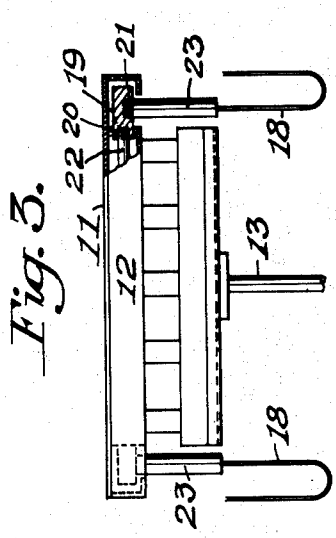
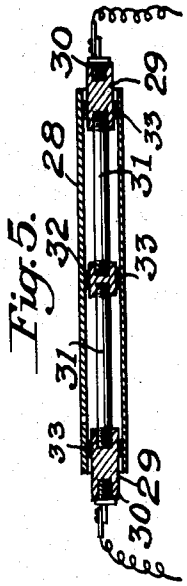
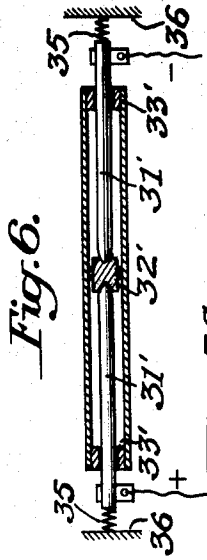
May 26, 1931. F. W. BROOKE 1,807,147

FURNACE

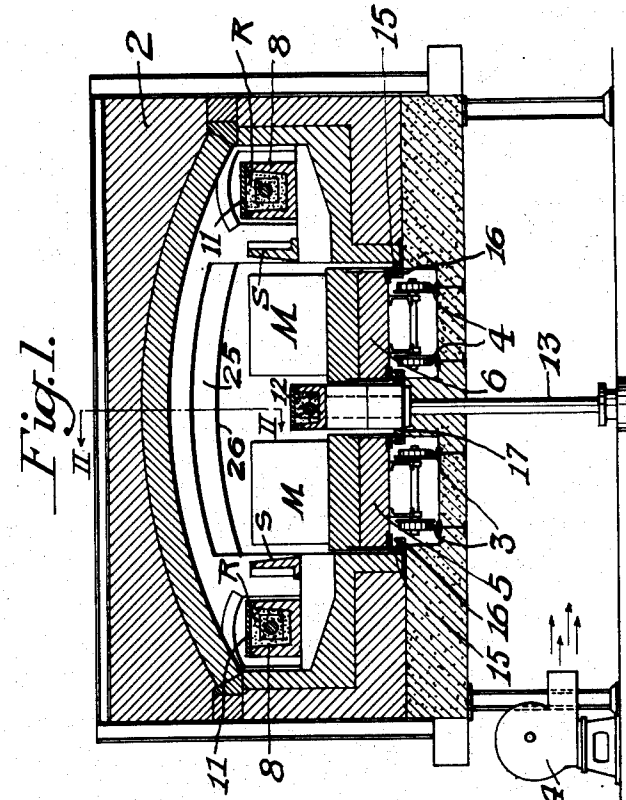
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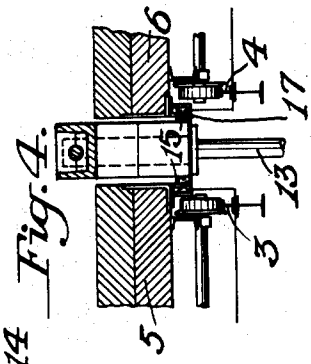


