United States Patent [19]

Cooper

[11] **3,731,738**

[45] **May 8, 1973**

[54] **TUBE FINS OF OUTWARDLY-ORGANIZED MATERIALS**

[76] Inventor: **Herbert Wyane Cooper,** 17 St. Lawrence Place, Jericho, N.Y.

[22] Filed: **July 26, 1971**

[21] Appl. No.: **165,945**

[52] **U.S. Cl.** **165/180,** 263/20, 29/196.1, 29/196.6

[51] **Int. Cl.** **F28f 21/02**

[58] **Field of Search**.....29/196.1, 191, 196.6; 165/180–183, 186, 133, 180.1; 122/367 C; 263/20

[56] **References Cited**

UNITED STATES PATENTS

2,464,735	3/1949	Vanderweil	165/180
3,393,445	7/1968	Ulam	29/196.1 X
1,802,695	4/1931	Bennett	29/196.6

Primary Examiner—Charles J. Myhre
Assistant Examiner—Theophil W. Streule, Jr.
Attorney—Charles E. Baxley

[57] **ABSTRACT**

This disclosure teaches a finned tube (or studded tube or the like) for convection sections of process heaters or boilers to improve heat transfer and reduce pressure drops of both process streams and flue gas. Tubes in this service are preferably of carbon steel which is, within this context, a relatively-high heat-conducting but relatively-low heat-resisting material. The finned tube is made of at least two materials organized proximally and distally relative the tube wall to which it is connected and from which it projects outwardly. The distal portion is made of a relatively-high heat-resisting but relatively-low heat-conducting material such as stainless steel. The proximal portion may be of a material the same as that of the tube wall or it may be of a material with heat-conducting and heat-resisting properties intermediate those of the tube wall and of the distal portion.

7 Claims, 4 Drawing Figures

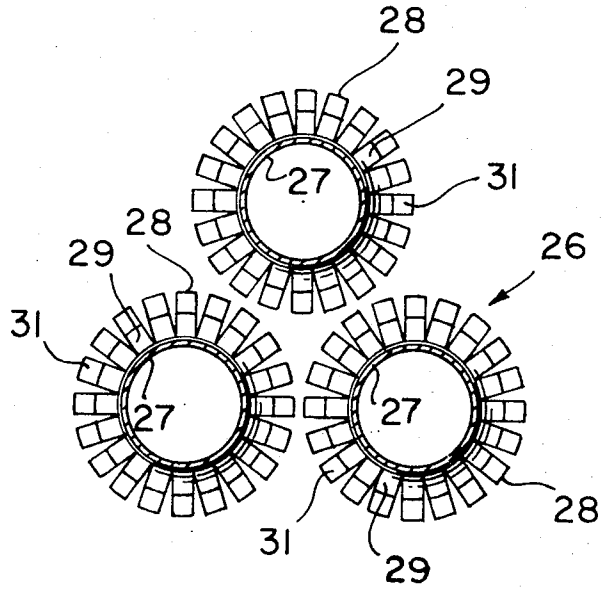
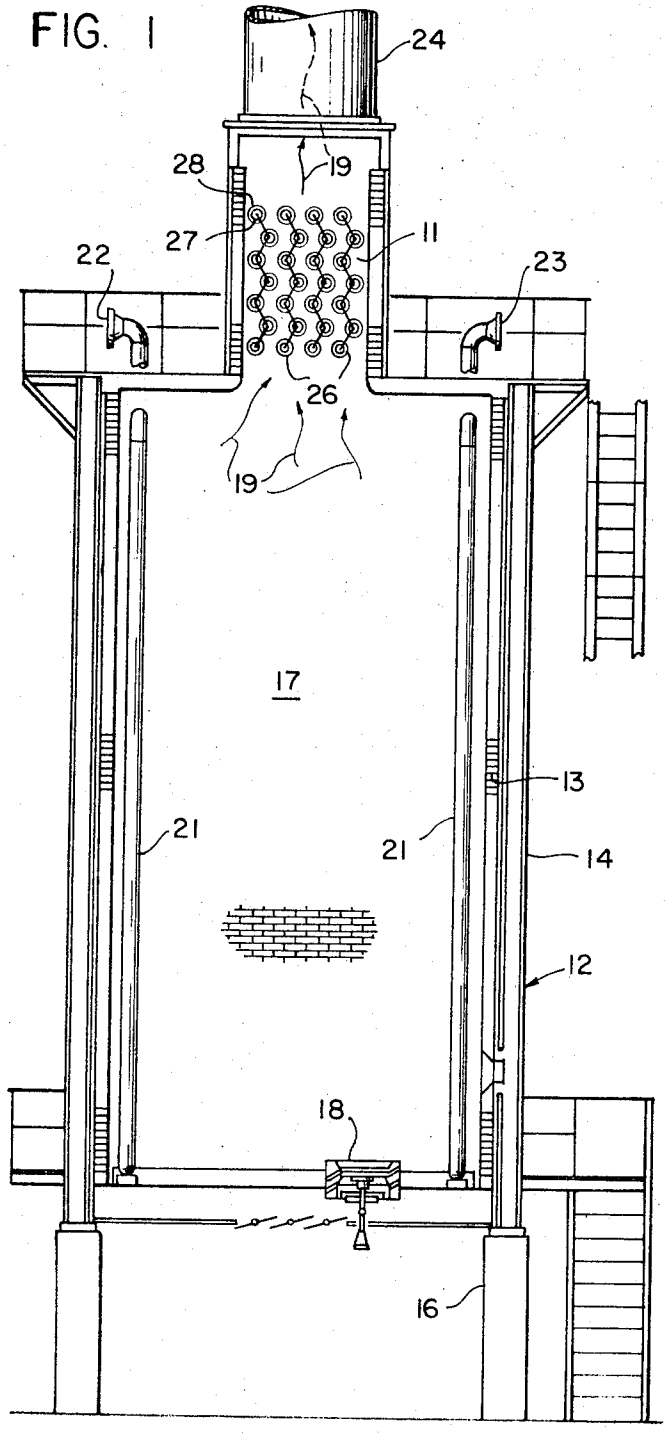


