United States Patent [19]

Beck

[11] **3,829,285**

[45] **Aug. 13, 1974**

[54] **RECUPERATORS FOR INCINERATORS**

[75] Inventor: **Joseph J. Beck,** Berlin, Wis.

[73] Assignee: **McQuay-Perfex, Inc.,** Minneapolis, Minn.

[22] Filed: **Feb. 28, 1973**

[21] Appl. No.: **336,436**

[52] **U.S. Cl.** ..... **432/223,** 432/255, 110/8 R, 122/DIG. 1, 110/56, 165/179

[51] **Int. Cl.** **F28f 1/10**

[58] **Field of Search** ..... 432/223–226, 432/247–249, 255, 22; 110/8 R, 56; 122/DIG. 1; 165/184, 179

[56] **References Cited**

UNITED STATES PATENTS

2,033,685	3/1936	Coutant	110/10
2,146,565	2/1939	Curtis	122/DIG. 1
2,188,133	1/1940	Hepburn	165/179
2,779,573	1/1957	Kuroda	110/56
3,002,729	10/1961	Welsh	165/179
3,078,919	2/1963	Brown, Jr.	110/56
3,309,072	3/1967	Cummings	165/179
3,406,956	10/1968	Canskaddan	432/249
3,499,400	3/1970	Altmann	110/8 R
3,509,834	5/1970	Rosenberg et al.	110/8 R
3,675,600	7/1972	Jones	110/8 R

OTHER PUBLICATIONS

Industrial Furnaces by W. Trink, 4th Edition, Vol. 1, Copyright 1950, pages 374–395.

Primary Examiner—John J. Camby
Assistant Examiner—Henry C. Yuen
Attorney, Agent, or Firm—Merchant, Gould, Smith & Edell

[57] **ABSTRACT**

A compact, low cost heat recuperator for incinerators and the like having one or more heat exchange tubes with internal and external fins, positioned within an outer tubular shell. Means at one end of the shell hold the heat exchange tubes in fixed position, and an expansion seal is provided at the other. Means are provided for conducting exhaust gases through the heat exchange tubes and process air around the heat exchange tubes for preheating. Connecting means are disclosed for attaching the recuperator assembly to an existing incinerator so that minimum modifications are required.

