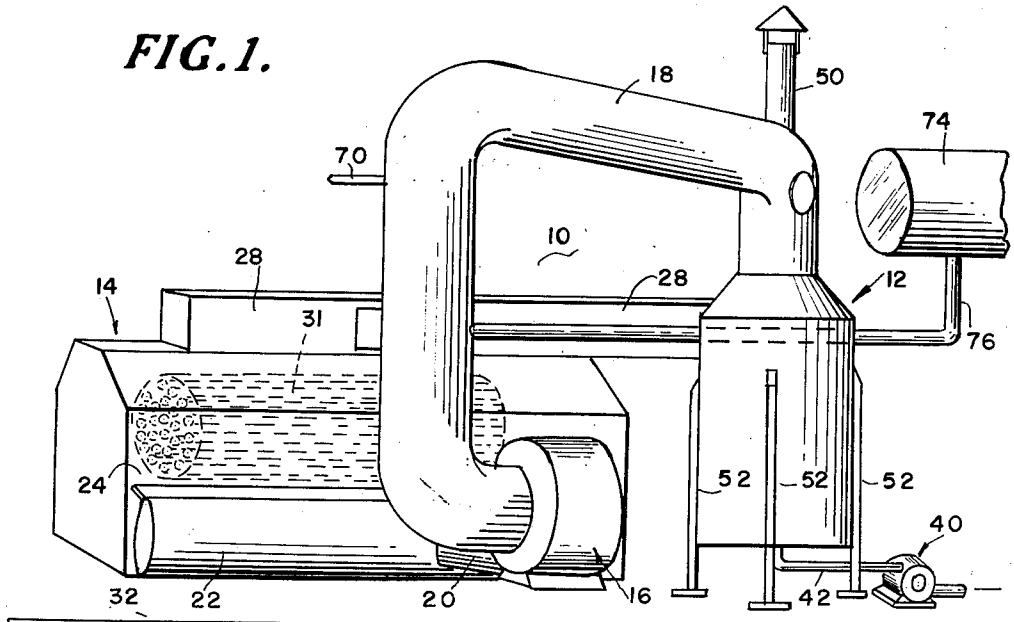
Oct. 30, 1962 G. E. OHMSTEDE 3,061,294

APPARATUS FOR CLEANING HEAT EXCHANGERS AND TUBE BUNDLES

Filed Sept. 16, 1960

2 Sheets-Sheet 1

FIG. 1.



