

Oct. 28, 1930.

C. B. GRADY

1,779,538

HEAT EXCHANGER

Filed Jan. 24, 1927

5 Sheets-Sheet 1

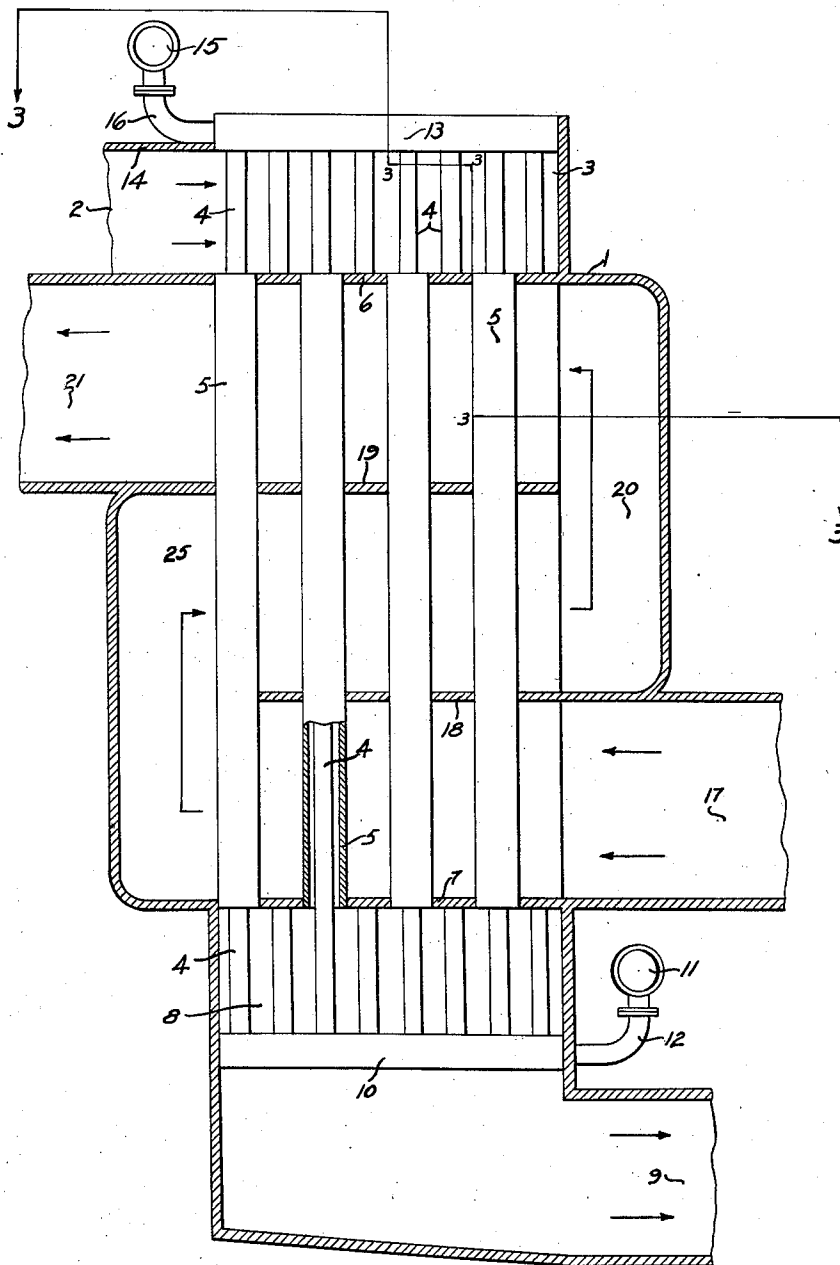


Fig. 1.

