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PROCESS OF AND APPARATUS FOR TRANSFERRING HEAT

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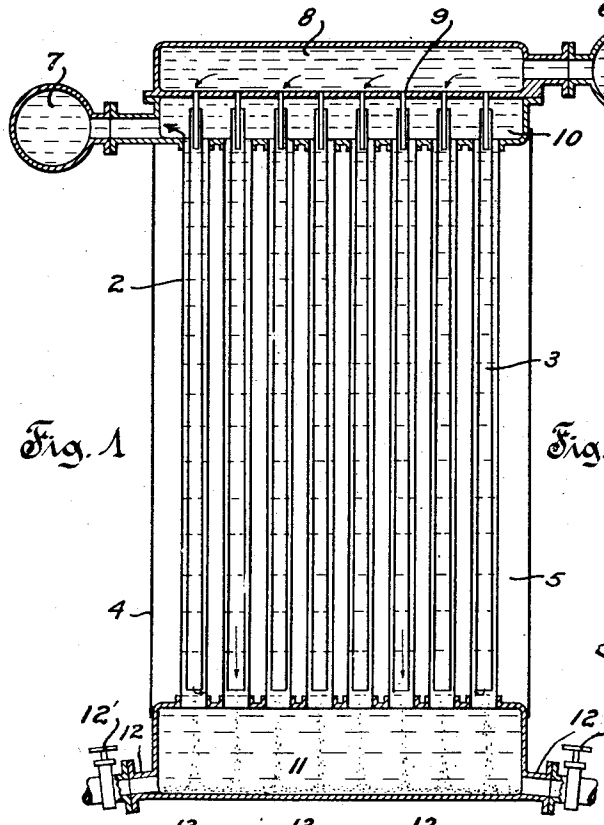


Fig. 1

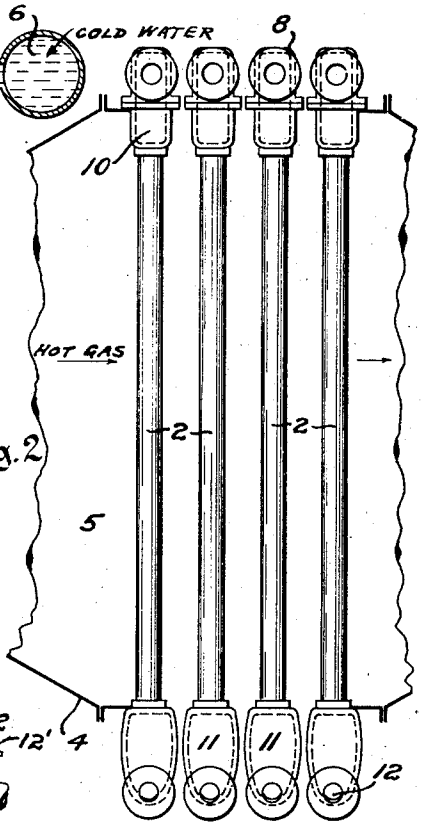


Fig. 2

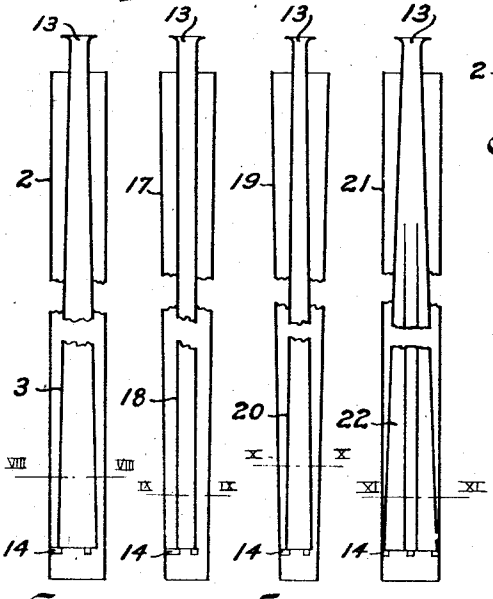


Fig. 4 Fig. 5 Fig. 6 Fig. 7

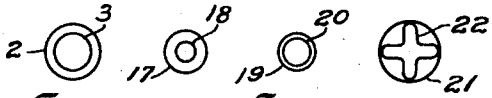


Fig. 8 Fig. 9 Fig. 10 Fig. 11

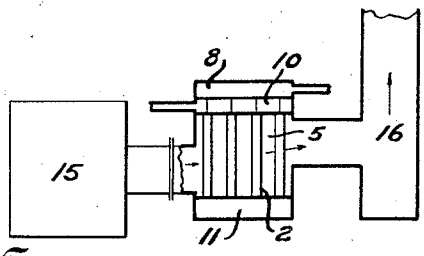


Fig. 3

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UNITED STATES PATENT OFFICE.