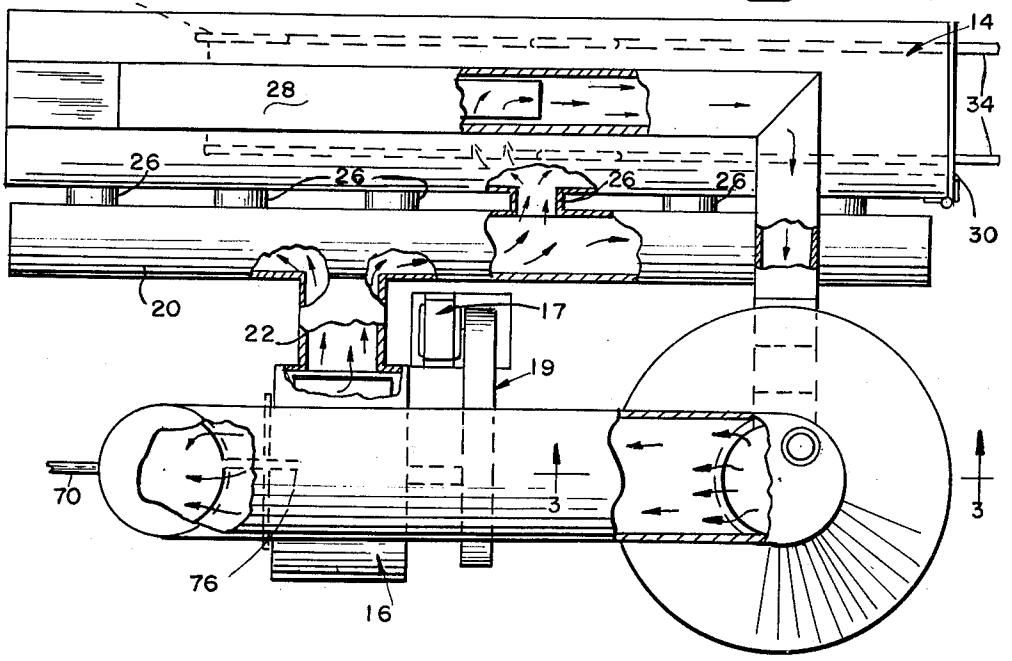


FIG. 2.

INVENTOR

GENE E. OHMSTEDE

BY Cushman, Darby & Cushman

ATTORNEYS

Oct. 30, 1962 G. E. OHMSTEDE 3,061,294

APPARATUS FOR CLEANING HEAT EXCHANGERS AND TUBE BUNDLES

Filed Sept. 16, 1960 2 Sheets-Sheet 2

FIG. 3.

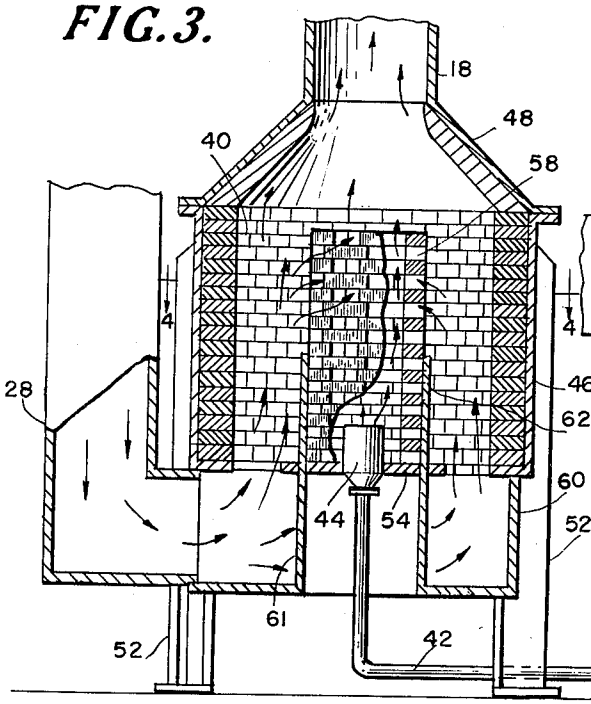
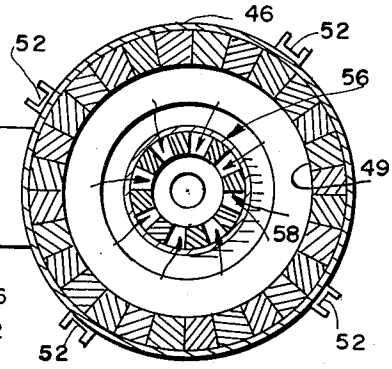


FIG. 4.