1 Claim, 7 Drawing Figures

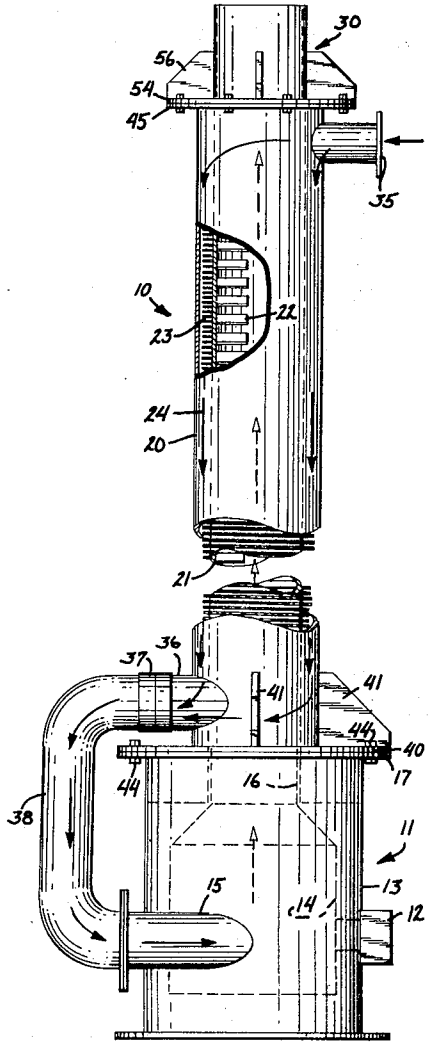


FIG. 1

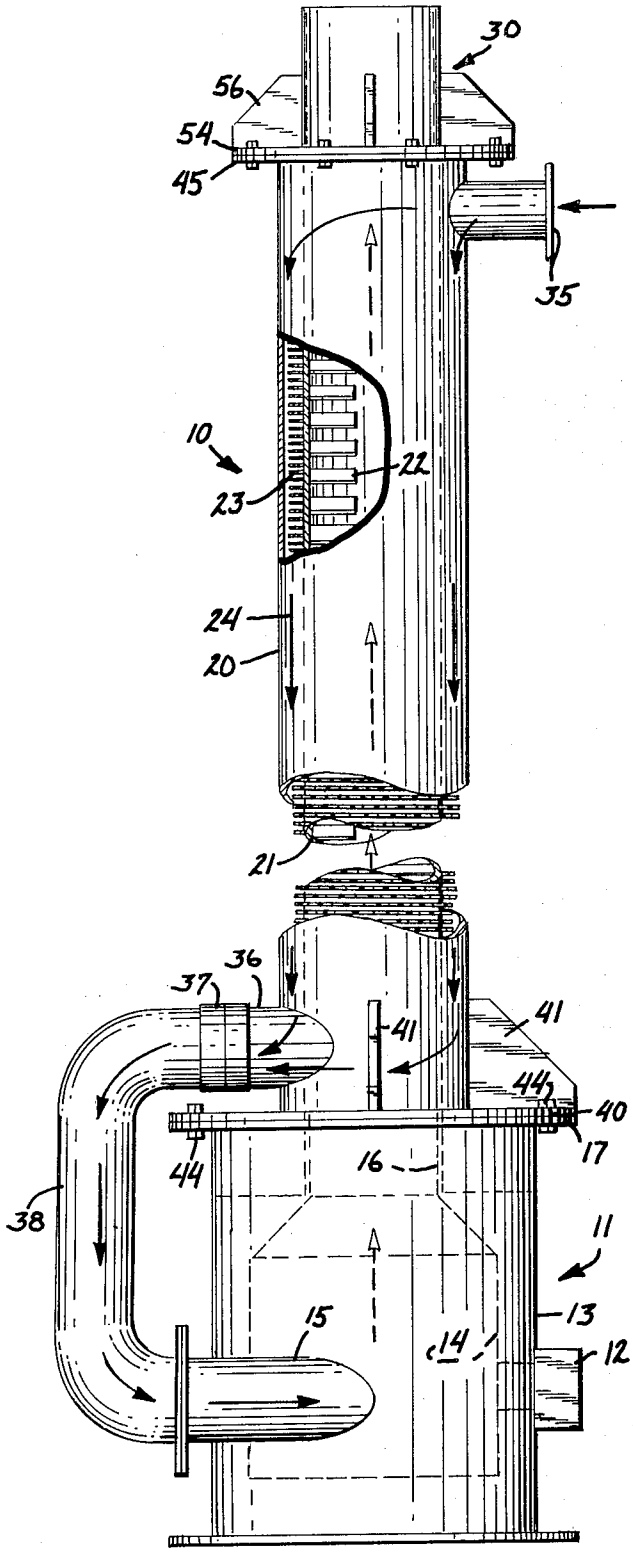


FIG. 3

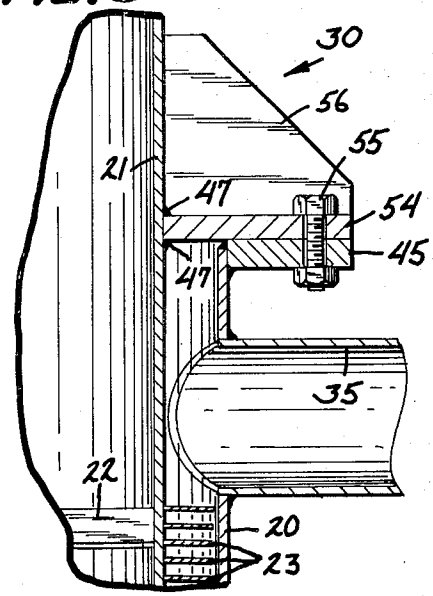
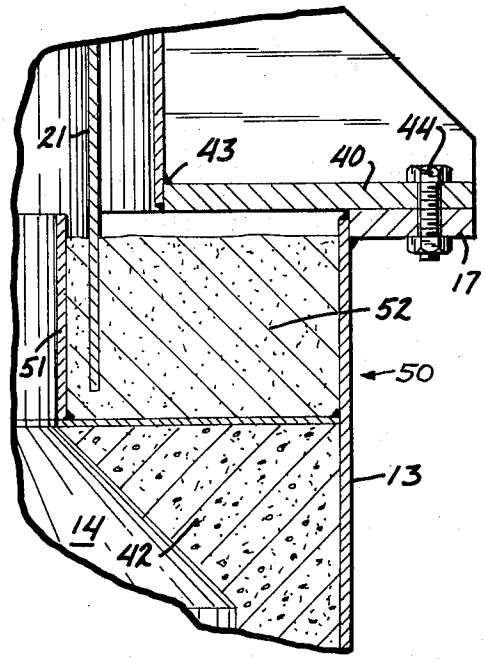