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PROCESS OF AND APPARATUS FOR TRANSFERRING HEAT.

Application filed December 14, 1923. Serial No. 680,578.

This invention relates in general to improvements in the art of heat transfer, and relates more specifically to an improved method of and apparatus for transferring heat from one fluid such as gases of combustion to another fluid such as water.

A general object of the invention is to provide an improved process of utilizing hot gases to heat fluid having an initial temperature below the dew point temperature of the gases. Another general object of the invention is to provide improved heat transfer apparatus which is especially adapted to effect commercial exploitation of the improved process, but which is capable of general application.

It has heretofore been attempted to utilize gases of combustion derived from various sources, to directly heat liquid such as boiler feed water, by conducting the hot gases in contact with metal tubes through which the water was caused to flow. It is an established fact that gases of combustion usually contain in suspension substances such as minute solid particles, which upon being brought in contact with moist surfaces form a scale or coating and thus prevent efficient transfer of heat through the coated elements. When the initial temperature of the water within the tubes or prior feed water heaters of this type, was below the dew point temperature of the gases of combustion which were brought in contact with the tubes, the moisture of the gases was quickly condensed and deposited upon the heat transferring surfaces thus permitting the suspended solids to accumulate in the form of heat insulating scale. This scale as well as the corrosion produced by the moisture alone, so reduced the efficiency of these heaters, that it became necessary to initially heat the water with the aid of steam, to a temperature above the dew point temperature of the gases, before admitting the water to the heaters. This pre-heating of the water while reducing corrosion and coating of the tubes, is relatively cumbersome and costly.

One of the more specific objects of the present invention is to provide an improved method of and apparatus for utilizing gases of combustion containing moisture and scale producing substances, to economically and effectively heat liquid having an initial temperature below the dew point temperature of the gases, without danger of corrosion of the heat transferring elements due to deposition of moisture, and without danger of depositing heat insulating coatings upon the heat transfer surfaces. With the aid of the present improvement, the heat transfer surfaces which are exposed to the hot gases, are always automatically maintained heated to a temperature at least equal to the dew point temperature of the gases, thereby effectively preventing condensation of moisture from the gases and deposition thereof upon these surfaces.

The invention additionally contemplates provision of simple, compact and efficient heat transfer apparatus capable of general application. The improved apparatus is entirely automatic in operation and has relatively large capacity for relatively limited space occupied. The improved heater may be manufactured at minimum cost, is readily accessible for inspection and cleaning, and may be conveniently assembled and dismantled. The various elements of the improved apparatus are subjected only to gradual variations in temperature and the pressures thereon are substantially balanced. These and other objects and advantages of the present invention will be apparent in the course of the following description.

A clear conception of the several steps of the improved process of heat transfer, and of the details of construction of several embodiments of the improved heat transfer apparatus, may be had by referring to the drawing accompanying and forming part of this specification, in which like reference characters designate the same or similar parts in the various views.

Fig. 1 is a vertical cross-section through an improved water heater, the section being taken transversely of the direction of flow of the heating gases.

Fig. 2 is a side elevation of several sections of heat transfer elements, showing the relative disposition of the gas conducting casing.

Fig. 3 is a diagrammatic disclosure of the improved heater showing the relative location of the same with respect to a source of gases of combustion.

Fig. 4 is an enlarged fragmentary vertical section through one of the heat transfer elements.

Fig. 5 is an enlarged fragmentary vertical section through another form of heat transfer element.

Fig. 6 is an enlarged fragmentary vertical

section through another form of heat transfer element.

Fig. 7 is an enlarged fragmentary vertical section through still another form of heat transfer element.

Fig. 8 is a transverse section through the lower portion of the element shown in section in Fig. 4, the section being taken along the line VIII—VIII of Fig. 4.

Fig. 9 is a transverse section through the lower portion of the element shown in section in Fig. 5, the section being taken along the line IX—IX of Fig. 5.

Fig. 10 is a transverse section through the lower portion of the element shown in section in Fig. 6, the section being taken along the line X—X of Fig. 6.

Fig. 11 is a transverse section through the lower portion of the element shown in section in Fig. 7, the section being taken along the line XI—XI of Fig. 7.

