

[54] **CLOSED LOOP, INERT ATMOSPHERE,
PAINT LINE OVEN HEAT SOURCE**

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[56] **References Cited**

UNITED STATES PATENTS

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Primary Examiner—John J. Camby

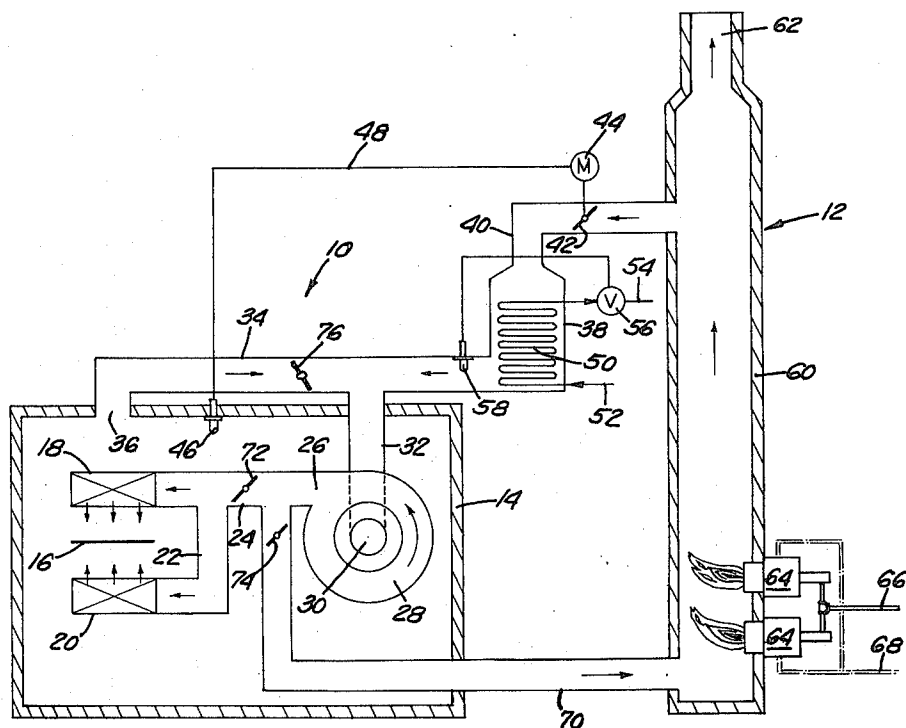
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[57]

ABSTRACT

A paint line oven and heat source comprising a stack having fuel-fired burners in the lower portion thereof, and a closed loop conduit system with a circulating blower therein, which takes hot, inert stack gas from the stack above the burners, and circulates it through the oven, where paint solvent is evaporated from the painted product. Solvent-laden oven atmosphere is discharged into the stack below the burners and mixes with excess air supplied through the burners, where the solvent burns, adding its heat to the heat of the burners. Stack atmosphere at the conduit intake is substantially oxygen-free, and is hotter than the predetermined oven temperature. A water-cooled heat exchanger in the conduit cools the stack atmosphere down to the preselected oven temperature before discharging it into the oven. In one embodiment, temperature-controlled valves regulate the volume of stack atmosphere delivered to the oven, and the rate of flow of coolant in the heat exchanger, so that uniform temperature is maintained automatically.

