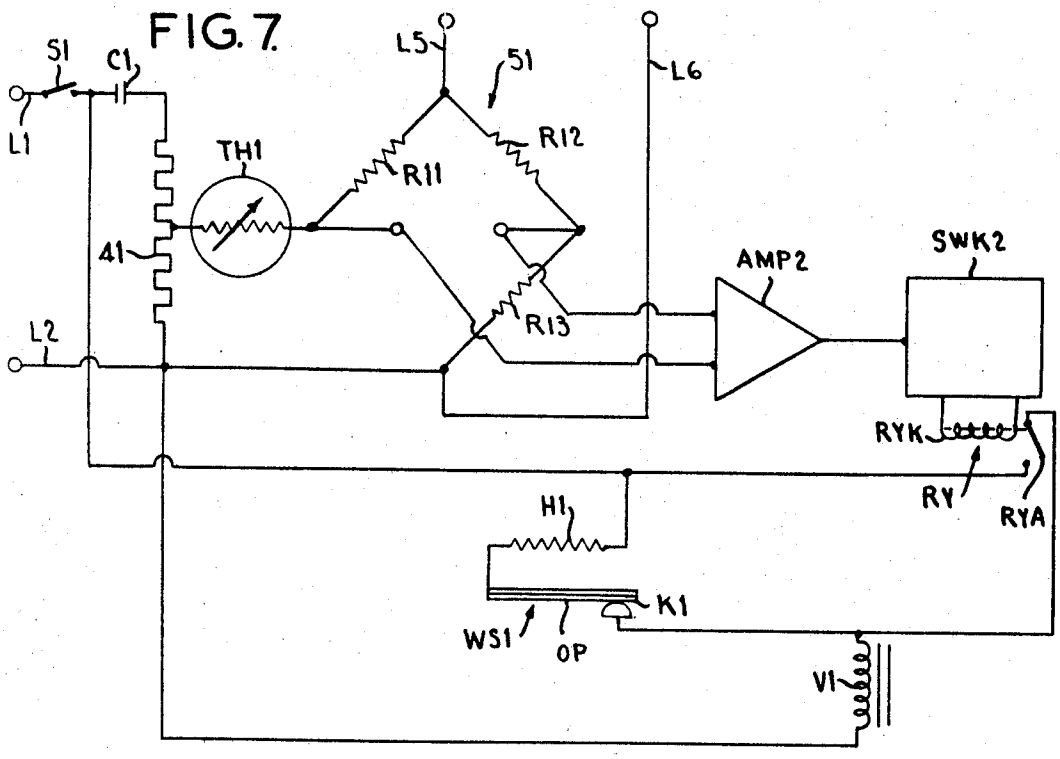
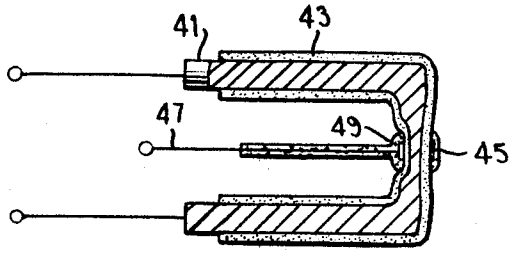

S1
C1
L1
L2
TH1
41
L5
51
L6
R11
R12
R13
AMP2
SWK2
RYK
RY
RYA
H1
K1
WS1
OP
V1

FIG. 6.


41
43
47
49
45

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3,393,038

IGNITION SYSTEMS

Thomas S. Burkhalter, Attleboro, Joseph W. Waseleski, Jr., Mansfield, and Francis P. Buiting, Plainville, Mass., assignors to Texas Instruments Incorporated, Dallas, Tex., a corporation of Delaware

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11 Claims. (Cl. 431—66)

This invention relates to ignition systems and more particularly to such systems which are adapted to ignite a combustible fuel in a burner.