The improved heat transfer apparatus comprises in general one or more sections or units each consisting of a plurality of substantially parallel tubular heat transfer elements spaced laterally apart and communicating with water supply and discharge chambers 8, 10 at one end, and with a settling chamber 11 at the other end. As illustrated in Figs. 1 and 2, there are four sections and the heat transfer elements are disposed vertically, the chambers 8, 10 being located above and the settling chambers 11 being located below the elements. There may however be any desired number of sections or units, depending upon the capacity required, and the tubular elements may be disposed otherwise than vertical. The space surrounding the groups of tubular heat transfer elements provides a heating zone 5 confined within a casing 4 which communicates with a source 15 of hot gases and with a stack 16 as shown in Fig. 3. The cold water supply chambers 8 are detachable from the adjacent discharge chambers 10, communicating with a common supply header 6 and with the individual heat transfer elements through depending pipes 9, see Fig. 1. The warm water discharge chambers 10 communicate with a common discharge header 7, the headers 6, 7 being connected with any suitable sources of cold and warm water respectively. The settling chambers 11 are in open communication with the lower extremities of the tubular heat transfer elements, and are provided with cleaning or flush pipes 12 and valves 12′ for effecting convenient removal of accumulated solids.

In the embodiment of the invention disclosed in Figs. 1, 2, 4 and 8, each of the tubular heat transfer elements comprises an outer cylindrical tube 2 the upper extremity of which is in open communication with an adjacent discharge chamber 10 and the lower extremity of which is in open communication with an adjacent settling chamber 11; and an inner downwardly enlarging frusto-conical tube 3 the upper extremity 13 of which is trumpet shaped and loosely embraces an adjacent cold water supply pipe 9, and the lower extremity of which rests loosely upon lugs 14 projecting from the lower inner portion of the outer tube 2. The outer tubes 2 are fixed in position, while the inner tubes 3 are freely upwardly removable upon removal of the chamber 8 and pipes 9.

In the embodiment of the invention disclosed in Figs. 5 and 9, each of the tubular heat transfer elements comprises an outer upwardly enlarging frusto-conical tube 17 the upper extremity of which is in open communication with an adjacent discharge chamber 10 and the lower extremity of which is in open communication with an adjacent settling chamber 11; and an inner cylindrical tube 18 the upper extremity 13 of which is trumpet shaped and is adapted to loosely embrace a supply pipe 9, and the lower extremity of which rests loosely upon lugs 14 projecting inwardly from the inner lower portion of the outer tube 17.

In the embodiment of the invention disclosed in Figs. 6 and 10, each of the tubular heat transfer elements comprises an outer upwardly enlarging frusto-conical tube 19 the upper extremity of which is in open communication with an adjacent discharge chamber 10 and the lower extremity of which is in open communication with an adjacent settling chamber 11; and an inner downwardly enlarging frusto-conical tube 20 the upper extremity 13 of which is trumpet shaped and is adapted to loosely embrace a supply pipe 9, and the lower extremity of which rests loosely upon lugs 14 projecting inwardly from the lower inner portion of the outer tube 19.

In the embodiment of the invention disclosed in Figs. 7 and 11, each of the tubular heat transfer elements comprises an outer cylindrical tube 21 the upper extremity of which is in open communication with an adjacent discharge chamber 10 and the lower extremity of which is in open communication with an adjacent settling chamber 11; and an inner downwardly enlarging longitudinally corrugated tube 22 the upper extremity 13 of which is trumpet shaped and is adapted to loosely embrace a supply pipe 9, and the lower extremity of which rests loosely upon lugs 14 projecting from the inner lower portion of the outer tube 21.

The several forms of heat transfer elements disclosed in Figs. 4 to 11 inclusive, represent only a few of the numerous forms which the improved apparatus may have, it being desirable however in most cases to avoid direct contact between the water delivered from the supply chamber 8 and a wall which is in direct contact with the heat-

ing zone 5. The inner tubes 3, 18, 20, 22 are preferably always completely surrounded by a pre-heated jacket of liquid or other media the temperature of which is at least equal to the dew point temperature of the gases within the heating zone 5.

During normal operation of the improved apparatus the improved process is automatically exploited by producing a continuous flow of water from the header 6 to the inner tubes of the heat transfer elements, through the chambers 8 and depending pipes 9. As the water admitted to the inner tubes flows downwardly toward the settling chambers 11, it is gradually exposed to increasing heat transmitting surface due to enlargement of the cross-sectional areas of the inner tubes. If the water contains solids in suspension, these will automatically settle in the chambers 11, such tendency of the solids to settle being augmented in cases where the inner tubes are formed of gradually enlarging cross-sectional area.

Upon reaching the lower extremities of the inner tubes of the heat transfer elements, the flow of the water is reversed from downward to upward and the liquid passes into the space between the inner and outer tubes. In this space the liquid is exposed to direct transmission of heat from the gases in the heating zone 5. The upwardly progressing liquid transmits sufficient heat to the downwardly flowing liquid in the inner tubes, so that the liquid upon entering the outer tubes has attained a temperature at least equal to the dew point temperature of the gases. The temperature of the liquid within and without the lower portion of the inner tubes is substantially equal and the temperature of the liquid in the space between the tubes is maintained substantially uniform due to the fact that the temperature of the liquid within the inner tubes gradually increases from top to bottom and this liquid therefore abstracts decreasing quantities of heat from the surrounding jackets as it proceeds downwardly.