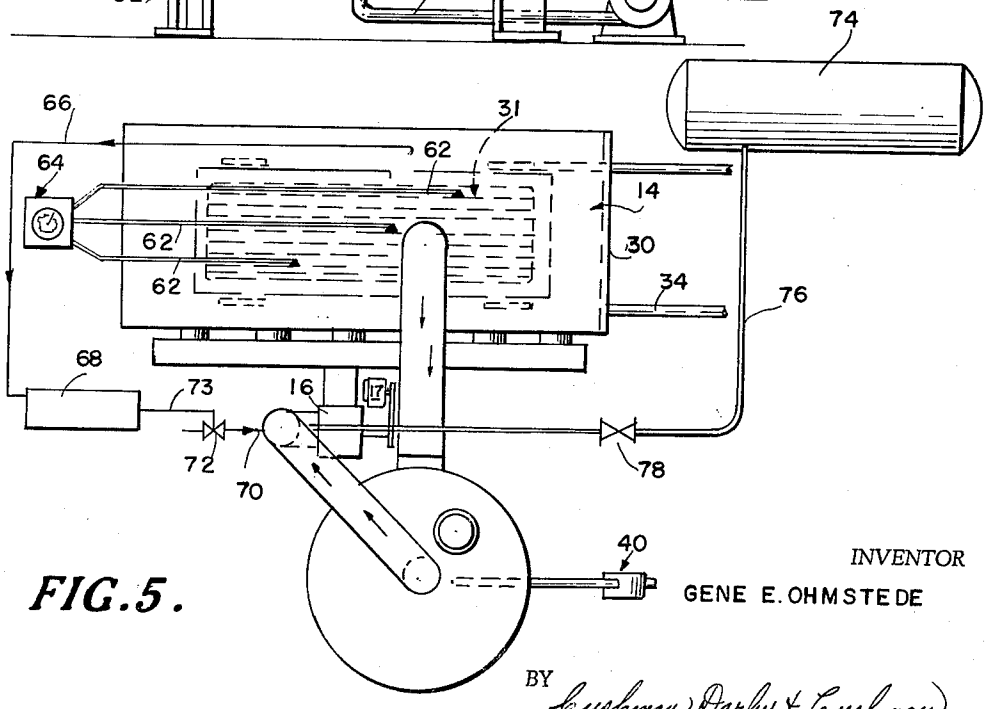


FIG. 5.

INVENTOR
GENE E. OHMSTEDE

BY Cushman, Darby & Cushman
ATTORNEYS

United States Patent Office 3,061,294 Patented Oct. 30, 1962

3,061,294

APPARATUS FOR CLEANING HEAT EXCHANGERS AND TUBE BUNDLES

Gene E. Ohmstede, Beaumont, Tex., assignor to Ohmstede Machine Works, Inc., Beaumont, Tex., a corporation of Texas

Filed Sept. 16, 1960, Ser. No. 56,469
8 Claims. (Cl. 263—43)

This invention relates to a cleaning apparatus, and in particular, to an apparatus adapted to clean heat exchangers, tube bundles, and other chemical processing equipment which are fouled with various polymers, synthetic resins, rubber compounds, and the like.

The upkeep and maintenance of chemical processing equipment, such as heat exchangers, is a major economic expenditure in the chemical processing industry, and diverse efforts have been directed to the cleaning of chemical processing equipment in a more rapid and efficient manner in order to avoid undue delay in placing the equipment back in operation.

A particular area of the chemical industry wherein this problem is of considerable importance relates to the cleaning and otherwise defouling of heat exchangers, tube bundles, and the like, which are fouled with "pop corn" polymers, various rubber compounds, monomeric materials that have polymerized, and solid materials generally having a burning or melting point in the order of approximately 600–900° F. These compounds are generally insoluble in ordinary solvents such as benzene and carbon tetrachloride, and cleaning by mechanical methods, and such conventional solvents are largely ineffective.

For these reasons, new processes have been developed, for example, as set forth in the patent to Utsinger 2,563,085, which teaches a method of igniting various polymers in a controlled atmosphere of flue gas and air, to effectively "burn off" these deposits on chemical processing equipment.

It accordingly is an object of my invention to provide a new and improved apparatus for cleaning chemical processing equipment, such as heat exchangers, which have become fouled with various polymeric materials, rubber compounds, and the like, by igniting and burning off, or otherwise melting these undesirable materials, under controlled conditions.

A further object of my invention is to provide an apparatus for cleaning heat exchangers and the like, by igniting and burning the deposits thereon, which have an ignition point in the order of approximately 600–900° F., in controlled atmosphere of flue gas and oxygen.

Yet another object of my invention is to provide a cleaning apparatus, adapted for the controlled ignition and burning of solid chemical compounds of the nature described, by a new and improved means for controlling the conditions under which the burning takes place.

Still another object of my invention is to provide a closed cycle cleaning apparatus employing a regenerative gas means, with provision for close control of the oxygen content of the gas, for controlling the burning rate of the undesirable chemicals on heat exchangers and the like.

Further objects and advantages of my invention will become apparent with reference to the foregoing description and the appended drawings wherein:

FIGURE 1 shows a perspective view of the apparatus embodying certain features of my invention.