FIG. 1



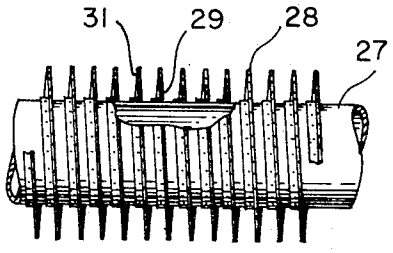


FIG. 3

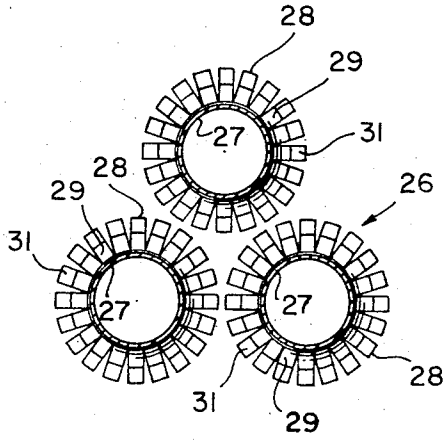


FIG. 2

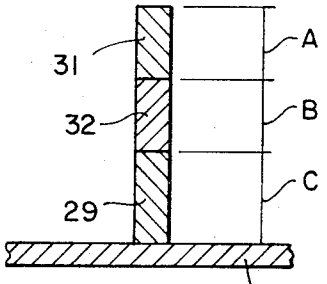


FIG. 4

INVENTOR.
HERBERT W. COOPER

TUBE FINS OF OUTWARDLY-ORGANIZED MATERIALS

BACKGROUND OF THE INVENTION

In designing a convection section for a process heater or a boiler, desirable size of the convection section and allowable pressure drops make finned tubes attractive. The fins offer added heat transfer surface thereby reducing the number of tubes necessary for a given service and consequently reducing pressure drop of flue gas passing thereacross. The reduced number of tubes and related bends also reduce the pressure drop of the process stream passing therethrough. However, when a relatively-high temperature of flue gas is encountered, a problem arises of excessive heating and consequent physical deterioration of fin tips whose temperatures rise to substantially hotter levels than those of the tube walls to which they are attached.

