G. H. BENJAMIN.

TUNNEL KILN.

APPLICATION FILED MAY 21, 1917. RENEWED JULY 10, 1918.

1,294,756. Patented Feb. 18, 1919.

3 SHEETS—SHEET 1.

FIG. 1.

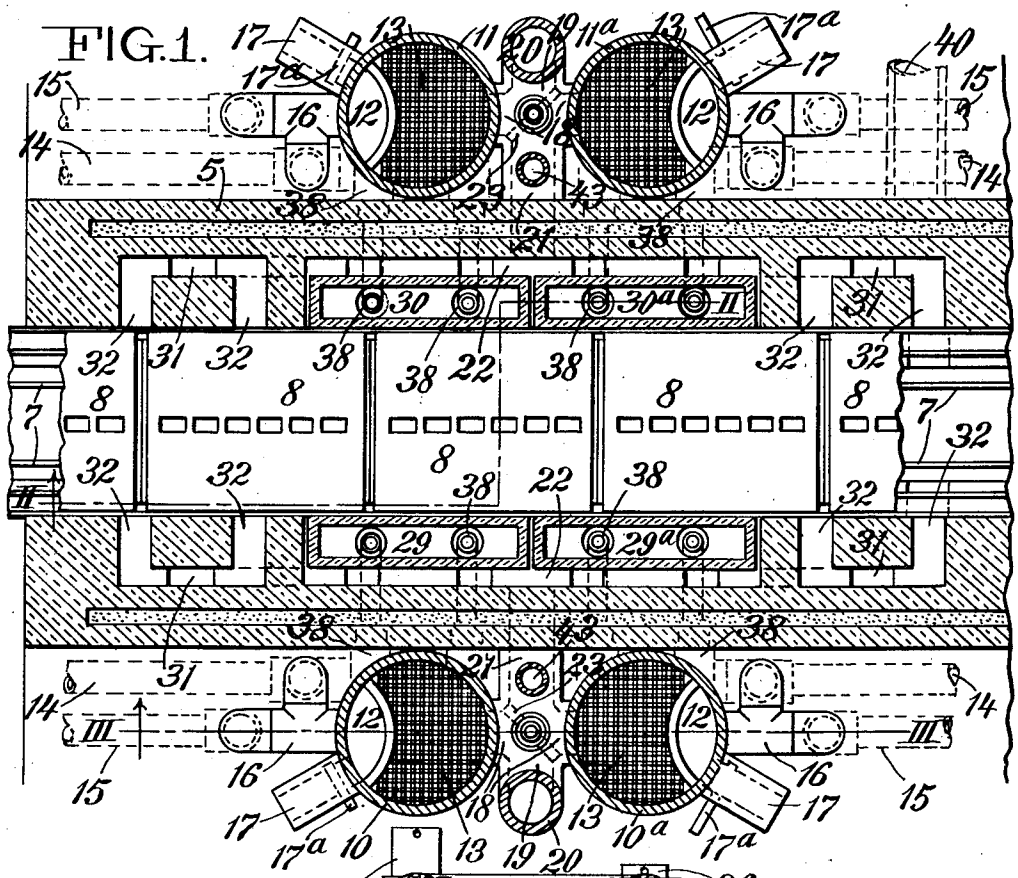
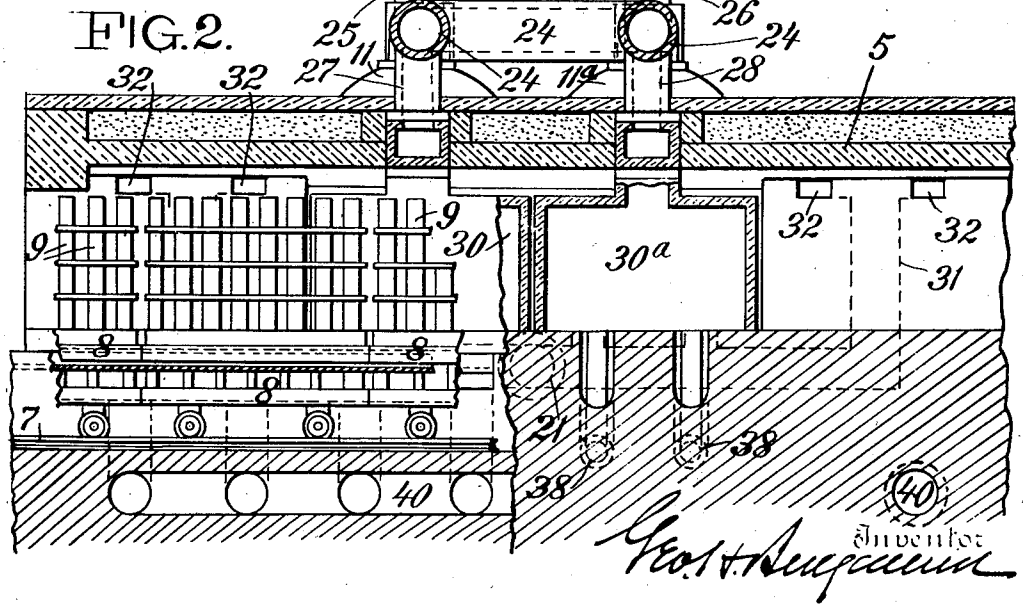


