Jan. 12, 1932. A. H. DAVIS, JR 1,840,835

AIR HEATER

Filed April 10, 1929 2 Sheets-Sheet 1

Fig. 2.

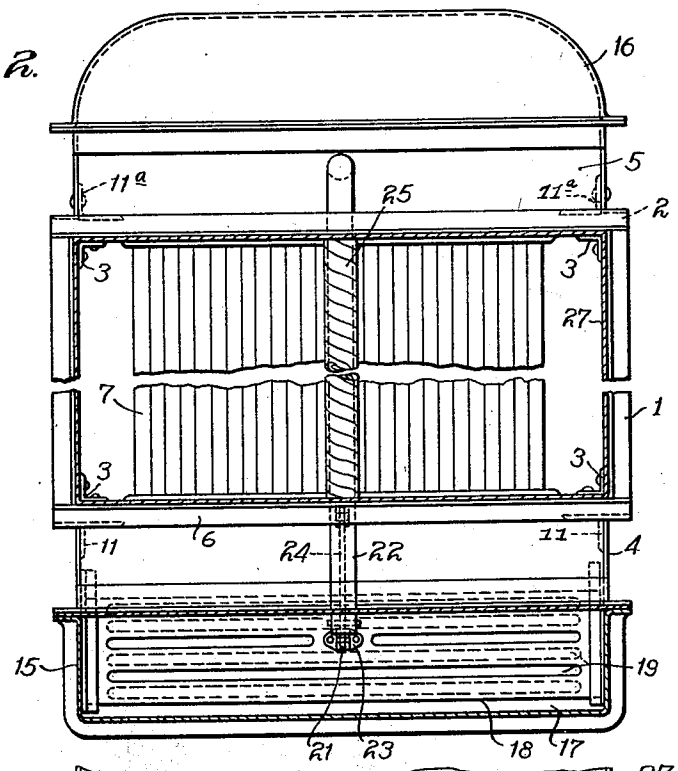
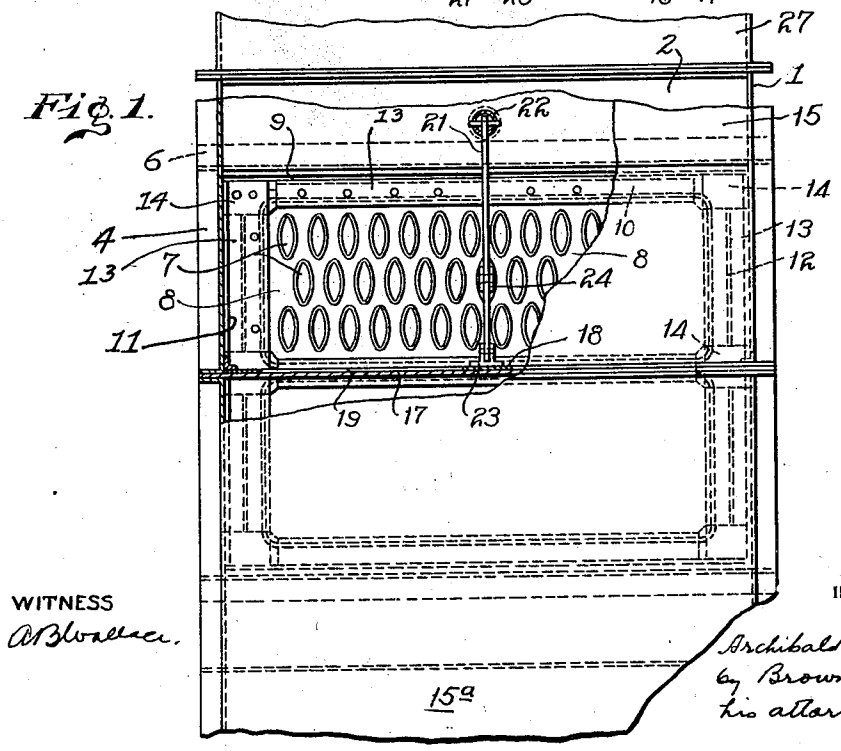


Fig. 1.