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5 Sheets-Sheet 2

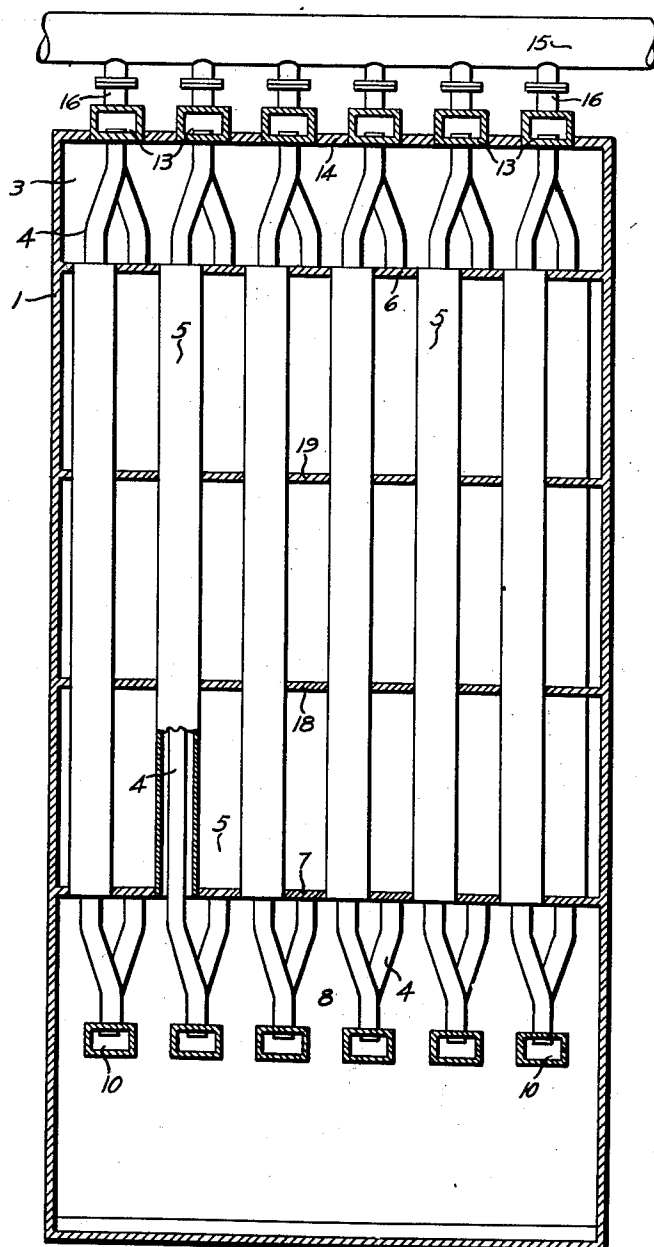


Fig. 2.