Among the several objects of the invention may be noted the provision of a fuel ignition system which is reliable and requires little service; the provision of such a system which incorporates means for sensing the occurrence of ignition in a burner; the provision of such a system which incorporates a long-lived, resistance heated filament; the provision of such a system wherein a filament and a flame sensor are incorporated into a single inexpensive element; and the provision of such a system which is relatively simple and inexpensive. Other objects and features will be in part apparent and in part pointed out hereinafter.

Briefly, an ignition system according to the invention is useful in a burner construction including valve means which when actuated admits a combustible fuel into the burner. The ignition system includes a filament having a wire core of a malleable metal, the core having an overlying coating of a material the oxides of which form a stable film for protecting the metal from oxidization upon heating of the filament. Electric current is applied to the filament to heat it to a temperature above the ignition temperature of the fuel. The ignition system also includes timed switch means which actuates the valve means for a preselected interval, as well as means responsive to the burning of fuel in the burner for maintaining the valve means actuated independently of the timed switch means after the preselected interval.

The invention accordingly comprises the constructions hereinafter described, the scope of the invention being indicated in the following claims.

In the accompanying drawings, in which several of various possible embodiments of the invention are illustrated,

FIG. 1 illsutrates an igniter for an ignition system of the present invention;

FIG. 2 is an enlarged view, partially in section, of the filament employed in the igniter of FIG. 1;

FIG. 3 illustrates a helical igniter filament configuration;

FIG. 4 is a schematic circuit diagram of an ignition system employing the igniter of FIG. 1;

FIG. 5 is a schematic circuit diagram of a modified ignition system which employs the igniter of FIG. 1 also as a flame sensor;

FIG. 6 illustrates a combination igniter-thermistor flame sensor; and

FIG. 7 is a schematic circuit diagram illustrating an ignition system employing the element of FIG. 6.

Corresponding reference characters indicate corresponding parts throughout the several views of the drawings.

Referring now to FIG. 1 there is shown an igniter **11** for initiating combustion of a fuel within a burner. Igniter **11** includes a pair of electrodes **13** and **15** which are supported on a bushing **17** for mounting the igniter on a burner. Electrodes **13** and **15** are provided with respective terminals **19** and **21** for connection to an appropriate power source. Between electrodes **13** and **15** extends a filament **23** which is adapted to be resistance heated by the passage of current to a temperature above the ignition point of the fuel with which the igniter **11** is to be used.

As may be seen in FIG. 2, filament **23** comprises a core **25** of tungsten wire and, over the core, a layer of silicon carbide **27**. The silicon carbide coating is, for example, applied to core **25** by vapor deposition so as to obtain a uniform dense coating of beta silicon carbide over the surface of the core. When the core **25** with its silicon carbide coating **27** is heated in an oxidizing atmosphere, such as exists in a typical oil or gas burner, the silicon carbide coating **27** oxidizes as indicated at **29** forming a continuous and stable film which prevents further consumption of the remainder of the silicon carbide coating **27** and also prevents oxidization of the tungsten wire core **25**. Examples of other materials which form stable protective films upon oxidization are boron nitride, nickel aluminide and various other chromatizing coatings known in the art. Other malleable metals having melting points above the temperatures expected in the burner may also be used for the wire core **25**. Examples of such metals which may be used in gas and oil burners are molybdenum, tantalum, hafnium and alloys thereof.

Another configuration of an igniter element is shown in FIG. 3. In this embodiment the protected filament is wound into a helix **31** which extends between a pair of electrodes **33** and **35**.

An ignition system utilizing igniter elements such as illustrated in FIGS. 1 and 3 is shown in FIG. 4. A valve solenoid V1 is provided for selectively operating a valve to admit gas for combustion in a suitable burner (not shown). The valve is actuated to its open condition upon energization of solenoid V1. Electric power for energizing solenoid V1 is obtained from a suitable source or supply mains through a pair of leads L1 and L2. A switch S1, which may for example be a typical room temperature thremostat, is provided for selectively energizing the system when the burner is to be operated. Connected in series with solenoid V1 is the primary winding W1 of a transformer T1. Transformer T1 includes a secondary winding W2 which is connected to the igniter filament **23**.