WITNESS

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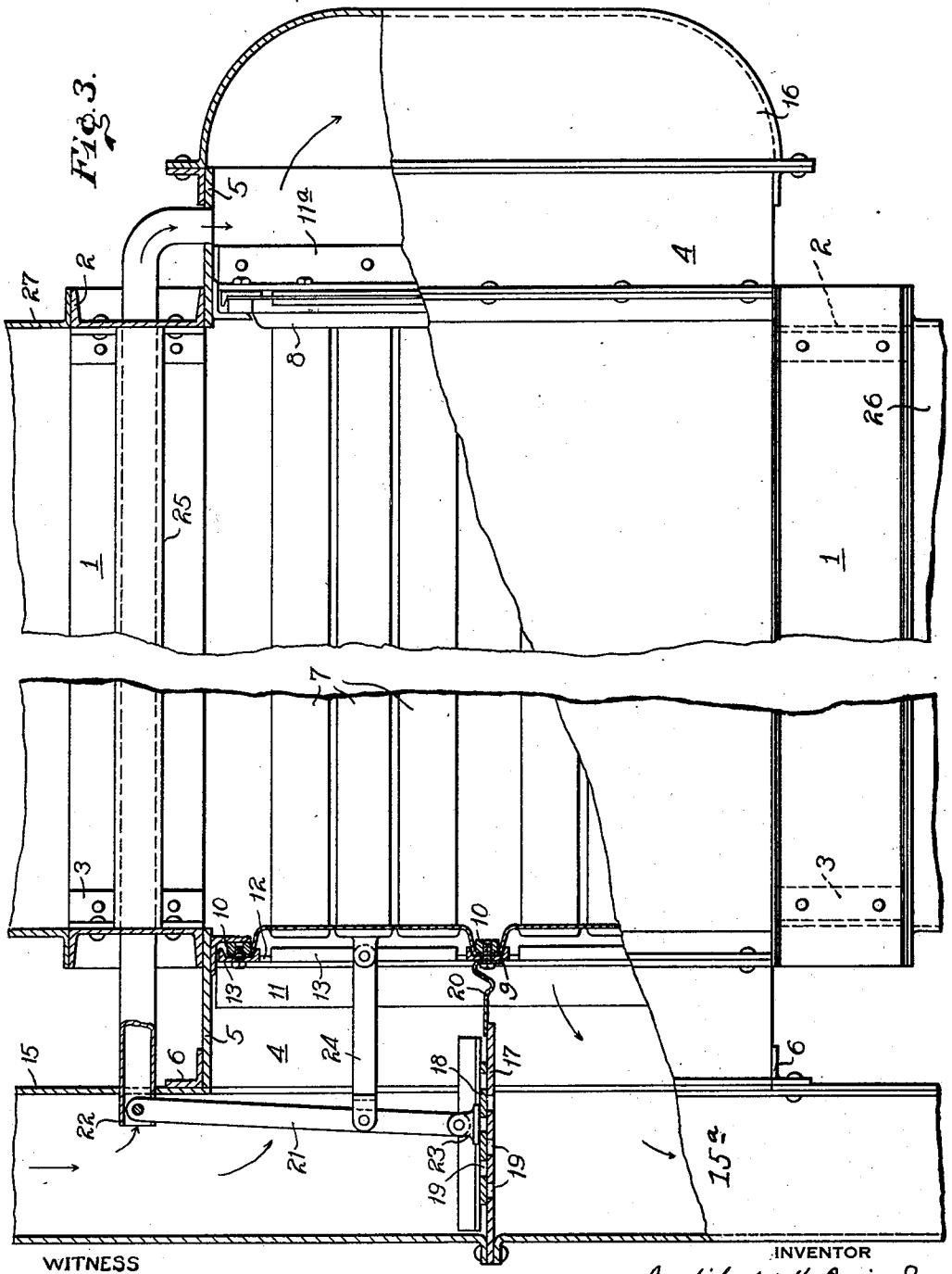
Fig. 3.



WITNESS

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Patented Jan. 12, 1932 1,840,835

UNITED STATES PATENT OFFICE

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AIR HEATER

Application filed April 10, 1929. Serial No. 353,967.

This invention relates to heat exchanging apparatus in which air or other fluid is heated by means of hot gases.