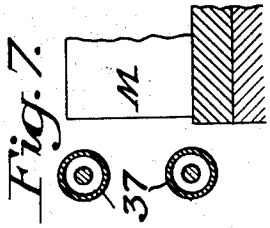












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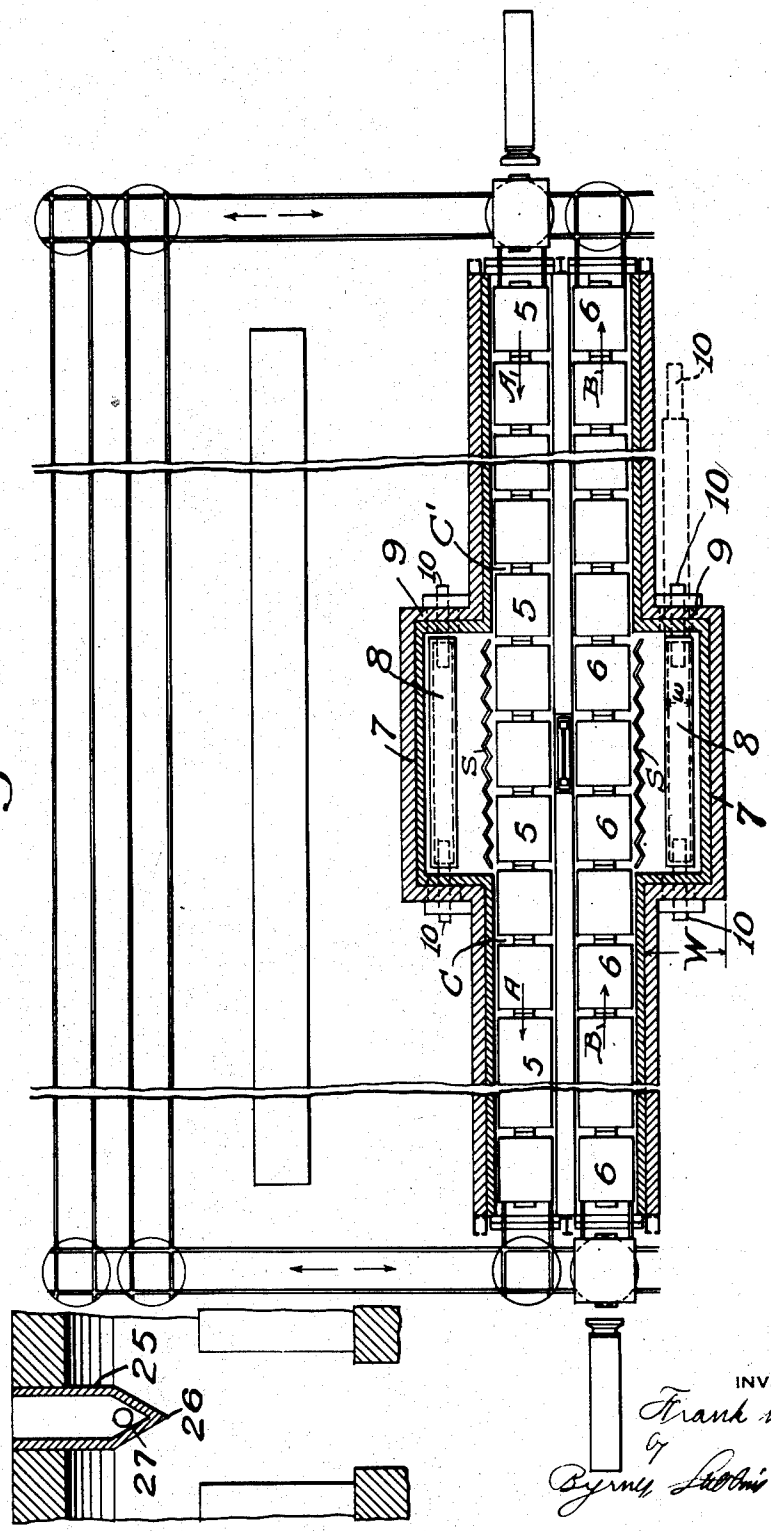


Fig. 2.

Fig. 2a.

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UNITED STATES PATENT OFFICE

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FURNACE

Application filed June 9, 1928. Serial No. 284,065.

The present invention relates broadly to the art of electric furnaces, and more particularly to electric furnaces of the type ordinarily referred to as continuous recuperative electric tunnel kilns. Furnaces of this type are especially adaptable for use in the ceramic industry. It will be understood, however, that the utility of the present invention is not limited with respect to the particular adaptation to which it is placed.

In the art to which the present invention relates, it has heretofore been proposed to provide elongated tunnel kilns through which suitable carriers or conveyors for the material to be heated are adapted to travel in side by side relationship in opposite directions. With such a construction, heating means are provided at desired points along the length of travel for the purpose of raising the temperature of the material carried by the conveyors to the required point. With such an operation, the material which has previously been heated on each conveyor during its travel in opposite directions, imparts heat to the incoming material on the other conveyor, thereby preheating it. In order to obtain the most efficient operation, in view of the nature of the material being handled, and the preheating and heat transfer conditions involved, it is essential to maintain continuous operation of the kiln.