FIG. 4



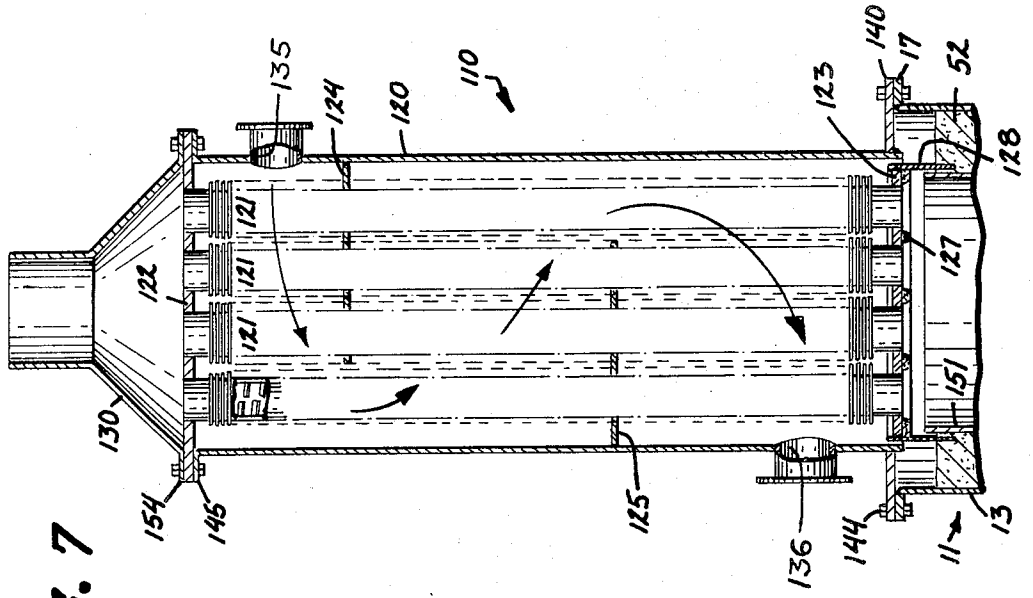


FIG. 7

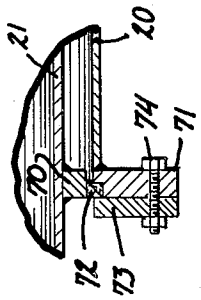


FIG. 6

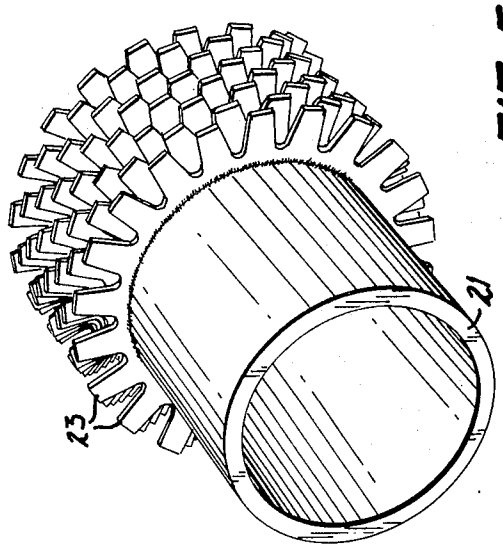


FIG. 2

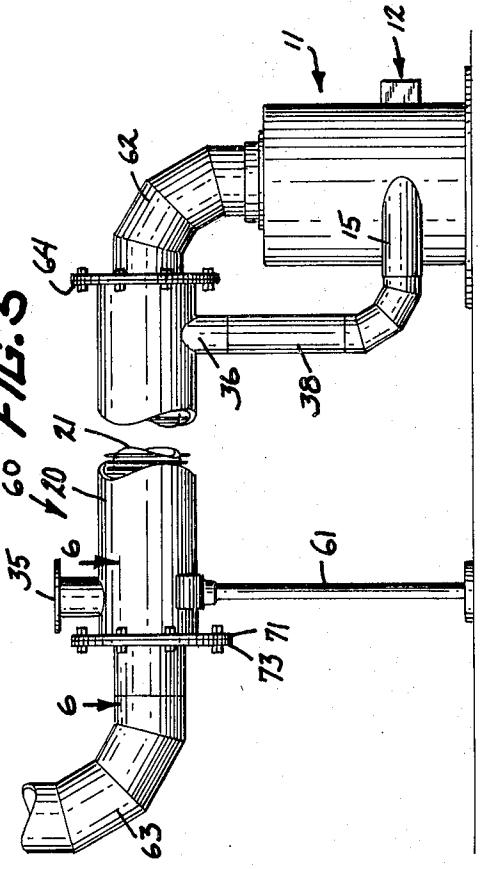


FIG. 5

RECUPERATORS FOR INCINERATORS

BACKGROUND OF THE INVENTION

This invention relates generally to the field of heat recuperators for incinerators, furnaces, and the like. More specifically, the present invention relates to a compact recuperator adapted for incorporation into an existing incinerator, requiring a minimum of modifications thereof.

Recuperators are widely used on furnaces in order to increase their efficiency and reduce fuel cost. Since the heat of the exhaust gases escaping out the chimney represents a loss, the recuperator is used to recover a good deal of this heat by using the exhaust gases to preheat the air being fed into the furnace. Less fuel is then required to heat the preheated air up to the operating temperature of the furnace. In the prior art, many different configurations have been used for recuperators. Many of these recuperators are very elaborate in design and are very expensive in construction, and this is especially true of recuperators designed for large furnaces, where the savings in fuel costs can be substantial. However, in medium sized and small sized furnaces or incinerators, recuperators are often not used because of the additional initial expense of the recuperator. Another stumbling block standing in the way of adding recuperators to existing incinerators is the fact that many prior art recuperators are integral with their furnaces, and would therefore require extensive modification to the incinerator for installation.