Metallic corrosion occurs principally in the presence of moisture in the liquid phase, and consequently if the operation of air preheaters, gas fired unit heaters, and other heat exchanging apparatus is such as to keep the metal surfaces in contact with the hot gases above the dew point of the moisture in the gases, corrosion of the metal by the acid-forming or corrosive constituents of the gases will be minimized. However, under the varying conditions of use of such heating apparatus, the metal surfaces may drop below the temperature at which moisture will condense, thus making it possible for corrosion to set in. For example, air preheaters used for power boilers are generally designed to operate at high efficiency when the plant is operating under high loads, and under such conditions the metal surfaces are above the dew point of the hot gases. Such heaters are, in effect, oversize when the plant operates at reduced load, so that under these conditions the heat exchanging surfaces are usually at a temperature low enough for condensation to take place. The corrosion of prior heat exchanging apparatus resulting from such condensation has been a serious problem, largely because the corrosion may be rapid and because of the expense incident to taking the unit out of service and repairing it.

An object of the invention is to provide heat exchanging apparatus with means for automatically controlling the operating temperatures of the gas contact surfaces, which means are simple, of rugged and inexpensive construction, and are fully automatic in operation.

Another object is to provide air heating apparatus with means for regulating the temperature of the heat exchanging unit by controlling flow of air or gas through the unit, which means are actuated by heat-induced movements of the unit.

Still another object is to provide an apparatus of the type referred to with means for automatically by-passing a portion of the air or heating gases around the unit in accordance with the temperature of the unit, whereby to regulate the temperature of the gas contact surfaces.

An especial object is to provide a tubular heat exchanging apparatus which embodies all the advantages and minimizes the disadvantages of prior tubular heaters, in which the heat exchanging unit comprises interchangeable tubular radiators which are individually removable, which is provided with means associated with the air ducts and actuated by expansion and contraction of the tubes for maintaining the tubes above the dew point, and which apparatus is compact, efficient, and of simple construction.

The preferred embodiment of the invention is shown in the accompanying drawings, in which Fig. 1 is an end elevation; Fig. 2 is a plan view; and Fig. 3 is a side elevation, parts being broken away in Figs. 1 and 3 for clarity of representation.

In accordance with the invention, heat exchanging apparatus, and especially air preheating apparatus, is provided with means responsive to the temperature of the heat exchanging unit for controlling the effluent temperatures of the air or of the heating gases. In this manner, the temperature of the gases or air may be regulated as desired, either above or below the dew point of the heating gases, but in the preferred practice, the means referred to operates to maintain the unit above the temperature at which moisture will condense from the hot gases. In the latter case, corrosion by the corrosive constituents of the heating gases is substantially reduced or eliminated. In either case, the purpose is effected by controlling the temperature of the gas contact surfaces and is so referred to herein.

The invention may be practiced in a variety of ways but in the preferred embodiment its objects are attained by regulating the flow of air or other fluid, or of heating gases, through the apparatus in accordance with the temperature of the unit so that the amount of fluid or gas passing through the unit is just sufficient to maintain the gas contact surfaces at a temperature which gives

the desired result. To this end, it is preferred to provide means to by-pass a portion of the cold air or gas as need be, and preferably the means used for this purpose is actuated by expansive and contractive movements of the unit caused by changes in its temperature. Such movements being caused by and directly related to changes in temperature may be said to control the operation in accordance with temperature, and may, for brevity be termed heat-induced movements.

Having reference to the drawings, the embodiment shown is represented as applied to an air preheater comprising a framework and interchangeable tubular radiator sections which are individually removable from the framework. This heater construction forms the subject of a copending application, Serial No. 336,746, filed by me on February 1, 1929.

The framework is preferably built up from structural sections, and in the form shown the top and bottom are formed of longitudinal channels 1 and transverse channels 2 connected by angles 3 bolted thereto at the corners. Vertical side channels 4, across the ends of which are connected plates 5, define end openings, and angles 6 are connected to the forward ends of plates 5 to form flanges. The flanges referred to, together with those formed by the outer legs of channels 1 and 2 may be used for connecting air and gas ducts to the framework.

Tubular heat exchanging units are preferably used, and tubular radiators of the type disclosed in United States Patent No. 1,320,652 to C. Sonneborn, dated November 4, 1919, are preferred. These radiator units comprise tubes 7 welded at their ends to pan-shaped headers 8 having an outwardly bent peripheral flange 9. The radiators are mounted in the framework one above another to give sectional stacks from which the individual units may be laterally withdrawn when necessary, and one stack or a plurality may be used, as described in my aforesaid copending application.