7 Claims, 2 Drawing Figures



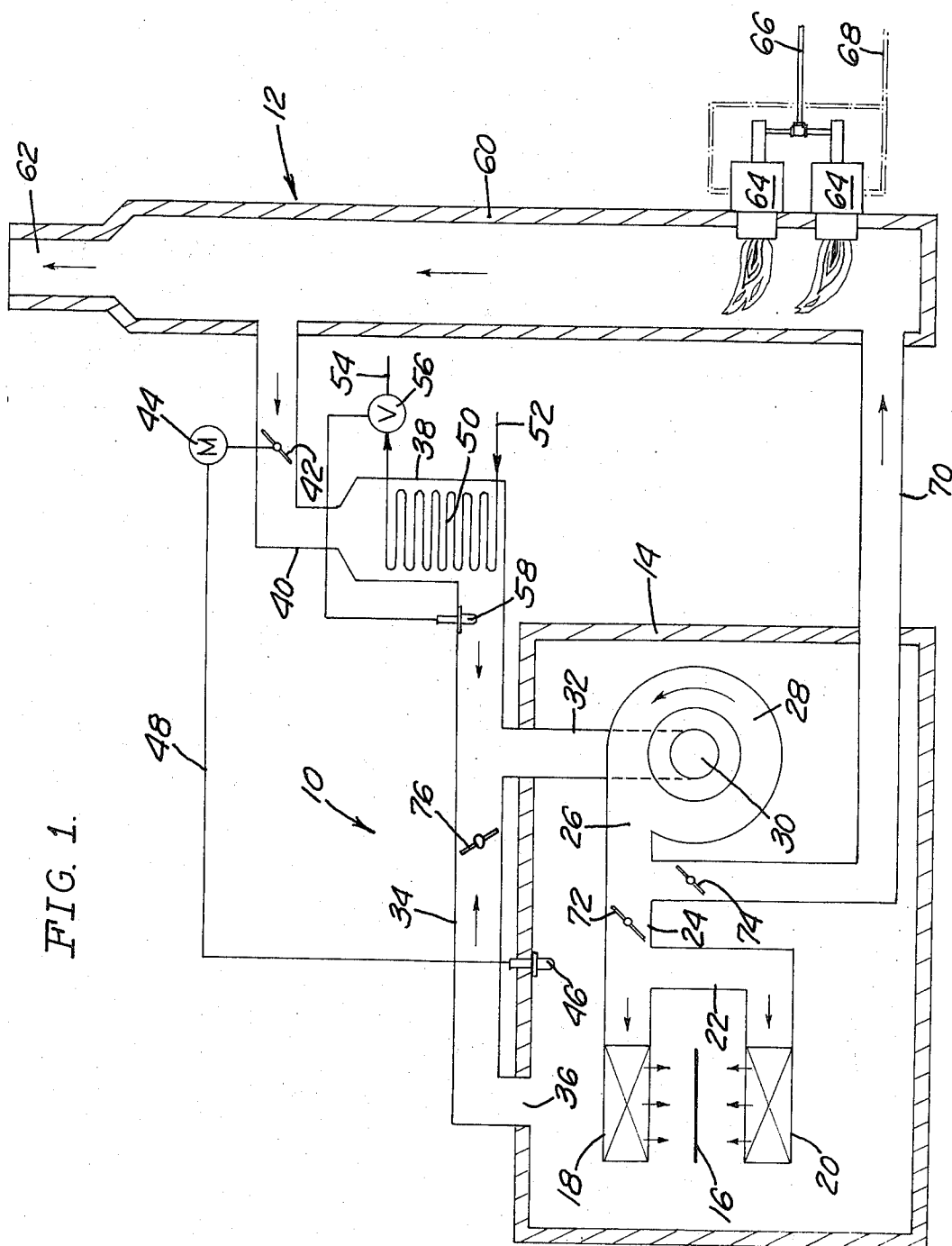


FIG. 1.