Connected in series with solenoid V1 and primary winding W1 is the parallel combination of a bimetallic flame sensing switch S2 and a warp switch WS1. Warp switch WS1 includes a heater element H1, a bimetallic operating arm OP and a set of normally closed contacts K1 which are operated by the operating member OP. When heater H1 is energized it begins to warm the operating member OP and, after a predetermined delay, the contacts K1 are opened by the operating member. Warp switch WS1 thus functions as a time delay relay. The contacts of flame sensing switch S2 are of the normally open type.

When power is initially applied to the system by the closure of switch S1, current flowing through contacts K1 energizes the igniter filament **23** and operates solenoid V1 to admit gas to the burner. If the system is operating properly and adequate fuel pressure is available, the hot igniter filament **23** will ignite the gas. The flame in the burner will then operate the bimetallic flame sensing switch S2 to its closed position. This closing of switch S2 will normally occur within the delay interval provided by warp switch WS1 and thus, after the delay interval, energization of valve solenoid V1 will be maintained independently of the timed warp switch. If, however, the fuel does not ignite within this predetermined time, warp switch contacts K1 will open the circuit supplying igniter filament **23** and actuating solenoid V1 will be deenergized. The solenoid will thus cut off the gas supply. After such a shutdown, warp switch WS1 will gradually cool down closing contacts K1 so that the system will recycle and again try to establish combustion within the burner.

FIG. 5 illustrates another embodiment of the invention which provides a particularly rapid sensing of the

initiation or occurrence of combustion. In this embodiment, filament 23 is employed both as an igniter and as a sensor to determine whether or not combustion has been initiated. The operation is based upon the changes in temperature and resistance which occur in the tungsten core of filament 23 when ignition occurs. When ignition occurs, the temperature of a resistance heated filament rises to a level above that which exists when only the resistance heating is provided. Tungsten has an appreciable positive temperature coefficient of resistance and thus the occurrence of ignition will also cause an increase in the resistance of the filament.

Filament 23 is connected across lines L1 and L2 by means of a circuit which includes, in addition to the thermostatic switch S1, a D.C. blocking capacitor C1. Thus, when switch S1 is closed, filament 23 is heated by A.C. power but is isolated from the line L1 for direct current. Valve solenoid V1 is connected across leads L1 and L2 for energization simultaneously with filament 23 by a circuit including warp switch WS1.

Filament 23 is also connected in a D.C. bridge 37. D.C. power is applied to the bridge through a pair of leads L3 and L4. A reference resistor R1 and the filament 23 constitute two arms of a bridge connected across the lines L3 and L4. The resistance value of resistor R1 is intermediate the resistance of filament 23 before ignition and its resistance after ignition occurs. A pair of resistors R2 and R3 of equal value constitute the two arms of the bridge.

One of the two input terminals of a D.C. differential amplifier AMP1 is connected to the D.C. bridge 37 between resistor R1 and filament 23 and the other input is connected to the bridge between resistor R2 and resistor R3. Differential amplifier AMP1 includes means for rejecting any A.C. component in its input signal and is thus responsive to the D.C. unbalance of the bridge. The output of the amplifier AMP1 is applied to a trigger or switching circuit SWK1 which energizes the coil RYK of a relay RY whenever the resistance of filament 23 exceeds that of the reference resistor R1 which establishes the operating threshold. Switching circuit SWK1 may, for example, be constituted by a Schmitt trigger. Coil RYK operates a set of normally open contacts RYA which are connnected for applying power from lines L1 and L2 to the valve operating solenoid V1 independently of the warp switch WS1.