FIG. 2.



Inventor

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FIG. 3.

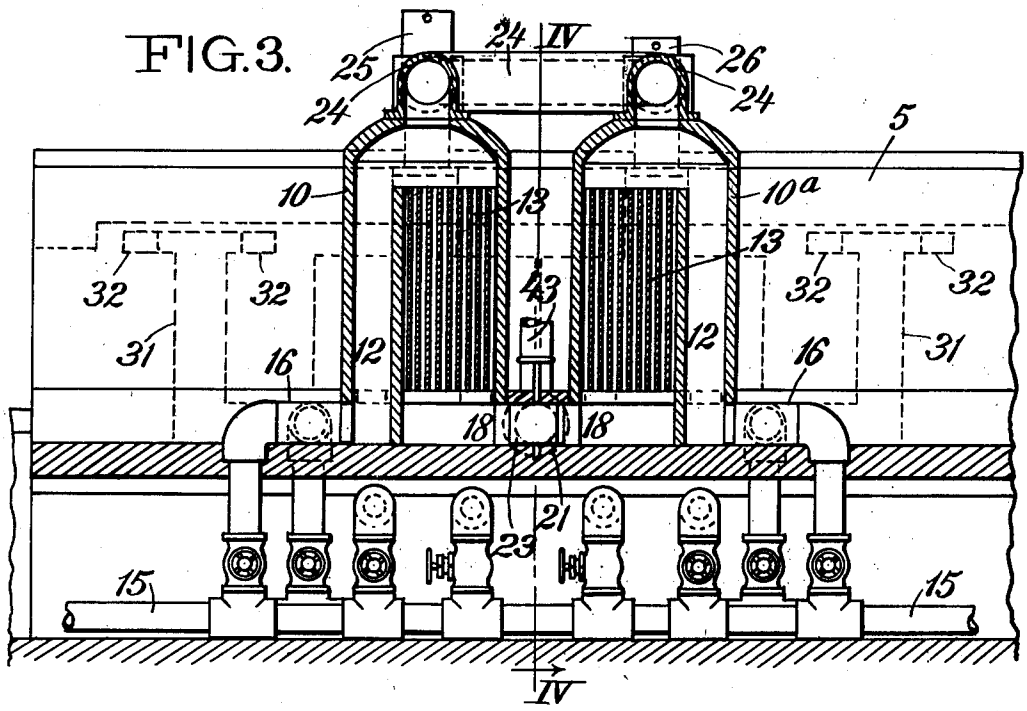
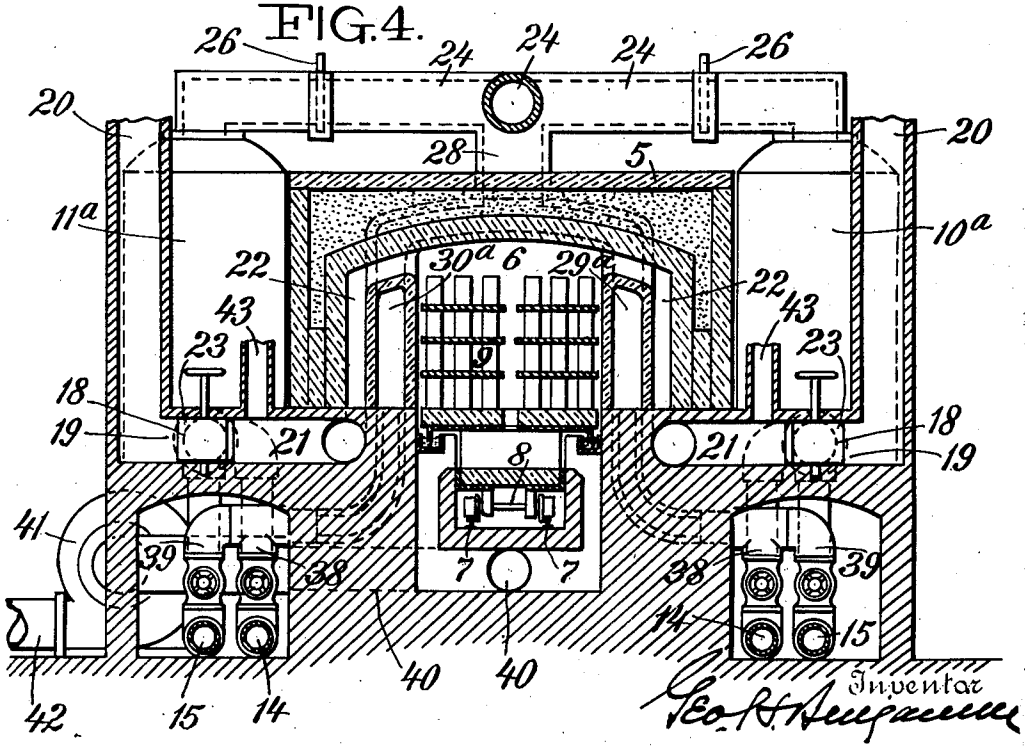