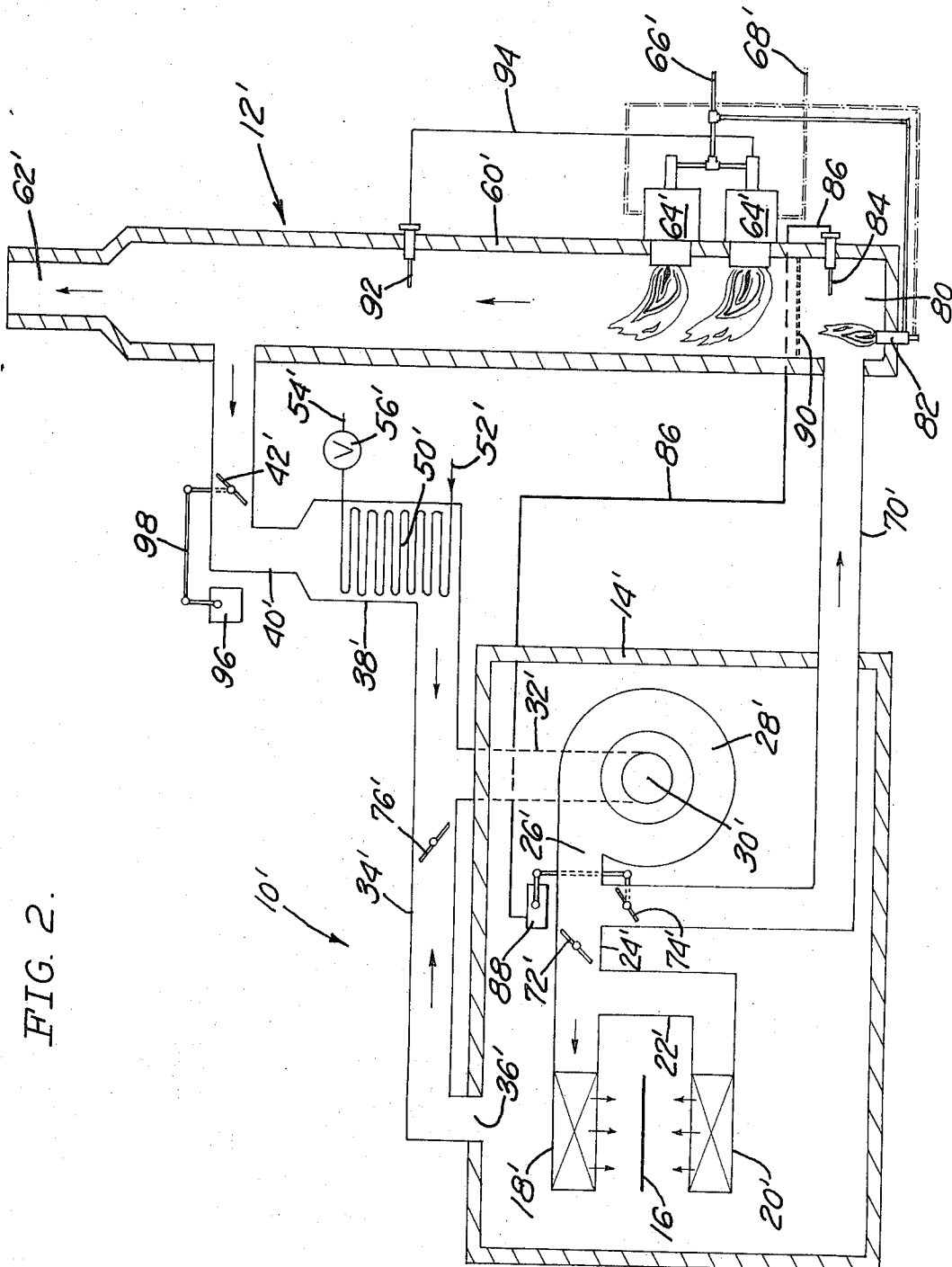


FIG. 2.

CLOSED LOOP, INERT ATMOSPHERE, PAINT LINE OVEN HEAT SOURCE

BACKGROUND OF THE INVENTION

The present invention relates generally to paint line ovens for evaporating the volatile solvent from painted metal strip, and then polymerizing the resin vehicle in the paint. Such ovens are usually maintained at temperatures ranging from 500° to about 750° F, and heat is supplied by blowers, which draw hot flue gas from an adjacent stack having burners discharging flame into the lower portion thereof, and mix it with a large volume of fresh air before discharging the mixture into the oven. The oven atmosphere is continuously recirculated by the blowers, and a volume of the oven atmosphere equal to the incoming volume of fresh air and hot flue gas is bled off into the stack and thence to the atmosphere.

