This invention relates to an air heating furnace and more particularly to an air heating furnace of the kind in which the air to be heated is moved at high velocity through a plurality of air conducting tubes having high heat conducting walls and positioned in a furnace employing substantially high temperatures. More specifically, the invention relates to an air heating furnace of the kind disclosed in United States Patent 1,488,011 to Leif Lee and is an improvement thereon.

The air heating furnace of the kind involved consists of a combustion chamber, an outwardly extending flue, a heating chamber coextensive with the flue and communicative with the end of the flue opposite the combustion chamber, exhaust ports for the heating chamber in the end thereof adjacent the combustion chamber and a plurality of heat transferring, air conducting tubes positioned in the heating chamber. The flue and the heating chamber are separated by a refractory wall and in practice this wall forms the roof of the heating chamber with the flue being provided between this wall and the roof of the furnace proper. Simplicity of design and economy of construction is effected by supporting the refractory tiles constituting the partition directly on the air conducting tubes which for various reasons are arch shaped.

In the construction of furnaces of the kind described it has been the usual practice to arrange the heating chamber as extending horizontally outward from the combustion chamber with the flue superimposed thereover. Since combustion continues and is completed in the flue, high temperatures are developed therein and the gaseous products of combustion enter the heating chamber also at high temperatures. In the modification specifically disclosed in the above mentioned patent the air heating tubes in the heating chamber are shown as being arranged transversely to the longitudinal path of travel of the heating gases through the heating chamber and it was found in practice that those tubes which are adjacent the opening between the flue and the heating chamber were subjected to much higher temperatures than the tubes positioned toward the other end of the heating chamber and would be burnt out long before the other tubes of the furnace were deteriorated. In an attempt to overcome this operating difficulty the tubes were arranged in planes parallel with the direction of flow of the gaseous products of combustion through the heating chamber and, since all the tubes were now subjected to a more equal temperatur, the above mentioned undesirable operating condition was somewhat alleviated. It was still found, however, that by reason of the nesting arrangement of the arch shaped tubes employed the outer tubes, i.e., those adjacent and supporting the refractory heating chamber roof, would attain a much higher temperature than the other tubes of the furnace and would consequently be subjected to more rapid deterioration.

It is the primary object of the invention to provide an arrangement in a furnace of the kind described immediately above whereby the metal of all the air heating tubes employed will be subjected to substantially the same temperatures, thus reducing the probability of early failure of any of the tubes.

Another object of the invention is the increasing of the efficiency of the operation of a furnace of the kind described and this is accomplished in accordance with the invention by increasing substantially the recuperative effect of the furnace.

In accordance with the invention the total amount of air passing through each of the independent tubes is proportioned in relation to the length of the tube and to the temperatures to which the tubes are subjected, thus a greater total volume of air is passed through the longer outer tubes which are also subjected to the highest temperatures and a lower total volume of air is passed through the shorter inner tubes which are subjected to the lowest temperatures. The control of the quantity of air passing through the different tubes may be effected either by varying the pressure exerted on the different tubes at their inlets or by varying the effective cross-sectional areas of the different tubes. For reasons which should be readily apparent, it is more practical to vary the cross-sectional areas of the tubes.

Other objects and advantages of the invention will be apparent from a consideration of the following detailed specification and the accompanying drawings wherein there is specifically disclosed a preferred embodiment of the invention.

In the drawings:

Figure 1 is a longitudinal sectional view of a furnace constructed in accordance with the principles of the invention; and

Figure 2 is a transverse sectional view of the furnace taken along the line II—II of Figure 1.

In the drawings reference numeral 10 indicates a combustion chamber which may be fired either by liquid, solid or gaseous fuel, the particular embodiment illustrated being arranged for liquid
fuel firing, the front wall 11 of the combustion chamber being provided with a plurality of spaced openings 12 to receive the burners. A vertically extending wall structure 13 at the rear of the combustion chamber 10 separates the combustion chamber from the heating chamber 14. Below the chamber 14 and preferably extending parallel with the combustion chamber 10 are the air ducts 15 and 16 which are conveniently incorporated in the concrete foundation for the furnace. As shown in Figure 2, the air ducts 15 and 16 are spaced a substantial distance apart, one being positioned at either end of the heating chamber and are each closed off at the top by means of a perforated plate 17. A plurality of arched air conducting tubes 20, 21 and 22 are carried by the plate 17 with each of the tubes having one of its ends secured in one of the perforations of one of the plates 17 and the other of its ends secured in one of the perforations of the other of the plates 17. As evident from Figure 1, the tubes extend upwardly from one of the plates into the heating chamber, thence horizontally through the heating chamber and downwardly into the other of the said plates.

The arrangement of the tubes in the furnace is a nesting one with a series of short tubes connecting the innermost apertures in the plate 11, a series of long tubes interconnecting the outermost apertures of the plate 17 and intermediate series of tubes interconnecting the intermediate apertures of the plates. In accordance with the present invention the inner or shorter tubes 20 may be of smaller cross-sectional area than that of the outer long tubes 22 with the intermediate tubes of intermediate or progressively larger cross-sectional area.

Extending horizontally outward from the upper portion of the combustion chamber 10 and under the roof 24 of the furnace is a flue 25 which is bounded on its bottom by a wall 26 made up of a plurality of refractory tiles conveniently supported on the outer series of air conducting tubes 22. The wall 26 separates the flue 25 from the heating chamber 14 and an opening 27 at the end of the flue 25 opposite the combustion chamber 10 provides communication between the flue 25 and the heating chamber. Extending transversely of the heating chamber 14 intermediate the two plates 17 are vertically disposed baffle wall 28, the function of which is to break up the flow of gases along the floor of the heating chamber and cause such gases to be diverted upwardly into the region of the horizontally extending reaches of the heat transferring tubes 20—22.