In actual practice, several difficulties with respect not only to continuous operation, but also with respect to uniform heating, have been encountered. The heating is customarily acomplished by means of a suitable resistance material placed within a refractory trough of high heat conducting material, such as silicon carbide. Under conditions of constant use, at the high temperatures involved, these heating units break down. Heretofore, so far as I am aware, it has been necessary to permit the entire furnace to drop to a workable temperature before the units could be repaired or removed. In many cases this results in tne loss of at least a large portion of the material within the furnace, as well as the loss of several days' time.

The present invention provides an improved kiln furnace structure adapted to effect more uniform heating of the material therein, and to permit the rapid renewal, repair, or substitution of heating elements without discontinuing the operation of the furnace.

In accordance with one embodiment of my invention, there may be provided heating units arranged in adjacent substantially parallel relationship, and so connected as to permit simultaneous use of both of the units, or the independent use of either of the units in case of break down of one of them. In this manner, it is possible to maintain the kiln at a working temperature even in case of failure of one or more of the heating units. Provision also may be made for adjusting the units either vertically or horizontally so as to obtain exactly the heat distribution and heat location desired for the most efficient results.

In the operation of kilns of the general nature herein contemplated, difficulties are also encountered due to the tendency of the coating or coloring glazes to sublime or vaporize, the vapor frequently traveling to a relatively cooler part of the kiln where it condenses and drops onto the ware, thereby spoiling certain parts of it. In accordance with the present invention, provision is preferably made for effecting condensation of any such vapors at predetermined definite points, so located with respect to the ware as to insure dropping of any condensed vapor at a point intermediate successive charges.

In the accompanying drawings, I have shown for purposes of illustration only, a preferred embodiment of the present invention, it being understood that the drawings are largely diagrammatic for purposes of illustrating the present invention, and not limiting the same. It will be understood that changes in the construction and arrangement of the parts and in the operation herein disclosed may be made without departing either from the spirit of my invention or the scope of my broader claims.

In the drawings:—

Figure 1 is a vertical transverse sectional view through a furnace or kiln structure, in accordance with the present invention;

Figure 2 is a horizontal longitudinal sectional view, partly broken away, illustrating the furnace or kiln construction and the manner of operating the same;

Figure 2ª is a detail sectional view, on an enlarged scale, on the line II—II of Figure 1;

Figure 3 is a detail elevational view, partly broken away, illustrating one manner of supporting renewable heating units;

Figure 4 is a detail sectional view, on an enlarged scale, of a portion of the kiln structure of Figure 1, illustrating the relationship between the center heating unit and the seal;

Figure 5 is a longitudinal sectional view through a modified form of heating unit;

Figure 5ª is a transverse sectional view, on an enlarged scale, through a heating unit as shown in Figure 5, modified by the addition of heat radiating means thereon;

Figure 6 is a view similar to Figure 5, illustrating another form of heating unit; and

Figure 7 is a partial transverse sectional view, similar to Figure 1, illustrating another embodiment of the invention.

In carrying out the present invention, there may be provided a kiln 2, of the tunnel type, of suitable length and construction, for the purposes intended, the invention not being limited with respect to the construction or manner of use thereof.

Extending lengthwise of the furnace in substantially parallel relationship, are tracks 3 and 4, upon which are adapted to travel carriers or conveyors 5 and 6 respectively. As illustrated in Figure 2 of the drawings, the carriers 5 may move in the direction indicated by the arrow A, while the carriers 6 may travel in the direction indicated by the arrow B. Each of the carriers may be loaded at any desired point exteriorly of the furnace so as to permit them to travel fully charged throughout the entire length of the kiln.

At a point, or points, intermediate the ends of the kiln, there is provided a heating zone or zones, in which the material M on the carriers is brought to the desired temperature.