Heretofore, it has been the practice to ventilate ovens with an excessive amount of fresh air in order to dilute the concentration of combustible solvent fumes down to a level well below the explosive level. This eliminates the explosion hazard, but one major objection is that it is extremely costly because of the excessive amount of fuel that must be used to heat up the large amount of air that is required. Another objection is that because the solvent fumes are so dilute in the oven atmosphere discharged into the stack, there is relatively little combustion of the solvent, and most of the fumes are discharged into the atmosphere as pollution.

SUMMARY OF THE INVENTION

The primary object of the present invention is to provide a new and improved heat source for paint line ovens, which requires only a small fraction of the amount of fuel consumed by conventional oven heat sources.

Another important object of the invention is to provide a paint line oven, and heat source therefor, which is completely explosion-proof. This object is achieved by providing a system in which a completely inert, almost totally oxygen-free atmosphere is circulated through the oven at all times. Without oxygen, the paint solvent vapor is incapable of burning or exploding, and therefore the explosion hazard is completely eliminated. This inert, oxygen-free oven atmosphere also makes possible the fuel saving mentioned above, since the volume of oven atmosphere that must be heated up to operating temperature is only a small fraction of the volume that was required to be heated in prior ovens, there is no large volume of diluent air added to the oven atmosphere to reduce the explosion hazard, and the fuel that has heretofore been required to heat the diluent air is thus saved. The only heat loss in the apparatus of the present invention is by radiation and conduction, including the heat carried off by the painted strip as it leaves the oven. One important economic advantage of the invention is that the cost of explosion-proofing the oven and duct structure is saved, since the inert atmosphere of the oven makes it inherently explosion-proof.

Another object of the invention is to provide a heat source of the class described in which raw solvent vapor is completely burned, adding its heat to the heat of the burners, and substantially eliminating raw solvent fumes from the stack emissions, thereby greatly reducing this source of atmospheric pollution. This object is achieved by discharging the solvent-laden oven

atmosphere into the stack below the burners, where the solvent vapor combines with a limited amount of excess air injected by the burners, and burns.

A further object of the invention is to provide a closed loop, inert atmosphere oven heat source, in which hot flue gases withdrawn from the stack above the burners pass through a heat exchanger before being discharged into the oven, said heat exchanger serving to cool the flue gases down to the preset oven temperature. Heretofore, the hot flue gases withdrawn from the stack were tempered by mixing cool atmospheric air with them, but this had the disadvantage of introducing oxygen into the oven, and in order to eliminate the explosion hazard, it was necessary to continuously add a large volume of air in order to dilute the solvent vapor down to safe concentration, well below the explosion level. This, in turn, necessitated the burning of a large amount of fuel in order to heat the large volume of make-up air to oven temperature. With the present invention, no diluent air is added, and the excess heat is removed from the inert, oxygen-free flue gas by passing it through a heat exchanger.

These and other objects and advantages of the invention will become apparent to those skilled in the art from the following detailed description of the preferred embodiment thereof, with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic representation of a paint line oven with associated heat source, embodying the principles of the invention; and

FIG. 2 is a similar view of a slightly modified form of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

In FIG. 1 of the drawings, the oven is designated in its entirety by the reference numeral 10, and the heat source is indicated by the numeral 12. The oven 10 comprises an elongated tunnel-like housing 14, through which freshly painted metal strip 16 passes in the direction perpendicular to the plane of the drawing. Extending parallel to the strip 16 above and below the latter are hot air ducts 18 and 20, having outlets on the sides thereof facing the strip, through which streams of hot air blow from the ducts onto the strip as shown by arrows. Ducts 18 and 20 are connected by other ducts 22 and 24 to the outlet 26 of a blower 28. The inlet 30 of the blower is connected by a duct 32 to a horizontal duct 34 above the oven, one end of which is connected at 36 to the interior of the oven, and the other end of which is connected to a heat exchanger chamber 38.

The heat exchanger chamber 38 rises vertically from the duct 34 and is connected at its top end to a flue gas intake duct 40, which opens into the interior of stack 12 near the upper end of the latter, as shown. A butterfly valve 42 controls the flow of flue gas through duct 40, and is actuated by a motor 44. Motor 44 is controlled by a thermocouple 46 mounted inside oven 14, to which it is connected by wire 48.