The liquid delivered from the upper extremities of the outer tubes passes through the chambers 10 to the header 7 and from thence to the source of utilization. It will thus be noted that the water admitted from the header 6 flows gradually through the heater and has its temperature automatically increased by being successively indirectly and then directly exposed to the hot gases in the heating zone 5. Due to the fact that the temperature within the jackets provided by the spaces between the inner and the outer tubes is at all times maintained at least equal to the dew point temperature of the gases passing through the heating zone 5, the moisture in the gases is not afforded the opportunity of condensing upon relatively cool surfaces, and the suspended solids cannot accumulate upon the heat transfer elements in the form of scale.

The settling chambers 11 may be readily cleaned by opening the valves 12′ and passing wash water longitudinally through the chambers 11. By removing the upper chambers 8 and the pipes 9, the inner tubes of the heat transfer elements are freely vertically removable thus making the entire interior of the heater accessible for cleaning. When assembling the heater the trumpet shaped upper ends 13 of the inner tubes facilitate insertion of the pipes 9. Due to the fact that the upper extremities 13 of the inner tubes do not snugly fit the pipes 9, the pressures upon the inner tubes are automatically substantially equalized. The number of units comprising the heater may be increased or diminished as desired and any one or more of these units may be readily replaced. The entire heater may be manufactured at minimum cost and the apparatus is efficient and entirely automatic in operation.

It should be understood that it is not desired to limit the invention to the exact steps of the process and to the precise details of construction herein described, for various modifications within the scope of the claims may occur to persons skilled in the art.

It is claimed and desired to secure by Letters Patent:—

1. The process of utilizing gases of combustion to heat fluid having an initial temperature below the dew point temperature of the gases, which comprises, producing a stream of the fluid having oppositely flowing adjacent portions at least one of which has gradually decreasing velocity, initially raising the temperature of one of said stream portions to at least the dew point temperature of the gases by transfer of heat from said gases through the other of said stream portions, and subsequently heating the fluid from said initially heated stream portion by direct transmission of heat from said gases.

2. The process of utilizing gases of combustion to heat fluid having an initial temperature below the dew point temperature of the gases, which comprises, producing a stream of fluid having oppositely flowing adjacent portions exposed to heat transfer surface of gradually increasing area, initially raising the temperature of one of said stream portions to at least the dew point temperature of the gases by transfer of heat from said gases through the other of said stream portions, and subsequently heating the fluid from said initially heated stream portion by direct transmission of heat from said gases.

3. The process of utilizing gases of combustion to heat fluid having an initial temperature below the dew point temperature of the gases, which comprises, producing a stream of fluid having inner and outer oppositely flowing portions at least one of which is exposed to heat transfer surface of gradually

increasing area, initially raising the temperature of said inner portion to at least the dew point temperature of the gases by transfer of heat from said gases through said outer portion, and subsequently heating the fluid from said inner portion by direct transmission of heat from said gases.

4. The process of utilizing gases of combustion to heat fluid having an initial temperature below the dew point temperature of the gases, which comprises, producing a stream of fluid having inner and outer oppositely flowing vertical portions the inner of which flows downwardly and has gradually decreasing velocity, initially raising the temperature of said inner stream portion to at least the dew point temperature of the gases by transfer of heat from said gases through said outer stream portion, simultaneously reversing the flow of the initially heated fluid and removing impurities therefrom, and subsequently converting the initially heated and purified fluid into an outer stream portion and further heating the same by direct transmission of heat from said gases.

5. A heat transfer device comprising, vertical tubular members located one within the other to provide inner and outer fluid passages, the inner of said passages having gradually downwardly enlarging cross-sectional area and the outer of said passages having gradually upwardly enlarging cross-sectional area, means forming an enlarged chamber connecting the open lower ends of said passages, means for delivering cool fluid downwardly through said inner member, means for receiving heated fluid upwardly from said outer member, and means for conducting heated gas in contact with the outer of said members.

6. A heat transfer device comprising, vertically disposed tubular members located one within the other to provide inner and outer fluid passages, the inner of said members having gradually downwardly enlarging cross-sectional area, means forming an enlarged chamber connecting the lower ends of said passages, means for delivering cool fluid downwardly through said inner member, means for receiving heated fluid upwardly from said outer member and means for conducting heated gas in contact with the outer of said members.

In testimony whereof, the signature of the inventor is affixed hereto.

RAY C. NEWHOUSE.