FIGURE 2 is a plan view of the apparatus shown in FIGURE 1.

FIGURE 3 is a full section elevational view of the furnace and related equipment used in my invention.

FIGURE 4 is a section view taken along line 4—4 of FIGURE 3, and

FIGURE 5 is a schematic plan view of the apparatus wherein the various control means for operation thereof are shown.

There is provided in this invention a closed cycle apparatus wherein flue gas is generated in a furnace and transmitted to an oven into which a fouled heat exchanger is placed for cleaning. Means are provided for regulating the percentage of oxygen in the flue gas atmosphere within the oven together with controls for regulating the temperature and pressure within the oven.

Referring now to FIGURE 1, there is shown an apparatus **10** comprising a furnace **12** and an oven **14**. The furnace **12** is connected to the suction side of a conventional blower **16** by means of duct **18**. The blower **16** is driven by a motor **17** through a conventional belt drive **19** operatively disposed between the drive shaft of the motor **17** and the driven shaft of the blower **16**. The blower has its discharge duct **20** communicating with a manifold **22** which is disposed along a side wall **24** of the oven **14**. The manifold is in communication with the interior of the oven **14** by means of a plurality of pipes **26**. The communication is further provided between the oven **14** and the furnace **12** for returning the gas from the oven **14** to the furnace **12** by means of an oven discharge duct **28**.

The oven **14** has an appropriate door **30** at one end thereof for receiving a heat exchanger **32** which is disposed on an appropriate cart **32**, riding on a track **34**. The oven **14** is preferably an airtight enclosure when the door **30** is secured by appropriate means (not shown).

Suitable pressure relief valves or the like (not shown) are provided on the oven, to prevent an excessive rise of pressure therein.

Gas to be ignited in the furnace **12** is introduced into a pre-mixer **40** which is, in turn, in communication with the underside of furnace **12** by means of pipe **42**. The gas is discharged into the furnace **12**, ignited and discharged through nozzle **44**, as clearly shown in FIGURE 3.

The furnace is of generally cylindrical construction having side walls **46** terminating in an inverted conical section **48**, and thence to discharge duct **18**. Appropriate bricking **49** is provided about the inside surface thereof. A vent stack **50** extends upwardly from the furnace **12**, as shown in FIGURE 1. The furnace **12** is supported by stanchions **52** which are secured to the furnace, as by welding. Within the furnace and extending upwardly from the bottom **54** is a cylindrical chamber member **56** of brick, construction having a staggered bricking arrangement whereby passageways **58** are provided communicating with the furnace interior. The furnace is further provided with means for returning the flue gas from the oven **14** to the underside of the furnace as by an annular duct **60** which communicates with the return duct **28** and the inside of the furnace. The duct **60** is secured to the underside of the furnace by conventional techniques as by welding. The inner wall **61** of duct **60** extends upwardly well into the furnace and is in abutment with the outside surface of chamber **56**, preferably to a point above the nozzle **44** of gas inlet line **42**. It may, therefore, be seen from the arrows in FIGURE 3 that the flue gas, upon returning to the furnace **12** through return duct **28** and annular duct **60** is mixed with the burning flue gas emitted from nozzle **44**, which passes through passages **58** in the chamber **56**. Of course, additional baffling may be provided to suitably mix the return flue gas with the newly ignited flue gas.

Referring now to FIGURE 5, the apparatus is shown with the controls associated therewith. The oven **14** is shown with a heat exchanger **31** mounted on a cart **32** which, in turn, is located on track **30**. Disposed in or

on the tubes of heat exchanger **31** are a number of thermocouples **62** which communicate with a temperature recorder **64**. A conventional multi-point temperature recorder such as "Leeds and Northrop Speedomax Type G" has been found to be suitable for this purpose.

A gas sampling pipe **66** is disposed in communication with the interior of the oven **14** for sampling the oxygen content of the atmosphere within the oven. This sampling pipe **66** is in communication with an oxygen analyzer **68** which provides an indication of the oxygen content in the flue gas atmosphere.