Enclosed within chamber 38 is a coil of heat exchanger pipe 50, one end of which is connected to a water supply pipe 52, and the other end of which is connected to a waste pipe 54. A motor-actuated valve 56 controlled by a thermocouple 58 in duct 34 regulates the flow of water through the pipe coil 50, and this

acts to control the rate at which heat is extracted from the hot flue gas passing through the chamber 38.

Heat source 12 is preferably a vertical stack 60 having a discharge outlet 62 at the top end, and burners 64 near the lower end thereof. Burners 64 may be fueled by gas or oil, and are supplied with fuel by lines 66, and with combustion air by lines 68. The burners 64 discharge their flames into the interior of the stack 60 to heat up the interior of the stack to around 1400°F.

Opening into the bottom end of the stack 60 is a duct 70, the other end of which is connected to the blower outlet duct 24. A butterfly valve 72 in duct 24 serves as a restriction, to maintain a slightly elevated back pressure in duct 24 so that a portion of the blower output will be diverted to the duct 70 and thence to the stack 60. A second butterfly valve 74 in duct 70 regulates the rate of flow of oven atmosphere being exhausted to the stack.

Located in duct 34 between oven outlet 36 and the junction with blower intake duct 32 is another butterfly valve 76, which also serves as a restrictor at that point, so that the relative proportions of oven-atmosphere recirculated to the blower 28 and fresh flue gas coming from the heat exchanger chamber 38 can be controlled and regulated. Thus, the blower 28 constantly recirculates a portion of the hot oven atmosphere with its burden of solvent vapor, and mixes this with a certain proportion of hot flue gas; the relative proportions of oven atmosphere and fresh flue gas being determined by the respective settings of the butterfly valves 72, 74 and 76, and by butterfly valve 42, which is controlled by thermocouple 46. Butterfly valves 72, 74 and 76 may be manually controlled, or they may be actuated by automatic controls responsive to signals from suitable sensors (not shown) which measure temperature, solvent concentration, or other parameters. The oven temperature may be from 350°F to 800°F, depending upon how fast the painted strip 16 is moving, the type of paint resin used, and the length of time it is exposed to the oven temperature. The average oven temperature is usually around 500°F to 550°F.

For each unit volume of hot flue gas withdrawn from the stack through duct 40, an equal volume of oven atmosphere must be discharged through duct 70 to the bottom end of stack 60. As the solvent-laden oven atmosphere rises in the stack, it mixes with the flame from burners 64, and the solvent vapor combines with the oxygen in a limited amount of excess air supplied through the burners, so that the solvent vapor burns and adds its heat to the heat output of the burners. The solvent vapors continue to burn as they rise in the stack 60, and by the time the flue gases reach the intake duct 40, the solvent is completely burned, and the flue gas is an inert mixture, consisting approximately of 88% N₂, 11% CO₂, 0.5% CO, and 0.5% H₂. The excess air injected by the burners 64 is carefully regulated to provide only enough oxygen to combine with the solvent vapor carried into the stack from the oven 10.

In this embodiment of the invention (e.g. FIG. 1), the burners 64 operate at a more or less constant rate, and the temperature in the stack 60 varies as the amount of solvent carried in through duct 70 varies. As the amount of solvent increases, the temperature within the stack rises, and the flue gases withdrawn through duct 40 are correspondingly hotter. When thermocouple 58 detects a rise in the temperature at that point, it actuates the coolant flow-rate valve 56, opening the

valve to allow more coolant water to flow through the heat exchanger coil 50, and thus increase the rate of heat extraction. Thermocouple 58 and coolant valve 56 thus cooperate to maintain a more or less uniform temperature of flue gas in duct 34, regardless of temperature fluctuations within the stack 60 due to changes in the amount of solvent being burned. Thermocouple 46 actuates the butterfly valve 42 to regulate the amount of hot flue gas being diverted from the stack to the oven; the rate of flow being increased when the oven temperature tends to drop, and decreased when the temperature tends to rise.