A series of laterally spaced exhaust ports 30 are provided in the end wall of the heating chamber 14 opposite the opening 27 to withdraw the products of combustion from the heating chamber. Ports 30 are located near the floor of the combustion chamber and open into flues 31 and 32 positioned beneath the combustion chamber through which the gases may pass to a suitable stack or other disposing means.

In operation the products of combustion, mixed with a suitable amount of air coming into the combustion chamber through the opening 33 in the floor wall of the furnace, pass from the combustion chamber horizontally outward through the flue 25, downwardly through the opening 27, thence horizontally through the heating chamber 14 while in contact with air conducting tube 22 and the exhaust ports 30 into the flues 31 and/or 32. By reason of the high temperatures developed in the horizontal flue 25 because of the refractory confining surfaces 24 and 26, complete combustion takes place in the flue, thus insuring high efficiency in the combustion of the fuel supply.

Air to be heated may be supplied under pressure to the main duct 15 from whence it flows upwardly through the tubes 20, 21 and 22 to the main duct 16 from where it may be distributed throughout the area to be heated. By reason of the substantial horizontal width and area of the ducts 15 and 16 the pressure will be such as to be equal at the inlets to each of the tubes and will be substantially equal at the outlets of each of the tubes. Greater resistance to flow will be encountered in the outer tubes 22 because of the greater length thereof but since the outer tubes are of relatively large cross-sectional area a large volume of air will pass through each of such tubes in a given length of time. The diameters of these tubes are so chosen in relation to their length, the pressure differential under which they operate and the temperatures encountered in the heating chamber adjacent the refractory wall 26, that a sufficient volume of flow therethrough to keep the tubes down to safe temperatures, while insuring an efficient temperature gradient between the inflowing and outflowing air, is effected. Less total friction would normally be encountered in the inner tubes 20 because of their substantially shorter length but, by making these tubes of smaller cross-sectional area, the rate of flow of the air through the tubes can be reduced thereby maintaining particular volumes of air in the tubes for a longer length of time to impart more heat to the air to insure its attaining a certain desired temperature before it leaves the tube. By decreasing the velocity of the flow of air in the tubes normally subjected to a lower temperature, the recuperative effect of the furnace is improved and consequently the overall efficiency of the furnace is increased. The metal of all the tubes is also maintained at substantially the same temperature, thereby preventing objectionable variations in expansion and premature failure of the tubes. Also, since the air discharged from each of the tubes into the exhaust duct 16 is substantially at the same temperature, air stratification within the duct 16 is eliminated, and this is of material advantage in large installations where such ducts are of large size and are divided into horizontal branches as they leave the furnace.

The above specifically described embodiment of the invention should be considered as illustrative only as obviously many changes may be made therein without departing from the spirit or scope of the invention. For example, instead of firing a furnace from an end the same may be center fired by positioning the combustion chamber within the arch of the tubes, in which case the products of combustion pass upwardly and outwardly about the tubes and are exhausted from the furnace along the outer lower ends of the outer tubes. In this rearrangement of the furnace obviously the shorter inner tubes, being closest to the combustion chamber, are exposed to the highest temperatures and would therefore probably be of larger cross-sectional area than the outer longer tubes, the latter then, being in a region of lower temperature, should pass air at a slower velocity to insure the air reaching a desirable temperature before it leaves the tubes and to improve the recuperative operation of the furnace.
What I claim is:
1. An air heating furnace comprising in combination a refractory lined casing having a transversely extending wall defining a combustion chamber positioned in the fore part of said casing, a pair of longitudinally spaced air ducts extending transversely below the rear part of said casing, a perforated plate closing off the top of each of said ducts, a plurality of series of arched air conducting tubes spanning said plates and having their ends communicating with the apertures in said plates, said tubes being positioned in said casing on the opposite side of said wall from said combustion chamber and lying in vertical planes extending longitudinally of said casing, said series of tubes being arranged in vested relation with the outer and longer of said tubes being of greater cross-sectional area than that of the inner and shorter of said tubes, a refractory baffle wall supported immediately above the outer of said tubes and extending from adjacent the upper end of said first mentioned wall to substantially the rear wall of said casing to define a horizontally extending flue for the products of combustion, and a plurality of exhaust ports for said products of combustion positioned adjacent the forward end of said tubes.

2. An air heating furnace comprising in combination a refractory lined casing having a transversely extending wall defining a combustion chamber positioned in the fore part of said casing, a pair of longitudinally spaced air ducts extending transversely below the rear part of said casing, a header plate closing off the top of each of said ducts, a plurality of series of arched air conducting tubes supported on said plates and having communication therethrough with said ducts, said tubes being positioned in said casing on the opposite side of said wall from said combustion chamber and lying in vertical planes extending longitudinally of said casing, said series of tubes being arranged in vested relation with the outer and longer of said tubes being of greater cross-sectional area than that of the inner and shorter of said tubes, a refractory baffle wall lying on the top of the outer of said tubes and extending from adjacent the upper end of said first mentioned wall to substantially the rear wall of said casing to define a horizontally extending flue for the products of combustion, a transversely extending flue below said combustion chamber, and a plurality of transversely spaced exhaust ports in the lower portion of said first mentioned wall and communicating with said last mentioned flue.

ARTHUR A. OLSON.