FIG. 4.



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3 SHEETS—SHEET 3.

FIG. 5.

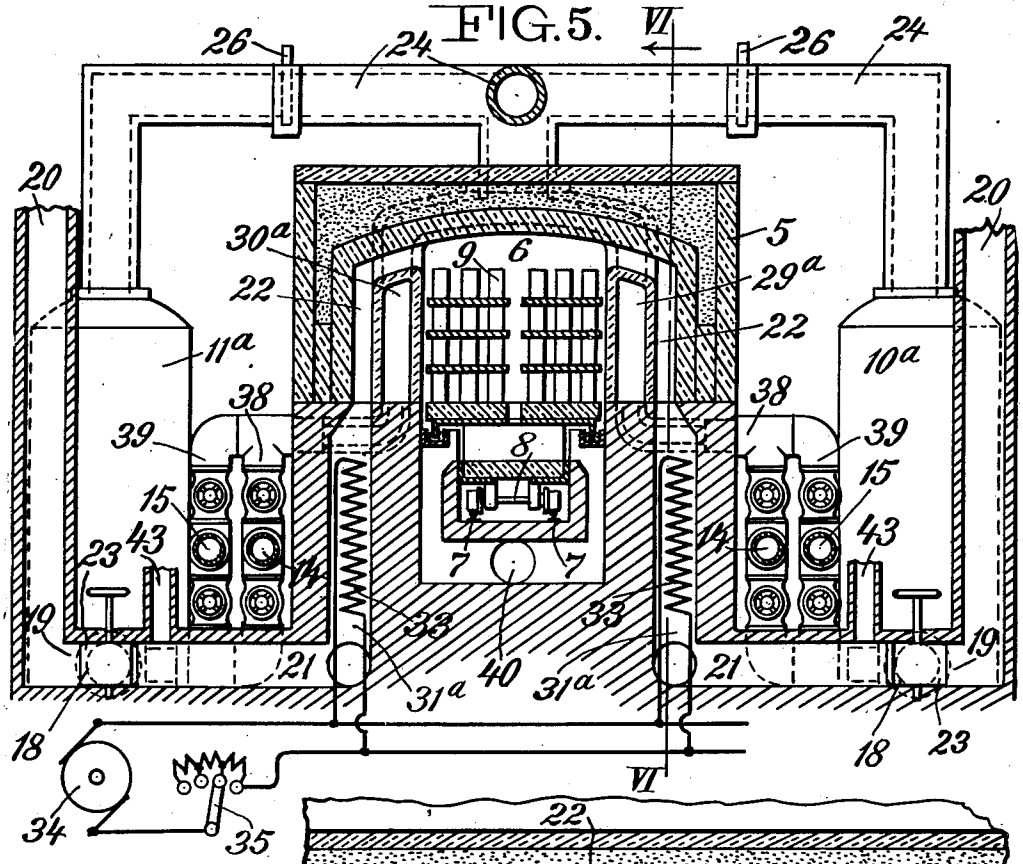
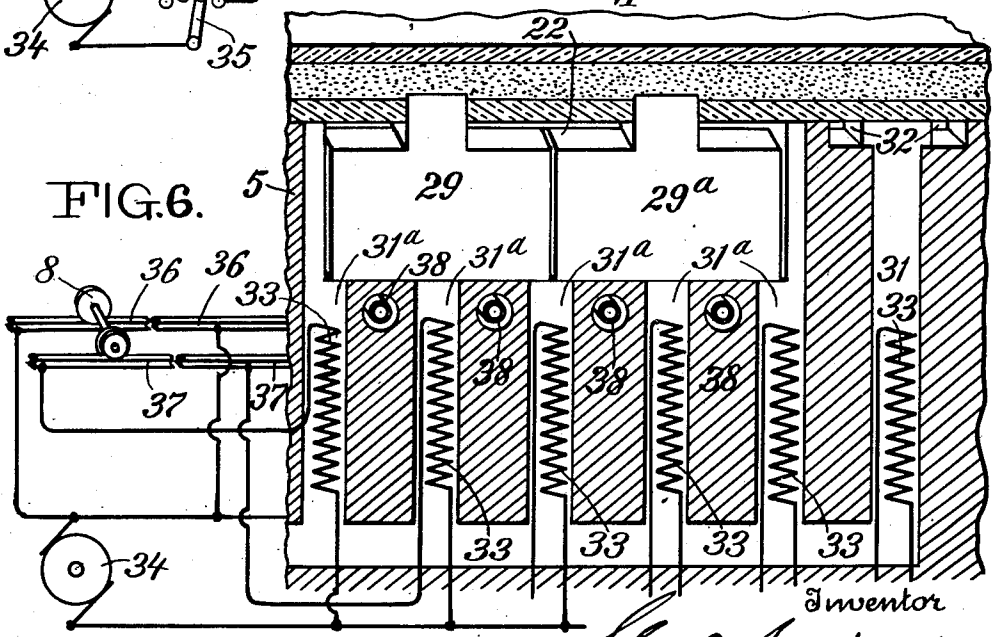


FIG. 6.



Inventor

Geo. H. Benjamin

UNITED STATES PATENT OFFICE.

GEORGE HILLARD BENJAMIN, OF NEW YORK, N. Y.

TUNNEL-KILN.

1,294,756. Specification of Letters Patent. Patented Feb. 18, 1919.

Application filed May 21, 1917, Serial No. 169,865. Renewed July 10, 1918. Serial No. 244,315.

To all whom it may concern:

Be it known that I, GEORGE HILLARD BENJAMIN, a citizen of the United States, residing at the city, county, and State of New York, have invented certain new and useful Improvements in Tunnel-Kilns, of which the following is a specification.