Being totally devoid of free oxygen, the oven atmosphere can safely carry any burden of solvent vapors, and the oven of the present invention is inherently explosion proof. All of the solvent vapors discharged into the stack 60 by duct 70 are burned by mixing with excess oxygen discharged into the stack by the burners 64, and after the solvent has burned, the stack flue gas is totally inert and substantially oxygen free. There is no unburned solvent emitted in the stack exhaust, and the system produces no atmospheric pollution. With only a small amount of oven atmosphere being constantly recirculated, there is a minimum of fuel required to supply the necessary heat for the ovens, and the burners 64 can be partially shut off to reduce the heat input once the system has become completely heated up and is functioning normally.

A second embodiment of the invention is shown in FIG. 2, to which attention is now directed. In this form of the invention, structural parts that are substantially identical to their counterparts in the embodiment of FIG. 1 have been given the same reference numerals as in the latter figure, but with a prime (') suffix. Thus, the oven 10' is substantially the same as oven 10, and its ducts 18', 20', 22', 24', 32', 34', and 70' are exactly the same as in FIG. 1. However, certain aspects of the heat source 12' and controls are similar to the disclosure in my pending application, Ser. No. 244,149, filed Apr. 14, 1972.

One of the chief differences between the two embodiments of FIGS. 1 and 2 is that in the latter, duct 70' discharges into a solvent-burner section 80 in the bottom of stack 60', where the solvent vapor mixes with a limited amount of excess air discharged by a pilot light burner 82, and is ignited by the flame of the pilot light. Burner 82 is also connected to the fuel and air lines 66', 68'. A temperature sensor 84 (preferably a thermocouple) is located in the solvent-burner section 80, and is connected by an electrical wire 86 to an actuator 88, which operates butterfly valve 74' in duct 70'. Sensor 84 is shielded from the radiant heat of the burners 64' by an infrared screen 90, which may be in the form of a perforated steel plate extending across the width of the stack between sensor 84 and the lower burner 64'.

The temperature in the solvent-burner section 80 is a function of the concentration of solvent vapor in the oven atmosphere discharged through duct 70', and as the temperature rises (indicating an increase in solvent concentration) sensor 84 reacts by opening valve 74' further, so that more of the blower output is bled off through by-pass duct 70', and less of it goes to the oven. This results in an increased amount of hot flue gas being drawn from the stack 60' into the heat exchanger 38' and thence into the oven.

Combustion of the solvent vapor in the burner section 80 and in the stack 60' adds a considerable amount of heat to the output of burners 64', with the result that the stack temperature tends to rise. However, a thermocouple 92 mounted in the upper portion of the stack and connected to the controls of burners 64' by a wire 94, reacts by shutting down the burners a corresponding amount, so that the total heat generated within the stack remains more or less constant, but with different proportions coming from the burners 64' and from the combustion of the solvent vapors in burner section 80 and in the stack 60'. Thus, the temperature of the flue gas in the upper portion of the stack remains more or less constant, and there is relatively little fluctuation in the temperature of the hot flue gas withdrawn through duct 40'. Because of the uniformity of the temperature of the flue gas entering the heat exchanger chamber 38', it is not necessary to provide for regulation of the coolant flow through the pipe coils 50', and valve 56' is therefore manually operated. As a general rule, valve 56' will be adjusted to one setting and will be left at that setting; being changed only when the water temperature changes with the season. Butterfly valve 42' is operated by an actuator 96, to which it is connected by linkage 98, and valve 42' may be actuated by manually operating a controller (not shown) regulating the actuator 96. The actuator 96 might also be automatically controlled by any suitable mechanism.

The hot flue gas atmosphere withdrawn from the upper part of the stack 60' through conduit 40' is totally inert and oxygen-free, and after having its temperature modified by the heat exchanger coils 50', is discharged by the blower 28' into the oven 10', where it evaporates more solvent from the painted strip 16. Being oxygen-free, the oven atmosphere is non-explosive, regardless of how much solvent vapor it is carrying, and there is no explosion hazard. The small amount of flue gas-oven atmosphere being circulated at all times results in an absolute minimum of fuel consumption.