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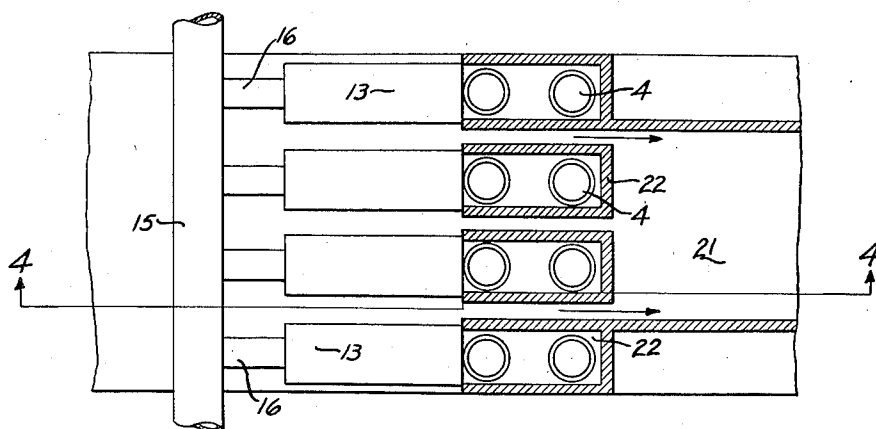
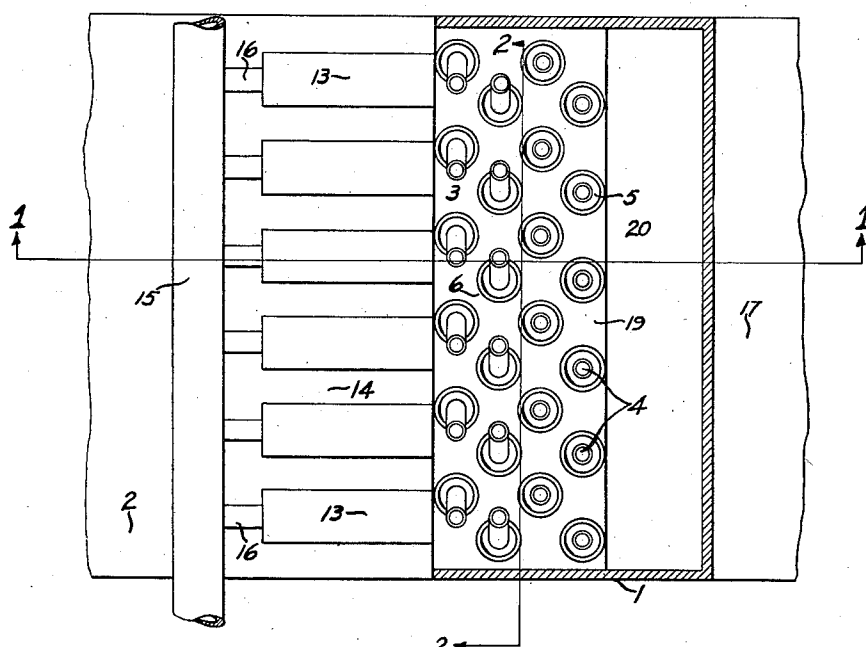
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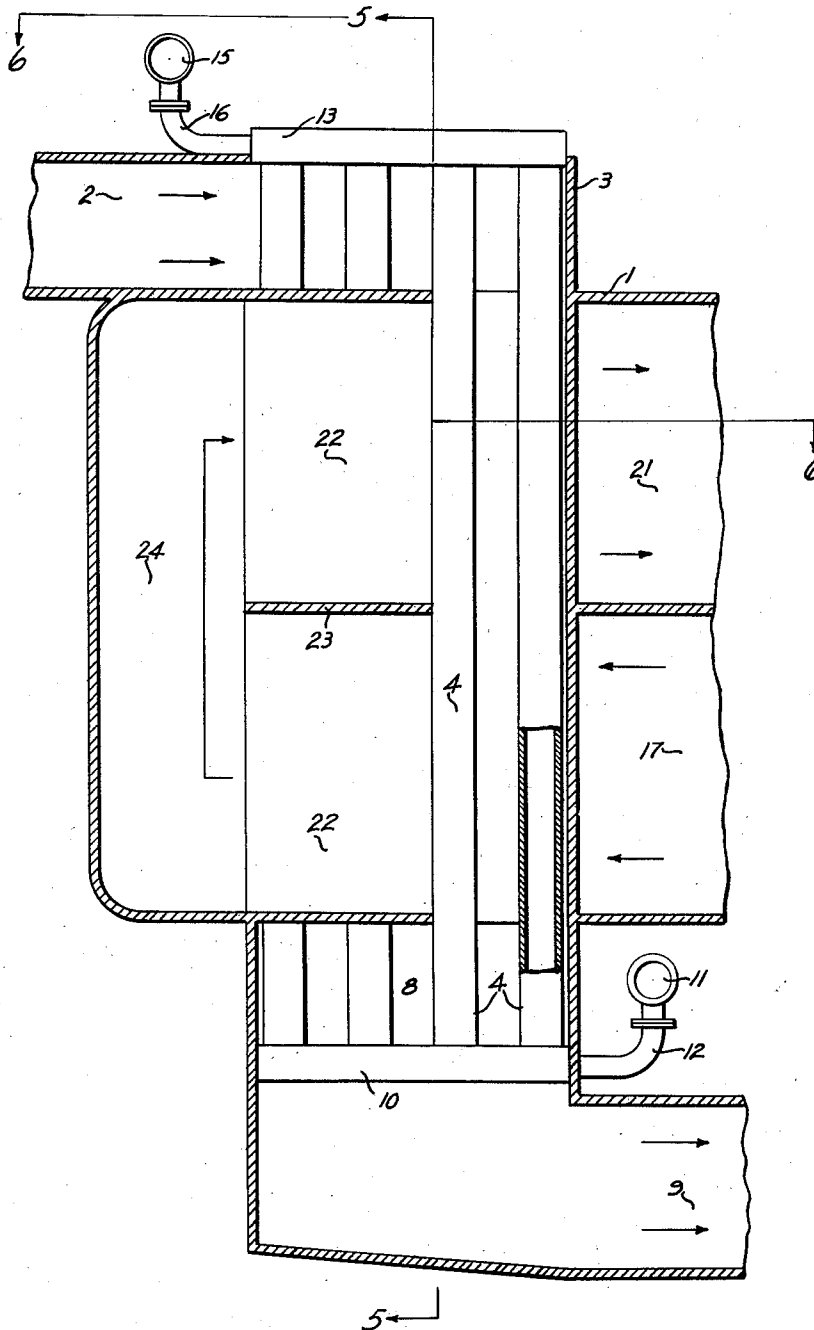


Fig. 4.