The increasing concern of the public over air pollution, and new, tighter laws governing factory emissions have placed new emphasis on the need for low cost and highly efficient recuperators for moderate sized incinerators. For example, certain industries such as paint and chemical industries are faced with the problem of disposal of noxious fumes or process air which are generated as a waste product, and which were formerly vented to the atmosphere. In many cases, buring of the fumes at high temperature is the only reasonable method of disposal. A low cost and highly efficient recuperator is necessary in order to keep costs down.

SUMMARY OF THE INVENTION

The present invention provides a recuperator for an incinerator which is both low in cost and very efficient in operation. Further, a recuperator according to the present invention can be added onto an existing incinerator with a minimum of modifications, or can be incorporated into new incinerators with a minimum of redesign.

According to the present invention there is provided a recuperator assembly for an incinerator, comprising an elongated generally cylindrical outer shell with one or more inner tubular members positioned within the outer shell and parallel therewith. The space between the inner tubular members and the outer shell defines a heating passage. The tubular member has a plurality of heat exchanging fins projecting both inside, and outside of the inner tube in the heating passage. The shell has an intake port at one end and an outlet port at the other. Means are provided for connecting the recuperator assembly to an incinerator. Means are provided for connecting the inner tubular member to receive exhaust gases from the incinerator, and further means are provided for connecting the outlet port to the air intake

of the incinerator, so that process air may be preheated by the exhaust gases prior to combustion.