The operation of this circuit is as follows. When switch S1 is closed, the filament 23 is heated by A.C. which is passed through capacitor C1. Simultaneously the fuel valve solenoid V1 is energized by current flowing through the closed warp switch contacts K1. Fuel is thus admitted to the burner to be ignited by filament 23. If ignition occurs normally, the resistance of sensor 23 will rise to a value which is greater than the resistance of resistor R1 so that the amplified unbalanced signal will trigger the switching circuit SWK1 to energize relay RY. Energization of relay RY closes contacts RYA thereby maintaining the valve solenoid V1 energized independently of the warp switch contacts. If, however, ignition does not occur within the time period determined by the characteristics of the warp switch, the warp switch contacts K1 will open and the fuel will be turned off. After the warp switch operating member OP cools sufficiently, contacts K1 again close and a repeated attempt is made to initiate combustion in the burner.

In FIG. 6 there is shown an igniter construction which incorporates both an igniting filament and a flame sensing thermistor within a single element. The filament again includes a tungsten wire core 41 which is covered and protected by a coating 43 of silicon carbide, the oxides of which form a stable film protecting the wire core from oxidization upon heating. In addition to its protective function, layer 43 is also employed as a temperature responsive material in a flame sensing thermistor, silicon carbide having a negative temperature coefficient of resistivity. An annular contact 45 is provided around the outer surface of layer 43 near the center of the filament. Contact 45 serves as one of the thermistor electrodes, the other being constituted by the tungsten core 41 itself. Contact 45 may, for example, be constituted by a layer of tungsten which is vapor deposited over the silicon carbide layer 43. A lead 47 is connected to contact 45 and both the contact 45 and the portion of lead 47 which is exposed to high temperatures are coated with a layer 49 of silicon carbide which protects contact 45 and lead 47 from oxidization when the igniter-sensor is heated.

In FIG. 7 there is shown a circuit diagram of an ignition system employing the igniter-sensor of FIG. 6. The wire core 41 which constitutes the igniter filament is connected across source leads L1 and L2 by a circuit which includes switch S1 and D.C. blocking capacitor C1. Valve solenoid V1 is connected across the source leads through the warp switch contacts K1. The resistance of the silicon carbide thermistor material underlying contact 45 is indicated in FIG. 7 at TH1 by a conventional thermistor symbol. Lead 47 and lead L2 are connected to a D.C. resistance bridge 51 so that the thermistor TH1 essentially constitutes one arm of the bridge. It will be seen that, due to the connection of one end of the thermistor material to the filament core 41, a portion of the filament is also included within that arm of the D.C. bridge. However, the D.C. resistance of that portion of tungsten core 41 is typically very much smaller than the resistance of thermistor resistance TH1 so that its effect is insignificant and can be neglected in considering the operation of this circuit.

Bridge 51 includes a resistor R11 connected in series with thermistor resistance TH1 thereby to provide one side of the bridge. The value of resistor R11 is chosen to lie between the value of resistance which thermistor TH1 exhibits in the presence of flame and that which it exhibits in the absence of flame, heating current being applied to the filament 41 in both instances. A pair of resistors R12 and R13 which are of equal resistance to each other constitute the other two arms of bridge 51. Direct current is applied to bridge 51 by means of a pair of leads L5 and L6.

One of the input terminals of a D.C. differential amplifier AMP2 is connected to the junction between resistor R11 and thermistor resistance TH1. The other input is connected to the junction between resistor R12 and resistor R13. The thereby amplified error signal from bridge 51 is applied to a switching circuit SWK2 which controls relay RY to energize the valve solenoid V1 independently of the warp switch WS1 when the resistance of thermistor TH1 falls below that of resistor R11.

The operation of this circuit is as follows. When switch S1 is closed, filament 41 is heated and the valve solenoid V1 is energized to admit fuel to the burner. If the fuel is ignited by filament 41 within the time interval provided by warp switch WS1, the resistance of thermistor TH1 will fall below that of resistor R11 so that the amplified error signal from the bridge causes the switching circuit SWK2 to maintain the energization of the valve solenoid V1 after the time interval provided by the warp switch. If however, the fuel initially admitted should not be ignited, the resistance TH1 will remain greater than that of resistor R11 so that the switching circuit SWK2 will not provide an alternate source of power to valve solenoid V1. Accordingly, at the end of the time interval provided by the warp switch for ignition to occur, valve solenoid V1 will be deenergized and the supply of fuel to the burner will be cut off.