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1,779,538

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Filed Jan. 24, 1927

5 Sheets-Sheet 5

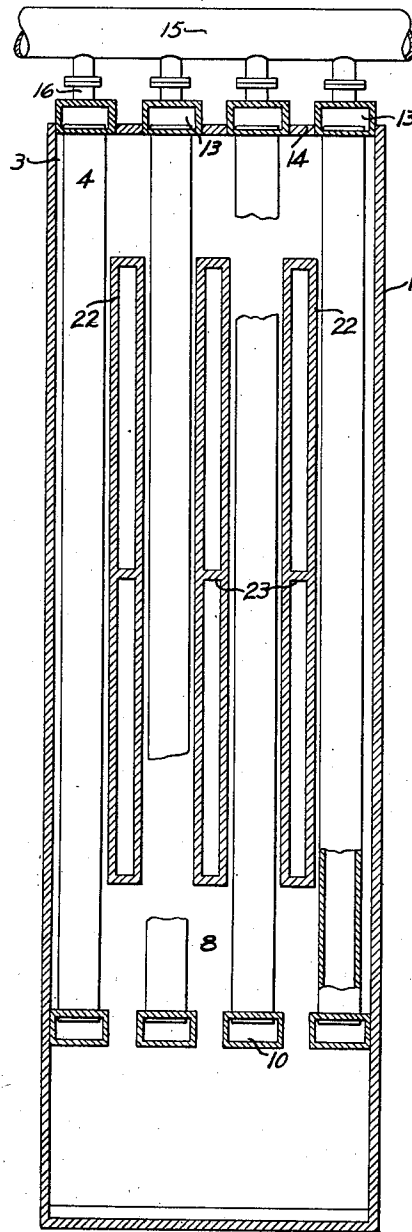


Fig. 5.

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UNITED STATES PATENT OFFICE

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HEAT EXCHANGER

Application filed January 24, 1927. Serial No. 163,065.

This invention relates to heat exchangers and, more particularly to a method and apparatus for effecting a transfer of heat to both a gas, and liquid or vapor, from a hot fluid medium, usually gaseous; and has for its object the provision of certain improvements whereby these results can be accomplished in a unitary structure, with a high rate and efficiency of heat transfer, low resistance to the flow of gaseous media and natural circulation of the liquid to be heated.

In accordance with my invention, heat is extracted usually from the waste gaseous products of combustion and utilized for the purpose of preheating combustion air and either to make steam, heat feedwater, or distill oil, and for kindred uses more specifically referred to hereinafter.

In general, the apparatus comprises a housing formed of boiler plate or similar material, provided with separate passageways for the three media passing through it. In the preferred embodiment of my invention, hot waste gases of combustion enter the housing through a conduit in the upper portion and pass around boiler tubing arranged in a preliminary heat absorbing chamber. The tubing is preferably arranged vertically in order to provide for natural circulation of the liquid or vapor contained therein and to prevent the formation of steam pockets. The hot gases first pass transversely of the hottest portion of the tubes and are then divided and directed around and along the tubes through vertically arranged ducts surrounding one or a plurality of tubes. For operation with low and medium temperature waste gas, metal ducts will be employed but if relatively high temperature waste gases are available from metallurgical furnaces or the like, I prefer to construct the ducts of material having a high fusion temperature and high heat conductivity such as carborundum or other refractory material capable of transmitting radiant heat. Although one such duct may surround an entire row or bank of tubes, I prefer to surround each tube with a duct of circular cross section positioned concentrically with respect to the axis of the tube. The waste gases discharge from the ducts into a collect-

ing and final heat absorbing chamber where they again pass along and across the tubes and are finally discharged from the apparatus through a conduit leading to the exhaust fan or stack.

Air to be preheated for combustion purposes, or other gas to be heated is forced or drawn through a conduit and into the apparatus immediately above the lower or collecting chamber and passes transversely around the ducts at least once and preferably two or more times in order to increase the temperature and to render the heating uniform.

In accordance with my method, the temperature of the liquid in the tubes may be controlled by varying the velocity of the air or other gas flowing in contact with the walls of the ducts for example; if the air flow is increased the walls of the ducts will be cooled more rapidly and less heat will be transferred to the tubes. This control may be accomplished manually or automatically by means of thermostats connected in circuit with the fan motor control or dampers in the air conduits, and the liquid or vapor temperature thus maintained at any predetermined degree.