In this embodiment, spaced horizontal rail members 10 disposed in two opposed ends of the framework are carried by supporting members 11 and 11*a*, preferably angles, vertically positioned in each side of the openings defined by the channels 4 and plates 5. The angles 11 and 11*a* are disposed with one leg against the web of the channels, the other leg being in the plane of the opening. The units are placed in the framework by insertion through the openings formed by channels 1, 1 and 4, 4, headers 8 and flanges 9 slidably engaging rails 10. Short rail sections or bars 12 are disposed vertically between rails 10 at the sides of the headers. When the units have been set in position in the framework they are connected to rails 10 and 12 by vertical and horizontal clamping members 13 which engage adjacent edges of the headers of two contiguous units. These clamps preferably are of channel form, the inner surfaces of their legs being tapered outwardly, as seen in Fig. 3, this construction giving a wedging action which provides for tight joints, and expansion of the headers between the rails and the tapered surfaces of the clamps is permitted. The horizontal clamps are bolted directly to rails 12, and the vertical side clamps are connected to the appropriate rails by bolts passing through both the rail-supporting angles and the rails. The spaces not occupied by the clamps are filled by plates 14 of appropriate shape bolted to the rails, as shown in Fig. 1. This provides a gas tight structure in which the fluids on opposite sides of the tube cannot intermix.

In order to provide for longitudinal movement of the radiators due to expansion of the tubes, the rail supporting members at one end of the apparatus, for example, angles 11*a*, are bolted to channels 4, those at the other end, angles 11 in this case, being free to move over the web of channel 4 upon expansion or contraction of the units. This provides for differential expansion of framework and units, and all of the heat-induced movement of the unit is effective at one end of the apparatus.

Air to be heated is passed into one of the tubes of a unit from a duct 15, and is caused to flow through the subsequent unit or units by a return 16 connected to the opening at the other end, and the heated air then passes into an extension 15*a* of duct 15. This circulation of air through successive units is indicated by arrows, Fig. 3.

In accordance with the invention, means are provided for controlling the temperature of the gas contact surfaces by regulation of the amount of fluid flowing through the apparatus, this being preferably accomplished by by-passing an amount in accordance with need. In the preferred embodiment this means comprises a valve which in the form described is situated between ducts 15 and 15*a*, the latter then forming an extension of cold air duct 15. In the form shown, the valve comprises a fixed plate 17 and a movable plate 18 slidable thereon. These plates are provided with slots or other openings 19 adapted to be moved into or out of register according to the relative position of the plates, and the amount of air passing through the apparatus thereby regulated. In order to prevent air from passing directly from the inlet of duct 15 into duct 15*a* when the valve is closed, the end of plate 17 is connected by a diaphragm 20 extending between channels 4 and connected to the front of the units. In order to avoid distortion of the fixed plate and consequent disturbance of valve action,

member 20 is preferably corrugated or otherwise made of an expansible nature, as shown in Fig. 3.

The valve-actuating mechanism comprises a lever 21 connected pivotally at its upper end to a fixed support 22 and at its lower end to a stud 23 carried by the movable plate. The lever is connected by a link 24, Fig. 3, to the movable end of a unit, so that expansive and contractive movements of the units are conveyed to plate 18, and the resulting movement of this plate brings the slots into or out of register with those of the fixed plate, the operation being more fully described hereinafter.

In order to prevent false operation of the valve, support 22 should not be affected by the thermal condition of the apparatus. This may be accomplished by using a support independent of the apparatus, but in the form shown, the support comprises a tube passing from duct 15 through the apparatus and discharging into return 16. The portion of the tube within the apparatus is provided with lagging 25, and cold air flowing through the tube serves to maintain it at constant temperature. In this manner, support 22 is substantially invariant and independent of movement of the apparatus, and the valve will function properly.

Heating fluid, for example flue gas, is passed to the other surface of the tubes from a duct 26, and the cooled fluid is exhausted through a duct 27. These ducts are connected to the openings defined by channels 1, 1 and 2, 2. The side openings of the apparatus, between channels 1, 1 and 4, 4 are closed by plates, not shown, or in any other suitable manner, the plates being preferably readily removable for ease of withdrawing the units when necessary.

In the use of the apparatus, the valve-actuating mechanism is adjusted so that all of the air from duct 15 flows through the apparatus as long as the gas contact surfaces are above the dew point, and to cause opening of the valve when those surfaces have cooled below the temperature at which moisture may condense from the gases.