One approach posed for solution of this problem has been to make tubes of a relatively-high heat-conducting but relatively-low heat-resisting material (such as carbon steel) while making the fins of a relatively-high heat-resisting material (such as stainless steel). However, this approach is limited by the fact that the relatively-high heat-resisting materials (including stainless steel) lack high heat-conducting capacity.

Another approach posed for solution of this problem has been to reduce height and/or adjust other geometric proportions of the fins, but that approach generally augers against heat transfer capacity and is counter productive to overall design results.

Accordingly there are numerous instances wherein furnace and/or boiler designers find it desirable to use finned tubes in applications where there is a high flue gas temperature, but they have been frustrated in this endeavor. Thus the matter has persisted for decades.

BRIEF STATEMENT OF INVENTION

Doctor Cooper has solved the foregoing problem by a novel, inventive and particularly facile approach. He has developed a finned tube with the fin having at least two materials arranged proximally and distally relative the tube wall to which it is attached and from which it projects outwardly. By making only the distal portion of the fin of a relatively-high heat-resisting but relatively-low heat-conducting material (such as stainless steel) the tube wall can be a relatively-high heat-conducting but relatively-low heat-resisting material (such as carbon steel). The proximal portion of the fin may be of the same material as that of the tube wall or it may be of a material intermediate between that of the tube wall and that of the distal portion in heat-conducting and heat-resisting properties. Therefore, one object of this invention (inter alia) is to increase heat transfer of convection tubes.

Another object of this invention is to increase the useful life of fins on convection tubes and prevent their deterioration.

Still another object of this invention is to reduce the number of tubes required in a convection section.

Still another object of this invention is to reduce the pressure drop of a flue gas in a convection section.

Still another object of this invention is to reduce the pressure drop in the process stream passing through the tube.

Still another object of this invention is to reduce the size of a convection section.

Still another object of this invention is to provide finned tubes which are simple and inexpensive to manufacture as well as capable otherwise of serving their intended functions.

BRIEF DESCRIPTION OF DRAWINGS

Other features and advantages will be understood from the following detailed description of preferred embodiments of the invention viewed in conjunction with the accompanying drawing wherein like numerals denote like parts and wherein:

FIG. 1 is an illustrative process heater embodying the present invention.

FIG. 2 is a cross section of finned tubes according to one embodiment of the present invention.

FIG. 3 is a partially broken longitudinal view of a finned tube according to the embodiment of FIG. 2.

FIG. 4 depicts a somewhat idealized tube wall and fin assembly referred to in the example and having the fin made of one, two or three different materials.

DESCRIPTION OF PREFERRED EMBODIMENTS

The invention pertains particularly to a convection section **11** of a process heater or boiler **12** illustrated typically as a process heater in FIG. 1. Process heater **12** is comprised of a refractory setting **13** supported by structural frame **14** mounted in turn on piers **16**. Setting **13** embraces radiation chamber **17** into which burner **18** penetrates for delivery of fuel and combustion-supporting air to produce hot flue gas generally designated **19**. Radiant tubes **21** with inlet **22** and outlet **23** are disposed in radiation chamber **17** for heat absorbtion predominantly by means of a radiant transfer mechanism. Flue gas **19** exits to stack **24** via convection section **11** in which convection tubes **26** are mounted for heat absorbtion predominantly by means of convective transfer.

As seen in FIGS. **2** and **3**, finned tubes **26** include tube walls **27** with fins **28** connected thereto (usually by welding) and projecting outwardly therefrom. Fins **28** have proximal portions **29** adjacent tube walls **27** and distal portions **31** remote therefrom. Fins **28** of FIG. **2** are serrated and wrapped helically about cylindrical tube walls **27**. It will be understood that fins **28** need not be serrated, nor need they be wound helically. Fins **28** could likewise be in the form of studs or otherwise within the context of this disclosure.

According to the teaching of this invention, tube walls **27** and proximal portions **29** are made preferably of carbon steel or a like relatively-high heat-conducting and relatively-low heat-resisting material. Of course, modified low carbon steels, such as United States Steel Company's Cor-Ten A which is similar to carbon steel but has better corrosion resistance, are contemplated here along with carbon steel. The composition of Core-Ten A is as follows:

Element	Percentage by weight
Carbon	0.12 – max.
Manganese	0.2 – 0.5
Phosphorous	0.07 – 0.15
Sulfur	0.05 – max.
Silicon	0.25 – 0.75
Copper	0.25 – 0.55
Chromium	0.30 – 1.25
Nickel	0.65 – max.
Iron	bal.