In Figure 2 of the drawings there is illustrated one heating zone only, this heating zone comprising laterally offset heating chambers 7, on opposite sides of the kiln, each heating chamber being provided with a heating unit 8. The dimensions of each of the heating chambers are preferably such as to constitute a relatively confined heating space for each unit, the width W of each chamber being such, with respect to the width *w* of each heating unit, as to make it possible to effect bodily endwise movement of either of the heating units 8, as indicated in dotted lines in Figure 2, it being understood that the end walls 9 of the heating chambers may be provided with openings temporarily luted or closed, of such diameter as to permit endwise movement of the character referred to. In order to facilitate this movement, the contacts 10 for the heating units extend substantially in longitudinal, axial alignment with the units so that they do not afford any obstruction to free endwise movement.

As illustrated more particularly in Figure 1, each of the heating units 8 may comprise a trough of suitable material, such as silicon carbide having a high heat transfer coefficient, the troughs being filled with a suitable resistance material R, protected by a cover 11. The improved furnace or kiln structure herein illustrated also provides means for effecting a more uniform heating of the material on the carriers.

This is obtained by an intermediate heating unit 12, of a construction generally similar to that of the units 8. The unit 12, however, is preferably carried on the upper end of a ram 13, adapted to be raised or lowered by the admission of fluid under pressure to one end or the other of a cylinder 14.

For effecting the desired sealing of the carriers, they may be provided on opposite sides thereof with downwardly projecting knife edges 15, with the two outside knife edges cooperating with troughs 16, in which are placed a pulverant sealing material. The innermost knife edges cooperate with troughs 17, formed on opposite sides of the ram 13, thereby permitting the ram to be bodily raised or lowered regardless of the presence or absence of carriers within the furnace, and regardless of whether such carriers are moving or stationary, the movement of the center unit into position effecting the desired sealing automatically.

The unit 12 may be provided with flexible electric leads 18, as indicated in Figure 3 of the drawings, thereby permitting the center unit to be bodily raised or lowered at any time during the operation of the furnace.

Considerable difficulty has heretofore been experienced in effecting an efficient connection for heating units of the general character referred to, and for preventing oxidation of the parts thereof under the temperature conditions to which they are subjected. In accordance with the present invention, I may provide terminal blocks 19 for each of the heating units, which blocks may be of graphite or other suitable material, and provided with angularly arranged, threaded openings 20 and 21 for the reception of the conductors 22 and terminals 23 respectively. In order to prevent the free access of air to these parts, the trough and the cover may be extended to embrace and substantially enclose these parts, and thereby shield the same.

At one, or both sides, of the ram, there may be provided a suitable arrangement of fans 24, adapted to direct blasts of cooling air onto the center unit when lowered, not only for the purpose of cooling the same, but for

the purpose of enabling workmen to perform the necessary repair operations thereon, or bodily removal of the same to substitute a new unit. By the substitution, or rapid repair, of such a unit, it will be apparent that it is possible to quickly elevate the same into place without interrupting the continuity of the furnace operation, and without permitting the material within the furnace to undergo such a change in temperature as to destroy the same.

This same operation is likewise possible with respect to the side units, which, as will be apparent, may also be supported by rams of a character similar to those provided for the center unit, or which may be moved endwise in the manner illustrated. The endwise arrangement is preferable, inasmuch as it provides a completely unobstructed space below the kiln, permitting the more expeditious removal of the center unit, or the making of the necessary repairs thereon.

All of the material within the zone defined by the heating units is raised to a substantially uniform temperature and thereafter travels onwardly in opposite directions from this heating zone in such manner that the previously heated material on the carriers 5 serves to preheat the incoming material on the carriers 6, while the previously heated material on the carriers 6 likewise serves to preheat the incoming material on the carriers 5.

I have found that by the provision of a center heating unit of the character herein illustrated, it is possible to maintain the two lines of carriers in such closely adjacent relationship as not to interfere with the desired heat interchange between previously heated material and the incoming raw material. Such a center heating unit also enables the width of the carriers to be materially increased without interfering with the proper heat treatment of the material carried thereby. This, as will be apparent, materially increases the capacity and economy of operation of the total installation. The economy is further increased by the use of removable heating units permitting the same to be almost immediately repaired or renewed, as may be required.