In one embodiment, a single heat exchange tube is used, and the relationship in size between the heat exchange tube and the shell is such that the shell fits snuggly around the external fins of the heat exchange tube so that process air in the heating passage is forced around the fins for efficient heat transfer. In another embodiment, a plurality of heat exchange tubes are used, and are positioned in fixed relationship within the shell by a tube sheet. One or more baffles are positioned inside the shell to direct process air flow transversely of the heat exchange tubes in this embodiment.

In one method of mounting, a flange at one end of the shell is used for vertical support and attachment of the recuperator assembly on the top of an incinerator. In a horizontal method of mounting the frame supports one end of the recuperator assembly, while a supporting duct connects the other end to the recuperator.

DESCRIPTION OF THE DRAWINGS

In the drawing,

FIG. **1** is a side elevation of an incinerator and recuperator according to the present invention, with portions thereof broken away to illustrate certain features thereof;

FIG. **2** is a perspective view of a portion of a heat exchanger tube showing the external fin arrangement;

FIG. **3** is an enlarged fragmentary detail showing the means for positioning the heat exchange tube within the outer shell;

FIG. **4** is an enlarged fragmentary detail showing the means for connecting the recuperator assembly to the incinerator;

FIG. **5** is a side elevation view showing a horizontal positioning of a recuperator assembly according to the present invention;

FIG. **6** shows a detail of an expansion joint used in the horizontal mounting embodiment of FIG. **5**; and

FIG. **7** is a cross sectional view of a multi-tube recuperator according to the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

In FIG. **1**, reference numeral **10** generally designates a recuperator according to the present invention. Recuperator **10** is shown mounted upon an incinerator generally designated **11**. And exhaust stack (not shown) can be positioned on top of the recuperator.

The incinerator **11** comprises a housing **13** which defines an inner combustion chamber **14**. Intake **15** introduces fumes or process air into the combustion chamber, and the burned exhaust gases pass upward from the combustion chamber through exhaust flu **16**. Incinerator **11** also includes a burner assembly **12** for supplying fuel-air mixture to the combustion chamber, according to the particular design of the incinerator and the type of fuel which is intended to use. At the top of the housing **13** of incinerator **11**, is a mounting flange **17**.

Recuperator **10** comprises an outer shell **20** which forms the housing for the recuperator. Shell **20** is a generally elongated cylindrical steel tube. Positioned coaxially within shell **20** is an inner, heat exchange tube **21**. Since heat exchange tube **21** is in direct contact with the hot exhaust gases, it is preferably made from

chrome-moly steel. Heat exchange tube **20** has a plurality of heat exchange fins **22** welded to the inside thereof, and projecting inwardly. Tube **21** also has a plurality of heat exchange fins **23** welded to the outside thereof. The space between shell **20** and heat exchange tube **21** defines a heating passage, as indicated by flow arrow **24.** In the single tube embodiment, shown in FIG. **1,** heat exchange tube **21,** fins **23,** and shell **20** are sized so that shell **20** fits closely around fins **23.**

The external fin structure of the heat exchange tube is shown better in FIG. **2.** Fins **23** are made from a serrated strip which is spirally wound around and welded to the outer surface of tube **21.** The serrations or notches divide the strip into individual fins. The notches on succeeding turns of the spiral tend to align so as to form a maze of spiral and zigzag passages. Since the outer shell **20** fits snuggly around fins **23,** process air passing through the heating passage, in a generally longitudinal direction to the heat exchange tube, is forced into flow patterns which create maximum contact between the process air and fins **23,** thereby helping a maximize efficiency of heat transfer. Since the external fins are usually not subjected to high temperatures, the normal material for their construction is carbon steel. In the preferred embodiment, the external fins are approximately one-eighth inch thick by one and a half inch high.