Preferably, an oxygen analyzer responsive to the magnetic permeability of the oxygen is used, as such a device affords highly accurate indications of the oxygen concentration within the oven **14**. An oxygen analyzer as described in Richardson Patents 2,658,384; 2,728,217; and 2,658,385 has been found to be particularly efficient in this regard. An air supply line **70** is provided with an appropriate valve **72** thereon for controlled admission of air into the oven, through duct **18** to provide oxygen thereto, the valve **72** being controlled by a signal generated in the oxygen analyzer **68** through an appropriate control line **73**. The valve **72** is of conventional type, which may take the form of a solenoid valve actuated by an electric signal transmitted through the line **73**. A steam source **74** is also provided with communication to the interior of oven **14** from duct **18**, as by steam supply pipe **76** having a valve **78** therein.

There is thus provided for the controls of this apparatus: temperature indicating means, air supply means, oxygen analyzing means, steam supply means, and regenerative flue gas supply in a closed system.

Operation

Reference will now be made to the operation of the apparatus to properly clean a heat exchanger which has become fouled with various polymers, rubber compounds and the like.

A heat exchanger **31** is placed on a cart **30** which is moved into the oven **14** on tracks **34**. Approximately ten thermocouples **62** are preferably secured to the heat exchanger in various positions to provide a representative reading of the temperature on the surface of the heat exchanger **31** by temperature recorder **64**.

The door **30** is then closed and the motor **17** is started, which, in turn, operates the blower **16**. Steam is admitted into the oven by opening the valve **78**, which admits steam into duct **18** from steam line **76**, to remove any explosive gases in the oven **14**. The steam supply is then shut off and the furnace **12** is placed into operation with gas being supplied to the underside of the furnace from a pre-mixer **40**. The ignited gas is introduced into the chamber **56** from nozzle **44** of the oven **14** and out through duct **18**. The gas is discharged from duct **18** into the oven **14** through blower discharge duct **20**, manifold **22** and oven inlet pipes **26**. The flue gas is recirculated back to the furnace **12** by means of duct **28** which communicates with the underside of the oven **14** through annular duct **60**. The flue gas is mixed with the newly ignited gas in the oven by the provision of the staggered brick construction of the inner chamber **56** which provides for passages **58** communicating with the oven.

The temperature within the oven is brought up to approximately 500–600° F. at a rate of about 50° F. per hour, as will be indicated on the temperature recording meter **64**. This temperature rise is properly controlled by regulating the flow of the gas from the premix burner **40** to the furnace **12**.

The oxygen content of the atmosphere within the oven is preferably maintained at no more than approximately 5% concentration. This oxygen content is regulated by the sampling of the oxygen content and recording thereof on oxygen analyzer **68**. The air flow and the consequent oxygen content within the oven is regulated by valve **72** which provides the necessary flow of oxygen within the oven through air supply pipe **70**. If the oxygen content becomes too high, valve **52** may be merely shut off for a time, as the recirculation and ignition of the flue gas will necessarily lower the oxygen content; and, conversely, if the oxygen content is too low the valve **72** may be opened wider and properly regulated to maintain the proper concentration of oxygen. In view of the fact that the apparatus is of a sealed construction, after the initial setting of the valves **72**, there is relatively little regulation required to maintain the appropriate oxygen content within the oven **14**.

When the temperature of the oven reaches approximately 800° F., the premix burner **40** is adjusted so as to maintain this temperature for approximately ten hours or until all the fouling material in the tube bundle is burned off. If the temperature of the tube bundle rises excessively, the oxygen content may be decreased as previously described, or, in an emergency, steam may be admitted to the oven by opening valve **78**, which will provide an immediate cooling of the heat exchanger **31**.