Under the temperature conditions to which the ceramic material is raised, the glaze or coating, particularly where it comprises a lead compound, is caused to sublime, the resulting vapors traveling to cooler portions of the kiln wherein they condense, the condensate dropping indiscriminately at different points throughout the length of the kiln. In accordance with the present invention, there may be provided on opposite sides of each heating zone, regardless of the number of zones, a definite condensation zone. In Figure 2 of the drawings these condensation zones are designated C and C', respectively. In Figure 2ª there is illustrated one form of kiln construction effective for providing definitely located zones of this nature. Such a construction embodies a baffle 25, formed on the roof of the kiln, as indicated in Figure 1, and preferably provided with downwardly converging side walls terminating in a relatively sharp condensate collecting edge 26.

This edge is so located with respect to the length of the individual carriers and/or the disposition of ware thereon, as to cause any condensate to drip downwardly between successive charges, as illustrated diagrammatically in Figure 2ª. In this manner, the possibility of damage to the material is correspondingly reduced. While such a construction does not preclude the possibility of dropping some of the condensate on the ware while the carriers are moving, the moving period under ordinary operation comprises only about two (2%) per cent. of the total time, it thus being obvious that the chances of damage of the character herein contemplated are materially reduced.

If desired, artificial cooling means 27 may be provided for cooperation with each of the condensation baffles in order to produce such a marked change in temperature as to insure the condensation of vapors at the desired points and preclude the passage of any substantial quantity of uncondensed vapors to other parts of the kiln.

In Figure 5 there is illustrated a slightly modified form of heating unit adapted to replace the heating units heretofore described. Such a unit may comprise an outer shell or shield 28, preferably of substantially cylindrical shape, of silicon carbide or other high heat conducting material. Mounted in the opposite ends of this shield are terminal blocks 29, of graphite or similar material, threaded at one end for the reception of terminals 30 and at the opposite end for cooperation with current carrying conductors 31. These conductors are preferably formed in relatively short lengths and are connected at their inner ends by supplemental blocks 32 threaded to provide the desired support and electrical connection therewith.

By making the blocks 29 and 32 of relatively larger cross-sectional area than that of the conductors 31, they are kept at a relatively lower temperature, and thereby the tendency toward oxidation and deterioration is minimized. In order to operatively support the blocks 29 and 32, and also electrically insulate them from the shield 28, there may be provided spacing rings 33 for each of these blocks, such rings preferably comprising a material of refractory nature such as fire clay, or the like.

As illustrated in Figure 5ª, the shield 28', corresponding to the shield 28, may be provided with any desired number or arrange-

ment of heat radiating fins 34 for increasing the dispersion rate of heat therefrom.

In Figure 6 there is illustrated another embodiment of the invention in which conductors 31′ project into opposite ends of a shield through fire clay or other non-conducting refractory rings 33′. The conductors are normally urged inwardly into conducting relationship with the center block 32′, by means of springs or the like 35, working against suitable abutments 36. This construction has the advantage of permitting a quicker replacement of any of the units should occasion require.

The heating units illustrated in Figures 5 and 6 constitute a very decided advance, obviating difficulties heretofore encountered commercially. Heretofore, the high resistances necessitated have required constant reduction in the cross-sectional areas of the resistance units, thereby weakening the same to such an extent that they have frequently failed either due to their inherent weakness or due to excessive operation.

With the present construction, the sectionalizing of the units with an intermediate support or supports obviates this difficulty of inherent weakness, and enables the individual sections to be made as small in diameter as desired for any given resistance. It has been found in actual practice that the intermediate joint or joints constituting a combined tie and support, give the desired results with respect to current carrying ability so that the unit has substantially perfect heat uniformity throughout the entire length. It will be apparent that the number of intermediate joints or supports may be increased at will.

The structure also takes care of excessive oxidation due to the fact that the initial oxygen contained in the shield is immediately changed to carbon monoxide and further oxidation thereby eliminated. In any particular case if excessive infiltration of air should develop, it may be counteracted by trickling into the tube or shield 28 a stream of inert or reducing atmosphere.

In the form of the invention illustrated in Figures 1 and 2, there is shown a combined shield and distributing means in the form of a baffle wall S, located between the side heating units and the tunnel portion of the kiln. Such baffles are rendered unnecessary by the use of heating means of the character illustrated in Figures 5 and 6, in which the shields effectively operate in substantially the same manner. Where the baffle walls S are utilized, they will preferably be of the serrated or corrugated construction generally illustrated in Figure 2 in order to obtain, by virtue of the larger surface, greater heat absorption and heat emission properties.