Under normal operating conditions, the tubes of the unit will be above the temperature at which moisture will condense. Under these conditions the tubes will have expanded, and being free to move at the end supported by channels 11, expansion of the unit will have actuated lever 21 to close the valve. This position being shown in Fig. 3. That is, the perforations will be out of register and all of the air supplied to the apparatus from duct 15 will pass through the radiators. When for any reason, for example reduction of load on the boiler, the unit cools, the tubes will contract, and this movement will be transmitted to the movable plate. When the unit has cooled to a point where moisture may condense, the plate has been moved sufficiently to bring perforations 19 into register, and a portion of the air will be by-passed around the apparatus by flowing directly from duct 15 into 15*a*. This reduction in the amount of air passing through the tubes reduces the cooling effect of the air upon the tubes, and in consequence, the tubes run hotter than if the full air supply were passing through them. As the tubes heat or cool, plate 18 is moved accordingly to regulate the relative position of the plates and thus to permit more or less air flow through the valve, and it can be adjusted in position so that the tubes are always above the dew point and no chemical corrosion can occur.

The foregoing description applies to the use of the control means for preventing corrosion. Where corrosion is not apt to occur, or where control of either gas or air temperature above or below the gas dew point is desired, the apparatus is equally applicable. In this case the mechanism may be adjusted in any suitable manner so as to actuate the valve to pass sufficient air to reach the desired temperature, or to cool the gases to the desired temperature. In either case, this is controlling the temperature of the gas contact surfaces. The temperature responsive element described above is in effect the heating surface, and when that construction is applied to this modified use, it may not in all cases give suitable control, because it operates at a temperature intermediate that of the two gases. For this reason the construction explained above is modified so that the temperature responsive element is situated in one of the gas passages to respond solely to the temperature of that gas instead of being responsive to the heating surface temperature. This construction operates in the same manner as before, and will be readily understood by those skilled in the art without further illustration or extended description.

It will also be understood that instead of by-passing air, gas may be by-passed, the construction and operation of the valve being the same as before. In this manner temperature control is attainable from either side of the units.

The invention is not limited to its application to heaters of the type illustrated, nor to tubular heat exchanging apparatus, but is generally applicable to air or other fluid preheaters, gas fired unit heaters, and the like. Nor is it limited to the particular type of control mechanism shown and described, various modifications being within the knowledge of those skilled in the art. For example, motion-magnifying mechanism might be used instead of the simple linkage shown. Also, in the form shown the number of radiator units or their disposition in the apparatus may be varied according to need; and in some cases a single heat exchanging unit may be

used, the construction in such cases being modified in a manner clearly understood by competent designers.

I claim:

1. Heating apparatus comprising a framework, a tubular heat exchanging unit mounted in said framework for free expansion and contraction at one end, a conduit for supplying cold air to one surface of the tubes, means for applying hot gases to the other surface of the tubes, and a valve in said conduit operatively connected to the movable end of said unit for actuation by movement of the unit, contraction of the unit opening the valve to by-pass air when the temperature of the unit is below a predetermined value.

2. Heating apparatus comprising a framework, a tubular heat exchanging unit carried by the framework, one end of said unit being connected to the framework and the other end being free to move in response to heat-induced movements of the tubes, conduits for passing heating fluid over and removing it from one surface of the tubes, conduits for supplying a cold fluid to and removing heated fluid from the other surface of the tubes, a connection between the conduits supplying one surface, fixed and movable perforated plates in said connection, and mechanism connected to the free end of the unit for moving said movable plate in response to movement of the unit to bring the perforations into register and pass a portion of the fluid directly through the conduits to maintain the gas contact surfaces at a predetermined temperature.

3. Heating apparatus comprising a framework, a tubular heat exchanging unit carried by the framework, one end of said unit being connected to the framework and the other end being free to move in response to heat-induced movements of the tubes, an intake for passing hot gases over one surface of the tubes, conduits for supplying cold air to and removing heated air from the other surface of the tubes, a connection between the air conduits, fixed and movable perforated plates in said connection, and mechanism connected to the free end of the unit for moving said movable plate in response to movement of the unit to bring the perforations into register and pass a portion of the air directly through the conduits when the unit has fallen below a predetermined temperature.

4. Heating apparatus comprising a framework, rails supported in two opposed ends of the framework, a heating unit comprising a plurality of radiators carried by the rails and individually removable from the framework, one end of each of said radiators being connected to the framework and the other end being free to move upon expansion and contraction of the tubes, a duct connected to the framework for supplying cold air to the tubes of one of the radiators and for removing heated air from a subsequent radiator, a connection between radiators for circulating air through the tubes of successive radiators, a valve in said duct intermediate the cold air inlet and heated air outlet operatively connected to the free end of one of the radiators for actuation by movement thereof, said valve when closed passing all of the air through the unit and being opened when the unit is below a predetermined temperature to pass a portion of the air directly through the duct.