For purposes of compactness and to increase the surface exposed to the hot gases, the liquid carrying tubes are preferably so arranged in rows that one header at the top and one at the bottom will accommodate two rows. The headers are positioned half-way between rows and the tubes bent inwardly and expanded into the headers along the center lines thereof. The lower headers are connected to a cross header into which the liquid to be heated is admitted and the upper headers likewise open into a cross header for collecting the heated liquid or vapor.

The hot gases entering the apparatus come into contact with the hottest portion of the tubing at their highest temperature whereby advantage of this temperature may be taken either to make steam, increase steam temperature, vaporize oil, or as an alternative, to permit a rapid flow of a large volume of liquid to be preheated such as boiler feedwater or oil passing to a still. The waste gases in passing along the tubes in the ducts

above referred to are gradually cooled by transferring a portion of their heat to the tubes and a portion to the walls of the ducts around which the air to be preheated is passed, the relative quantities of heat transferred to ducts and tube walls being dependent upon the respective areas of the walls of the ducts and tubes. By varying the areas of the duct with respect to the tubes the quantities of heat transferred to either medium can be varied to suit the requirements of the installation. In order that an efficient transfer of heat to the air and liquid can be effected, and to obtain desired temperatures in both media, the air first passes around the lower, cooler portion of the ducts and is discharged from the hottest portion; the liquid first enters the coolest portion of the apparatus, the collecting and final heat adsorbing chamber, and it follows that in the upper portion of the apparatus the liquid, air and waste gas will be at their highest temperatures, the heat transfer to liquid being counterflow and to the air substantially counterflow. In all cases the transfer of heat is effected by direct conduction through thin walls and for this reason the transfer of heat is substantially direct.

The heat exchanger is applicable for use as a combined air heater and economizer suitable for steam boilers, and particularly for boilers having relatively little convection surface, and in this case the tube surface exposed in the preliminary heat absorbing chamber will function similarly to a boiler pass, feedwater may be heated in the tubing and the preheated air used for combustion purposes. It may also be used as a waste heat boiler, hot gases of combustion being taken from a cement kiln, oil still, metallurgical furnace or the like and the preheated air being used for combustion purposes. If the apparatus is to be used as a waste heat boiler, the lower cross header will function as a collecting or mud drum and the upper cross header as the steam drum. Its application to the distillation of oils is similar to its use as an air heater and economizer, and in this case the oil will be forced through the tube, the air used for combustion purposes in the still, or if the waste gas temperature is sufficiently high, distillation may take place in the tube and the distillate taken from the upper cross header, or if desired, the apparatus may be used to reboil the oil, and control the temperature of the oil as heretofore stated.

These and other features of the invention will be more clearly apparent by reference to the following description and accompanying drawings, in which:

Fig. 1 is a vertical, longitudinal section of the heat exchanger, taken on line 1—1 of Fig. 3,

Fig. 2 is a vertical cross section on line 2—2 of Fig. 3,

Fig. 3 is a sectional plan taken on line 3—3 of Fig. 1,

Fig. 4 is a sectional plan of a modified form of the heat exchanger taken on line 4—4 of Fig. 6.

Fig. 5 is a vertical cross section taken on line 5—5 of Fig. 4, and

Fig. 6 is a sectional plan taken on line 6—6 of Fig. 4.

Referring to the drawings, and particularly to Figs. 1, 2 and 3, the apparatus is seen to consist of a housing 1, made of boiler plate or similar material, into which hot waste gases or other fluid media are drawn or forced through a conduit 2 into a preliminary heat absorbing chamber 3. In the preliminary heat absorbing chamber, the gases pass transversely of the tubes 4, which may be of boiler tubing, and are then divided and passed into ducts 5. Ducts 5 may be made of metal and expanded into the tube sheet 6 which forms the bottom wall of the preliminary heat absorbing chamber. If high temperature gases are employed, such as the waste gaseous products of certain metallurgical processes, the ducts may be made of refractory tubing of high heat conductivity and high fusion temperature such as carborundum. The gases then pass downwardly within the ducts around and along the tubes 4 transferring a part of their heat to the walls of the ducts and tubes, the relative quantity of heat so transferred being governed by the relative area of the walls of the tubes and ducts. The lower ends of the ducts 5 are expanded into tube sheet 7, which forms the upper wall of the collecting chamber 8 in which the gases again pass around the lower ends of the tubes 4 and are finally discharged through the exhaust conduit 9 leading to the exhaust fan or stack.