In some cases I have found it advantageous to provide duplicate heating units at both sides of the kiln and in the center thereof, as indicated in Figure 7, wherein there are shown units 37 in superimposed relationship. These units are preferably connected in parallel with respect to the power supply, whereby either unit may be removed at will independently of the other without interfering with the operation of the furnace. The necessary changes in connections to permit the removal of one unit could be made, as well understood in the art, by means of a suitable series-parallel switch, or its equivalent. A construction of this character insures the provision of at least one heating unit at all times effective for supplying heat to the material and enables the kiln operation to be carried on regardless of the failure of one unit.

A series-parallel arrangement of the general character referred to has also been found to be of advantage in obtaining a slower initial heating with a consequent minimizing of the possibility of cracking and breaking. For example, if a furnace or kiln is started up cold, the units may be placed in series and later switched over to parallel. With two units in series, they will obviously develop only one-fourth as much heat as will be developed when in parallel, while with three units in series, the heat developed will only be one-ninth of what it will be with three in parallel. A small rate of heat input during the starting will slowly cure the tubes and units, and decrease the possibility of damage thereto.

The construction of the heating chambers 7 will also preferably be such as to permit the heating units, particularly when of the construction illustrated in Figures 5 and 6, to be adjusted vertically or laterally with respect to the material in the kiln whereby the desired heating and heat distribution may be obtained in order to give the most satisfactory results.

I claim:—

1. In a continuous, direct, electric resistance heating furnace, a plurality of material conveying means arranged in substantially parallel horizontally extending paths, a support mounted between the paths and extending through the bottom of the furnace, an electric resistance heating unit mounted on the support, and means for lowering the support with the heating unit thereon clear of said material conveying means to a point without the furnace.

2. In a continuous, direct, electric resistance heating furnace, a plurality of material conveying means arranged in substantially parallel horizontally extending paths and extending through the bottom of the furnace, a support between the paths, means for preventing loss of heat from the furnace between the conveying means and the aforesaid support, an electric resistance heating unit

removably mounted on the support, and means for lowering the support and the heating means thereon clear of said material conveying means to a point without the furnace.

3. In a continuous, direct, electric resistance heating furnace, a plurality of material conveying means arranged in substantially parallel horizontally extending paths, said conveying means being provided with means for moving them in opposite directions through the furnace, angles attached to the material conveying means, a support mounted between the paths, means attached to the support cooperating with the aforesaid angles for effecting sealing of the heating chamber, an electric resistance heating unit removably mounted on the support, and means for lowering the support with the heating unit thereon clear of the material conveying means and the angle attached thereto to a point without the furnace.

4. In a continuous, direct, electric resistance heating furnace, a plurality of material conveying means arranged in substantially parallel horizontally extending paths, a support mounted between the paths and extending through the bottom of the furnace, a substantial rigid intermediate electric resistance heating unit mounted on the support, means for lowering the support and the heating unit thereon clear of said material conveying means to a point without the furnace, and electric resistance heating units located along the outside edges of the aforesaid paths, said last mentioned heating units being mounted for easy removal from the furnace, whereby the furnace may be continued in operation during the period of removal of the intermediate heating unit.

5. In a continuous, direct, electric resistance heating furnace, a plurality of material conveying means arranged in substantially parallel horizontally extending paths, a support mounted between the paths and extending through the bottom of the furnace, an electric resistance heating unit mounted on the support, means for lowering the support and the heating unit thereon clear of the material conveying means to a point without the furnace, and heating units and baffle plates located along the outside edges of the aforesaid paths whereby the furnace may be continued in operation during the period of removal of the first mentioned heating unit.

6. In a continuous, direct, electric resistance heating furnace, a plurality of material conveying means arranged in substantially parallel horizontally extending paths, a heating unit mounted between the paths and extending through the bottom of the furnace, heating units located in laterally offset portions of the furnace and adjacent the outside edges of said paths and individual means for removing each heating unit from the furnace without disturbing the continued operation thereof, the remaining units being arranged to substantially maintain the furnace heat.

In testimony whereof I have hereunto set my hand.

FRANK W. BROOKE.