Internal fins **22** are made of lengths of bar stock, which are welded to the inner wall of tube **21.** Fins **22** are welded at an angle and spaced in a spiral pattern so as to impart a spiral flow to the exhaust gases passing therethrough. This spiral flow ensures that maximum contact and heat transfer will be realized. Since the internal fins **22** are subjected to highest temperature and also to corrosion and errosion from the exhaust gases, they are preferably made of chrome-moly steel or stainless steel, depending upon the economics and life expectancy of the unit. In the preferred embodiment, internal fins **22** are approximately one-quarter inch by one inch by three inches.

Due to the plurality of internal fins **22,** recuperators according to the present invention are not intended for use with incinerators which put out large amounts of dirt or soot, because of the likelihood of fouling or plugging. Rather, recuperators according to the present invention are better adapted for use on incinerators for burning off process air or toxic fumes.

Referring again to FIG. **1,** an inlet port **35** is provided near the top of shell **20.** Near the bottom of shell **20** is an outlet port **36.** Air admitted to inlet port **35** travels down through the air passages as indicated by flow arrow **24** and exits at outlet port **36.** An intake duct **38** connects from port **36** to the incinerator intake **15.** An expansion joint is provided at **37** to allow for dimensional changes caused by heating. Shell **20** which is the outer housing of the recuperator is mounted to incinerator **11** by means of a flange **40,** and is supported by a plurality of vertical support braces **41.** The details of the mounting are shown more clearly in FIG. **4.** The inside of incinerator housing **13** is lined with a refractory material **42** for protection from the heat generated within the combustion chamber **14.** Annular flange **17** is welded to the top of housing **14.** Another annular flange **40** is welded to the bottom of shell **20,** at **43.** Flanges **17** and **40** are held together by bolt and nut assembly **44** at a plurality of locations around the circumference thereof. Brace **41** helps give the vertical support needed for the structure.

FIG. **4** also shows the details of the expansion seal generally indicated by reference numeral **50.** Member **51** in conjunction with the upper portion of incinerator housing **13** defines an annular channel around the top of the incinerator. The bottom of the heat exchange tube **21** extends loosely into this channel but is not attached to member **51,** so that it can expand when heated. The seal is a accomplished by a sand packing **52** which fills the channel including the space between member **51** and the bottom of heat exchange tube **21.**

As shown in FIGS. **1** and **3,** a cap **30** is provided at the top of shell **20** for fixing the positioning of heat exchange tube **21** and shell **20.** Cap **30** comprises a flange **54** and a plurality of braces **56.** Flange **54** is welded to heat exchange tube **21,** as shown at **47.** A flange **45** is welded to the top of shell **20.** A plurality of nut and bolt assemblies **55** hold flanges **54** and **45** together. Cap member **30** thus serves to fix the inner tube and outer shell in position with respect to each other. Since they are not fastened together at the bottom end, but rather are sealed by expansion seal **50,** the heat exchange tube can be removed by undoing bolt and nut assemblies **55** and lifting tube **21** out the top.

A preferred installation of the heat recuperator assembly of FIG. **1** would one in which a portion of the stack of an existing incinerator would be removed. The existing incinerator would then be equipped with a sand seal and flange as shown in FIG. **4,** for attaching the recuperator. If the incinerator is not strong enough it would of course be necessary to give additional support to the recuperator. A stack can then be attached to the top of heat exchange tube **21** which extends through the top of cap **30,** by any convenient means.

If space would not permit a vertical installation, a horizontal installation such as shown in FIG. **5** could be used. In FIG. **5,** a single tube recuperator assembly **60** is shown which is substantially identical to recuperator assembly **10** of FIG. **1.** For purposes of clarity, like elements are given the same reference numerals as in FIG. **1.** Horizontal mounting is accomplished through a frame **61** which supports one end of recuperator **60,** and a supporting duct **62** which connects the other end of recuperator **20** to incinerator **11.** Supporting duct **62** also functions to convey exhaust gases from the incinerator to the heat exchange tube **21.** An exhaust duct **63** at the other end of recuperator **60** conveys exhaust gases to a stack (not shown). Because it is not feasible to use a sand expansion seal in the horizontal arrangement, an alternate expansion packing seal is used. In the embodiment of FIG. **5,** heat exchange tube **21** and shell **20** are fixed together by an internal extension of flange **64,** in a manner similar to that shown in FIG. **3.** The expansion seal is used at the other end of the recuperator, as shown in FIG. **6,** which is taken along lines **6—6** in FIG. **5.**