Also according to the teaching of this invention, distal portions **31** are made of a relatively-low heat-conducting and relatively-high heat-resisting material such as stainless steel, preferably with one of the compositions set forth in Table I. As shown in FIG. **4**, a second proximal portion **32** may also be included.

TABLE I

Nominal Compositions of Stainless Steels

Intermediate Alloys:

	Weight Percent						
	Cr	Ni	C max.	Mn max.	Si max.	Mo	Fe
SS 410	11.5–13.5		0.15	1.0	1.0		bal.
SS 430	14 – 18		0.12	1.0	1.0		bal.
E2 (Crucible Steel Company)	10.5–11.75	0.5	0.08	1.0	1.0		bal.

High Alloys:

	Weight Percent						
	Cr	Ni	C max.	Mn max.	Si max.	Mo	Fe
SS 304	16 – 20	8 – 11	0.08	2.0	1.0		bal.
SS 316	16 – 18	10 – 14	0.08	2.0	1.0	2–3	bal.

Thermal conductivities and temperature limits of various materials are set forth in Table II.

TABLE II

Thermal Conductivities

and

Temperature Limits

Metal	Thermal Conductivity (BTU/Hr.Ft. °F.)	Maximum Temperature (°F.)
Carbon Steel	24.1	900
Cor-Ten A	24.1	900
410 SS	16.5	1100
430 SS	13.5	1100
E2 (Crucible Steel Company)	16.5	1200
304 SS	12.6	1500
316 SS	12.6	1500

EXAMPLE

A finned tube was placed in a flue gas stream of 1,600°F., flowing at a rate such as to give a heat-transfer coefficient of 6 BTU/Hr - Sq Ft - F°. The tube metal was maintained at 745°F. Each fin was 1.50 inches high (total), 0.05 inches thick, and had a segment width of 0.25 inches. The maximum allowable fin metal temperatures were as follows:

SS 304	1500°F.
11% Chrome alloy	1100°F.
Carbon steel	900°F.

It was found that fin tip temperatures were appreciably lower, and the amount of heat transferred was higher in multi-metal fins than in a fin consisting of only No. 304 stainless steel.

The dimensions A, B and C in inches per FIG. **4** were as follows with A No. 304 stainless steel, B 11% chrome alloy and C carbon steel.

Case	A	B	C
1	1.500	0.0	0.0
2	1.025	0.475	0.0
3	1.250	0.0	0.250
4	0.925	0.325	0.250

Tip temperatures and heat transfers were as follows:

Case	Tip Temperature (°F.)	Heat Transfer (BTU/Hr/Fin)
1	1365.0	15.22
2	1344.5	16.28
3	1333.5	17.10
4	1320.0	17.61

It will be understood by those skilled in the design of convection sections and in heat transfer that wide deviations may be made from the foregoing preferred embodiments without departing from the main theme of invention set forth in the claims which follow.

I claim:

1. A heat-transfer tube, for use in a convection section of a process heater or boiler and arrangeable therein for passage of a fluid therethrough in noncontact heat-exchange relationship with a relatively-hot gas having a temperature of from 1000° to 2000°F., and characterized by:

a tube wall provided with at least one fin connected thereto and projecting outwardly therefrom;

the fin having a proximal portion integrally secured to the tube wall and a distal portion remote from the tube wall;

the distal portion continuous from the proximal portion and joined integrally thereto;

the tube wall and the proximal portion made of low carbon steel;

the distal portion made of a material selected from a group consisting of No. 410, No. 430, E2, No. 304 and No. 316 stainless steels.

2. The tube of claim **1** with the distal portion made of No. 410 stainless steel.

3. The tube of claim **1** with the distal portion made of No. 430 stainless steel.

4. The tube of claim **1** with the distal portion made of E2 stainless steel.

5. The tube of claim **1** with the distal portion made of No. 304 stainless steel.

6. The tube of claim **1** with the distal portion made of No. 316 stainless steel.

7. The tube of claim **1** with the proximal portion made of a material having heat-conducting and heat-resisting properties each intermediate those of the tube wall and the distal portion.

* * * * *