5. Heating apparatus comprising a framework, parallel rails supported in two opposed ends of the framework, a plurality of radiators each comprising parallel tubes of generally elliptical cross section connected at their ends to headers, said radiators being removably supported in the framework with the headers slidably mounted between adjacent rails, one end of the radiators being connected to the framework and the other end being free to move upon expansion or contraction of the tubes, a return connection between radiators, a duct connected to the framework having a cold air outlet to the tubes of one of the radiators and a heated air inlet from a subsequent radiator, a valve disposed in the duct between said inlet and outlet comprising fixed and movable perforated plates, and operating connections between the movable plate and the free end of one of the radiators, contraction of the radiators in cooling to a predetermined temperature moving said plate to bring the perforations into register and pass a portion of the cold air directly through the duct.

6. Heating apparatus comprising a framework, a tubular heat exchanging unit mounted in said framework and having one end fixed and the other end free to move upon expansion and contraction of the unit, a conduit having a cold air outlet to the tubes of a portion of the unit and an inlet for heated air from the balance of the unit, a valve disposed in said conduit intermediate said outlet and inlet comprising fixed and movable perforated plates and mechanism associated with the movable plate connected to the free end of the unit, the perforations in the plates being brought into register by contraction of the unit when it is below a predetermined temperature.

7. Heating apparatus comprising a framework, a tubular heat exchanging unit comprising removable radiators mounted in said framework, a return connection between radiators for circulation of air through the unit, each radiator having one end fixed and the other end free to move upon expansion and contraction of the unit, a conduit having a cold air outlet to one of the radiators and an inlet for heated air from a subsequent radiator, a valve disposed in said conduit intermediate said outlet

and inlet comprising fixed and movable perforated plates and actuating linkage connecting said movable plate and the free end of one of the radiators and supported from a fixed member carried by the framework, contraction of the unit when below a predetermined temperature bringing the perforations of said plates into register to pass a portion of the cold air directly through the conduit.

8. Heating apparatus comprising a framework, parallel rails supported in two opposed ends of the framework, a plurality of radiators each comprising parallel tubes of generally elliptical cross section connected at their ends to headers, said radiators being removably supported in the framework with the headers slidably mounted between adjacent rails, one end of the radiators being connected to the framework and the other end being free to move upon expansion or contraction of the tubes, ducts for supplying hot gases to and removing them from one surface of the tubes, ducts for supplying cold air to and removing heated air from the other surface of the tubes, a connection between the inlet and outlet ducts of one of said surfaces, a valve in said connection comprising fixed and movable perforated plates, and operating connections between the movable plate and the free end of one of the radiators, expansion and contraction of the radiators moving said plate to bring the perforations into or out of register to regulate the temperature of the gas contact surfaces.

9. An air heater comprising in combination a framework, a heat exchanging unit mounted in said framework for movement relative thereto in response to temperature changes of the unit, a conduit for supplying air to be heated to one heat exchanging surface of the unit, a conduit for supplying heating gases to the other surface of the unit, and means associated with one of said conduits responsive to said movements of the unit for regulating the amount of fluid flowing from that conduit to the unit to maintain the unit at a temperature above the dew point of water.

10. Heating apparatus comprising in combination a framework, a heat exchanging unit mounted in the framework for movement relative thereto in response to temperature changes of the unit, a conduit for supplying air to be heated to one surface of the unit, a conduit for supplying heating gases to the other surface of the unit, and means associated with one of said conduits actuated by said movements of the unit to by-pass a portion of the fluid from that conduit to maintain the temperature of the gas contact surfaces of the unit near a predetermined value.

11. Heating apparatus comprising in combination a framework, a heat exchanging unit mounted in said framework for movement relative thereto in response to temperature changes of the unit, a conduit for supply cold air to one surface of the unit, a conduit for supplying heated gases to the other surface of the unit, and means associated with said air conduit actuated by said movements of the unit to by-pass a portion of the air when the temperature of the unit has fallen below a predetermined value.

In testimony whereof, I sign my name.

ARCHIBALD H. DAVIS, JR.