In FIG. **6,** heat exchange tube **21** has an annular bar which may be welded into place. A flange **71** is welded to the end of shell **20.** Flange **71** has an annular groove **72** in which is placed the expansion packing, which may be asbestos-graphite material. A retainer ring **73** is fixed to flange **71** by nut and bolt assemblies **74.** The seal is provided by annular bar **70** and the expansion packing, which also allows for expansion due to differential heating of the members.

In FIG. 7, reference numeral **110** generally designates a multiple tube recuperator assembly according to the present invention. Recuperator **110** comprises a shell member **120** which is similar to shell **20** of the embodiment of FIG. **1.** A plurality of heat exchange tubes **121** are positioned within shell **120** and aligned generally parallel therewith. Heat exchange tubes **121** have internal and external fins and may be identical to heat exchange tube **21** of FIG. **1.** Heat exchange tubes **121** are positioned into a bundle by upper tube sheet **122** and lower tube sheet **123.** These tube sheets have a plurality of apertures for receiving and holding the ends of heat exchange tubes **121,** which may be welded in place. Although only four heat exchange tubes are shown in FIG. **7,** it will be understood that any number could be used and that any convenient arrangement such as a circular or rectangular pattern could be used. A pair of baffles **124** and **125** are positioned within shell **120** around heat exchange tubes **121,** thereby forcing process air entering inlet port **135** to flow generally transversely of the heat exchange tubes and out outlet port **136.** In use, ducts are provided for conveying the process air to port **135,** and for conveying the heated process air from port **136** to the intake of the incinerator.

The entire assembly of heat exchange tubes **121,** baffles **124** and **125** and upper and lower tube sheets **122** and **123** are fixed in position within shell **120** at the upper end. A flange **145** is welded around the top of shell **120.** A cap member **130** has a matching flange **154.** Tube sheet **122** extends between the two flanges and is bolted in place by a plurality of bolt assemblies. The tubes can therefore be removed by removal of cap **130** and lifting the tube assembly out through the top. A sand expansion seal similar to the one shown in FIG. **4** is provided at the lower end of the recuperator. A member **151** and the outer wall **13** of the incinerator cooperate to define a channel. A skirt **128** is welded around tube sheet **123,** and extends downwardly into the channel. Sand packing **52** fills the channel to make the seal. A flange **140** is welded around the end of shell **120,** to match with flange **17** at the top of incinerator **11.** A plurality of bolt assemblies **144** connect the recuperator assembly to the incinerator. The bottom side of tube sheet **123** is covered with a refractory material **127,** leaving holes aligned with heat exchange tubes **121** for passage of exhaust gases. The refractory material protects the tube sheet from the high temperatures developed in the combustion chamber.

The use of fins on both surfaces of the heat exchange tube, together with the compact configuration as illustrated in the foregoing paragraphs and drawings, results in a highly efficient and low cost recuperator.

I claim:

1. A recuperator assembly adapted for adding on to an existing incinerator between the main housing and exhaust stack thereof for preheating process air to be burned therein comprising:

a. a generally cylindrical elongated shell;

b. means attached to the bottom end of said shell for mounting said shell in vertical position on the main housing of the incinerator over the exhaust flu thereof;

c. a heat exchange tube having internal and external fins, said internal fins arranged and configured to impart a swirling flow to gases passing through said heat exchange tube;

d. means attached to the top end of said shell for mounting said heat exchange tube coaxially within said shell in alignment with the exhaust flue, the inside diameter of said shell being slightly larger than the outside diameter of said heat exchange tube plus fins, to define a heating passage therebetween;

e. means defining a sand expansion seal around the bottom of said shell and heat exchange tube;

f. a process air inlet port in said shell near the top end thereof;

g. a process air outlet port in said shell near the bottom end thereof; and

h. means for conducting the preheated process air from said outlet port to the intake of the incinerator.

* * * * *