While bridge circuits have been illustrated as means for sensing resistance changes, it will be understood by those skilled in the art that various other known threshold-establishing circuits may be used. Similarly, devices other than the warp switch illustrated may be used for initially permitting fuel to be supplied to the burner for a predetermined interval.

In view of the above, it will be seen that the several objects of the invention are achieved and other advantageous results attained.

As various changes could be made in the above constructions without departing from the scope of the invention, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. In a burner construction including valve means which when actuated admits a combustible fuel into the burner, an ignition system comprising:
   - a filament including a wire core of a malleable metal, said core being coated by a layer of a material the oxides of which form a stable film which protects said metal from oxidation upon heating of said filament;
   - means for applying electric current to said filament to heat it to a temperature above the ignition temperature of said fuel;
   - timed switch means for actuating said valve means for a preselected interval; and
   - means responsive to burning of said fuel in said burner for maintaining said valve means actuated independently of said timed switch means.

2. An ignition system as set forth in claim 1 wherein said metal is tungsten and said material is silicon carbide.

3. An ignition system as set forth in claim 1 wherin said means responsive to the burning of said fuel includes a bimetal switch.

4. An ignition system as set forth in claim 1 wherein the resistance of said metal is dependent upon its temperature and wherein said means responsive to the burning of said fuel includes means responsive to the resistance of said filament for actuating said valve means when the resistance of said filament exceeds a preselected threshold level.

5. An ignition system as set forth in claim 1 wherein the resistance of said material is dependent upon its temperature and wherein said means responsive to the burning of said fuel includes means responsive to the resistance of said material for actuating said valve means when the resistance of said material varies beyond a preselected threshold level.

6. In a burner construction including valve means which when actuated admits a combustible fuel into the burner, an ignition system comprising:
   - a metallic filament having a positive temperature coefficient of resistance;
   - means for applying electric current to said filament to heat it to a temperature above the ignition temperature of said fuel;
   - timed switch means for actuating said valve means for a preselected interval; and
   - control means responsive to the resistance of said filament for maintaining said valve means actuated independently of said timed switch means when the resistance of said filament exceeds a preselected threshold level.

7. An ignition system as set forth in claim 6 wherein A.C. current is applied through a D.C. blocking capacitor to heat said filament and wherein said filament is interconnected in a D.C. bridge for sensing changes in the resistance of said filament.

8. In a burner construction including valve means which when actuated admits a combustible fuel into the burner, an ignition system comprising:
   - a filament-sensor including a wire core of a malleable metal, said core being coated by a layer of a semiconductor material the resistance of which varies with temperature and the oxides of which form a stable film which protects said metal from oxidization upon heating of said filament-sensor and, overlying said layer, a contact providing an electrical connection to said material;
   - means for applying electric current to said filament to heat it to a temperature above the ignition temperature of said fuel;
   - timed switch means for actuating said valve means for a preselected interval; and
   - control means responsive to the resistance between said contact and said core for maintaining said valve means actuated independently of said timed switch means when said filament-sensor is so heated by said burner that the resistance between said contact and said core varies beyond a preselected threshold level.

9. An ignition system as set forth in claim 8 wherein said material is silicon carbide and said control means actuates said valve means when said resistance falls below said threshold.

10. In a burner ignition system, a filament-sensor comprising:
   - a wire core of a malleable metal;
   - a coating over said core of a semiconductor material the resistance of which varies with temperature and the oxides of which form a stable film which protects said metal from oxidization upon heating of said filament-sensor; and
   - a contact overlying said coating for providing an electrical connection to said material whereby changes in the resistance of said material produce a change in the resistance between said contact and said core for signalling the occurrence of ignition within the burner.

11. A filament-sensor as set forth in claim 10 including a layer of said material overlying said contact thereby to protect said contact from oxidization.

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FREDERICK L. MATTESON, JR., *Primary Examiner.*

E. G. FAVORS, *Assistant Examiner.*