In the lower or collecting chamber 8, the lower ends of each two rows of tubes are bent inwardly, as shown in Fig. 2, and are expanded into headers 10, each header being positioned half-way between the two rows connected to it.

The headers 10 are connected to the inlet or cross header 11 by means of the elbows 12. If space permits these headers may be extended and expanded directly in the cross header 11.

In the preliminary heat absorbing chamber 3, the upper ends of the tubes 4 are likewise bent and are expanded into headers 13 so arranged that their under surfaces are exposed within the preliminary heat absorbing chamber and set flush with the under surface of the plate 14. This arrangement of tubes and headers decreases the resistance to flow of the waste gases and presents a greater exposure of heat absorbing surface. The headers 13 are connected to the upper cross

header 15 by means of elbows 16, cross header 15 serving to collect the heated fluid or vapor.

Air, or other gas to be preheated, enters the apparatus through the conduit 17, usually under fan pressure, and passes transversely of the lower portion of the ducts 5 and under baffle 18, then into chamber 25 which serves as a return bend to direct the air again around and past the ducts between baffles 18 and 19 and into chamber 20, which also serves as a return bend to direct the air transversely of the hottest portion of the ducts and between the baffle 19 and the tube sheet 6; the air finally discharging from the apparatus through the exhaust conduit 21 leading to the furnace. The number of baffles or other devices used to direct the air in transverse passes is dependent upon the temperature and volume of preheated air necessary to meet the requirements of the specific installations.

In Figs. 4, 5 and 6, I have shown a modified and more simple construction in which the resistance to flow of the waste gases and air is somewhat decreased, but the effective area of heat absorbing surface is less than in the preferred form. In the modified form of the apparatus the ducts 22, which correspond to the ducts 5, are of rectangular cross section and surround a plurality of the tubes 4, for instance an entire row as in the embodiment shown. The liquid carrying tubes 4 are straight and each row is expanded into the lower header 10 and upper header 13. Although I have shown but one horizontal baffle 23 and one return bend or chamber 24, it is to be understood that two or more may be used, or those shown may be omitted entirely, depending upon the degree of preheat desired. The operation of the apparatus as either an air heater and economizer, waste heat boiler and air heater, oil heater and oil still and air heater will be apparent from the foregoing description, but it is to be understood that various media other than those suggested may be circulated through it, and that waste heat may be extracted from hot vapors with condensation taking place in the ducts.

It is also to be understood that various modified constructions may be made within the scope of the invention as defined in the claims appended hereto, such as for example changes in the relative location of the various conduits and ducts and the entrance and exit sides for the various media circulated through the apparatus.

I claim:

1. A heat exchanger for transferring heat from a hot fluid medium to a liquid and a gas comprising a housing, an inlet conduit for the hot medium opening into a chamber in the housing, a plurality of ducts serving as passageways for the medium opening into the chamber and also into a second chamber

for collecting the medium, liquid carrying tubes arranged within the ducts, and means for causing the gas to flow in contact with the outer walls of the ducts and in a series of passes, in each of which the gas flows transverse to the axes of the ducts in a succession of passes in which the gas flows transverse to the axes of the ducts.

2. A heat exchanger for transferring heat from a hot gas to a liquid and a gas comprising a housing, a preliminary heat absorbing chamber in the upper portion of the housing, means for admitting the hot gas to the chamber, a plurality of ducts for dividing and directing the gas downwardly into a collecting chamber below the aforesaid chamber, a plurality of liquid carrying tubes arranged vertically within the ducts, the lower ends of the tubes being connected to headers connected to a cross header to which the liquid is admitted, the upper ends of the tubes terminating in headers connected to a cross header for collecting the heated liquid or vapor, means for directing the gas to be heated transversely of and in contact with the outer walls of the ducts adjacent to the lower ends thereof, means for returning and again directing the gas transversely of the outer walls of the ducts above the first named directing means, and means for discharging the gas from the housing adjacent to the upper ends of the ducts.

3. A heat exchanger for transferring heat from a hot gas to a liquid and a gas comprising in combination a housing, means for admitting the hot gas to the housing, a plurality of vertically arranged ducts within the housing, the ducts being of circular cross section, liquid carrying tubes positioned concentrically within the ducts the tubes being arranged in rows, the ends of each two rows being bent inwardly and connected to a common upper header and a common lower header, the headers being positioned half-way between rows, and means for directing the gas to be heated transversely of the outer walls of the ducts.

In testimony whereof, I affix my signature.
CHARLES B. GRADY.