While I have shown and described in considerable detail what I believe to be the preferred embodiments of the invention, it will be understood by those skilled in the art that the invention is not limited to the exact details shown, but might take various other forms within the scope of the invention. For example, the burners 64 or 64' might be replaced by an electric arc, or an air-cooled radiator might be used in place of the liquid-cooled heat exchanger 38, 50. Various other equivalent devices might be substituted for the specific components shown and described herein without departing from the broadest aspect of the invention, as defined by the claims.

I claim:

1. A closed loop, inert atmosphere, paint line oven for evaporating paint solvent from freshly painted metal strip, comprising:

- an enclosed oven through which said painted strip passes;
- a heat source comprising an enclosure having means therein for generating heat;
- an intake conduit connected into said enclosure above said heat generating means;
- a blower having an intake duct and an outlet duct, said outlet duct discharging into said oven and said intake duct including a first branch connected to

said oven and a second branch connected to said intake conduit;

a discharge duct connected at one end to said blower outlet and at the other end to said enclosure below said heat generating means;

valve means for deflecting a portion of the blower output into said discharge duct, whereby a portion of the oven atmosphere laden with solvent vapor is exhausted through said discharge duct into said enclosure;

means associated with said enclosure for introducing a quantity of fresh air into the interior thereof just sufficient to combine with the solvent vapor and cause combustion thereof, the oxygen in said introduced air being consumed by the combustion of said solvent vapor, so that the hot gas in said enclosure at the level of said intake conduit is substantially oxygen-free and inert; and

heat exchange means in said intake conduit for removing excess heat from the hot gas drawn from said enclosure before discharging the same into said oven, said heat exchange means reducing the temperature of said hot gas to substantially the same temperature as that of the oven.

2. A paint line oven as in claim 1, wherein said heat exchange means comprises a coil of pipe arranged in said intake conduit and connected to a source of coolant fluid.

3. A paint line oven as in claim 2, further comprising valve means connected into said coil of pipe to control the rate of flow of said fluid coolant therein, and a temperature sensor located downstream of said heat exchange means for measuring the temperature of the hot gas leaving said heat exchange means, said sensor being operatively connected to said valve means to increase the rate of flow of said coolant when the temperature rises above a predetermined level, and to decrease the rate of flow when the temperature falls below said level, whereby hot gas of substantially constant temperature is delivered to said oven.

4. A paint line oven as in claim 1, wherein said means for generating heat comprises at least one burner located in said enclosure between said discharge duct and said intake conduit, said burner being supplied with fuel and air, and the quantity of air being in excess of the amount required for combustion of the fuel, whereby there is an excess of oxygen supplied to the interior of said enclosure just sufficient to burn the solvent vapor.

5. A paint line oven as in claim 1, wherein said heat source enclosure has a solvent-burner section adjacent said heat generating means, said discharge duct emptying into said solvent burner section, and means supplying a limited quantity of oxygen to the solvent vapor laden gas discharged into said solvent burner section, so that said solvent vapor is caused to burn, thereby consuming both the solvent vapor and the oxygen, and leaving an inert atmosphere, the heat of combustion of said solvent being added to the heat output of said heat generating means.

6. A paint line oven as in claim 5, wherein said means for generating heat comprises at least one burner located in said enclosure between said solvent burner section and said intake conduit, said burner being supplied with fuel and air; a temperature sensor located within said enclosure above said burner; and control means actuated by said temperature sensor to shut

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down said burner when the temperature within said enclosure exceeds a predetermined level owing to the additional heat supplied by combustion of the solvent.

7. A paint line oven as in claim 6, wherein a second temperature sensor is located in said solvent burner section; and means actuated by said second temperature sensor responsive to variations in the temperature within said solvent burner section for increasing or de-

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creasing the proportion of blower output diverted to said solvent burner section; and said means being operable to increase the amount of oven atmosphere discharged into said solvent burner section when the temperature therein rises, indicating a higher concentration of solvent vapor.

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