Toward the end of the burning period, additional air is admitted to the oven **14**, and if the temperature of the heat exchanger does not rise as would be indicated on the temperature recorder, it can be assumed that all fouling material has burned off the tube bundle. The gas supply to the pre-mixer **40** is then shut off, the fan **16** continuing to circulate the heated flue gas through the system. After the temperature of the heat exchanger **31** drops to approximately 300° F., the oven doors **30** are opened, and the tube bundle **31** may be removed from the oven when the temperature drops to approximately 200° F. This cooling cycle from 800° F. to 200° F. takes approximately ten hours, depending, of course, on the size of the heat exchanger. A temperature drop of about 50° F. per hour during the cooling cycle is not so excessive as to distort or warp the tubes in the heat exchanger. Steam may be emitted to the oven **14** on the cooling cycle to assist in reducing the temperature therein. Additionally, the steam can be emitted to the oven to reduce the temperature in the oven if the chemical material burns at an accelerated rate, whereby danger of metal failure would otherwise result due to excessive temperatures on the surface of the heat exchanger. It has been found that such a heating-holding-cooling cycle takes approximately 35 to 80 hours depending on the size of the bundle and the degree of fouling.

The controls for the apparatus are preferably mounted on a control board, and the valves used herein may be remotely operable by solenoid means or the like, which are well-known in the art.

While the preferred embodiment of my invention is described herein, various modifications will be apparent to one skilled in the art, and therefore the disclosure should be considered in a descriptive and not in a limiting sense, when consideration is given to the foregoing claims.

What is claimed is:

1. An apparatus for cleaning chemical processing equipment which has become fouled with organic materials, polymers and the like comprising: an oven for reception of the equipment, a flue gas generator, means for supplying gas to said flue gas generator, means for recirculating flue gas between said oven and said generator including fan means associated therewith for imparting a super-atmospheric pressure to said oven, means for detecting the percentage of oxygen within said oven, oxygen supply means for said oven, means responsive to a pre-determined oxygen content within said oven for controlling said oxygen supply means to said oven, and means operatively disposed within said oven for measuring the temperature of the equipment therein.

2. An apparatus defined in claim 1 wherein said flue gas generator includes a closed housing having a stack,

and said gas supply means includes a pre-mix outside said housing, and a nozzle mounted within said housing and in communication with said pre-mixer.

3. Apparatus defined in claim 1 including means for introducing steam into said oven for cooling the equipment placed therein.

4. Apparatus defined in claim 1 wherein said flue gas generator includes baffle means therein for mixing recirculated flue gas with newly generated flue gas, said recirculating means including an annular duct positioned in communication with the lower end of said flue gas generator, and a feed duct in communication with the upper end of said flue gas generator and in communication with said fan means.

5. Apparatus defined in claim 4 wherein said flue gas generator is of cylindrical construction and said annular duct is mounted in co-extensive relationship with the bottom thereof, said flue gas generator including a frustro-conical upper wall communicating at its upper end with said feed duct.

6. Apparatus defined in claim 4 wherein said baffle means includes a centrally disposed upright stack mounted adjacent the bottom of said flue gas generator, said stack having apertures within the side walls thereof and said gas supply means is in communication with the interior of said stack.

7. Apparatus defined in claim 1 wherein said recirculating means includes an inlet manifold mounted along

the bottom region of a wall of said oven to provide an even distribution of flue gas throughout the length thereof and duct means at the upper end of said oven for returning flue gas therefrom to said flue gas generator.

8. Apparatus defined in claim 1 wherein said oxygen supply means includes an air line connected to the suction side of said fan means, said controlling means including an oxygen analyzer operatively connected to said oven, valve means in said air line responsive to the signal of said oxygen analyzer to open and close said valve means, and steam supply means communicating with the suction side of said fan means for selectively introducing steam in said oven for cooling the equipment placed therein.

References Cited in the file of this patent

UNITED STATES PATENTS

1,365,422	Meroney	Jan. 11, 1921
1,957,932	Berolzheimer et al.	May 8, 1934
1,979,639	Rebber et al.	Nov. 6, 1934
2,040,328	Olson	May 12, 1936
2,110,209	Engels	Mar. 8, 1938
2,475,077	Clancy	July 5, 1949
2,563,085	Utsinger	Aug. 7, 1951
2,607,576	Harter	Aug. 19, 1952
2,769,693	Bearer	Nov. 6, 1956