Tunnel kilns as heretofore constructed, have been heated, *i. e.*, those of the "direct fire" type by coal or gas furnaces, located external to the chamber in which the goods are treated, and situated either at one end of or at the center of the chamber; the products of combustion from such furnaces being carried through or partially through the treating chamber and out through a suitable chimney or chimneys. Those of the "muffle type," by closed combustion chambers located within the chamber, in which the goods are treated and situated along the floor at each side of the chamber, over which combustion chambers currents of air are caused to pass and are distributed through the chamber and the goods in the chamber, and are drawn out of the chamber, the products of combustion from the combustion chambers within the chamber, being carried out of the combustion chambers by a suitable chimney or chimneys.

Kilns of the "direct fire" type, may be used for the treatment of materials which will not be injured by the products of combustion passing through the treating chamber. Where used for treating materials which would be injured, it is necessary to employ saggers to protect the goods. When the construction is of the "muffle" type, it is not necessary to use saggers.

In each type of furnace as heretofore constructed, it has been found difficult to regulate the relative temperature of sections of the kiln along its length. In kilns of the "direct fire" type, the temperature of the introduced products of combustion is greatest at the point of the introduction of such products of combustion, whereas the proper treatment of materials which may be treated in such kilns, frequently requires that the temperature shall be greatest at some other point along the length of the kiln. In kilns of the "muffle" type, it is theoretically possible to regulate the relative temperature at different sections of the length of the kiln by controlling the degree of combustion in the different combustion chambers along the kiln and by controlling the ingress of air over such chambers, etc. Practically, however, there is a tendency of the heated air in the kiln to move from the zone of lowest temperature to the zone of highest temperature, which movement disturbs the balance or the special temperatures required at different points along the length of the kiln.

My present invention is designed to overcome the objections above stated, and this is accomplished by combining in a single kiln, the features of construction of the "direct fire" type and the "muffle" type, and in addition, the provision of means situated along the kiln for boosting (manually or automatically) the temperature of the introduced air at any desired point or points, at all times or as required.

I will describe my invention as applied to a kiln designed for the treatment of pottery having vitrified enameled surfaces. It will be understood by those skilled in the art, that by slight modifications in the construction, the kiln may be used for the treatment of bricks, annealing of metal and various other substances, as for instance kelp to effect dehydration, etc.

The accompanying drawings will serve to illustrate one form of construction of my improved kiln, in which:

Figure 1 is a plan view of the middle section of a kiln.

Fig. 2 is a double longitudinal section on the line II—II of Fig. 1.

Fig. 3 is a vertical section taken on the line III—III of Fig. 1, taken through the hot blast stoves and looking toward the body of the kiln.

Fig. 4 is a transverse section taken on the line IV—IV of Fig. 3, looking to the right of Fig. 3.

Fig. 5 is a transverse section showing a modification of the structure of the kiln taken substantially on the same line as Fig. 4.

Fig. 6 is a longitudinal vertical section taken substantially on the line VI—VI of Fig. 5, looking toward the body of the kiln, and also illustrating in perspective at the left of the drawing, rails used for conveying the material to be treated through the treating chamber, as also the circuit connections.

Referring to the drawings; 5 indicates the body of the kiln, which may have any suitable construction. Located within the body of the kiln, is a treating chamber 6.

Arranged in the bottom of the treating chamber are rails 7, on which is located a truck 8 adapted to support the material 9 to be treated, and carry such material through the kiln. Located outside and at opposite sides of the treating chamber, preferably at about its center, are pairs of hot blast stoves 10, 10ª, 11, 11ª. These stoves are adapted to be operated in pairs, one of each pair being situated at opposite sides of the kiln, for instance, 10 and 11, or 11 and 11ª. These hot blast stoves are of the usual construction given to such apparatus, and each consists of a combustion chamber 12, a heating chamber 13, a gas pipe 14, an air pipe 15, a mixing pipe 16 leading into the bottom of the combustion chamber, a dry air supply pipe 17 provided with a valve 17ª also leading into the bottom of the combustion chamber, and an exit pipe 18 connected to the bottom of the heating chamber 13 and having two branches, one branch 19 connected to the chimney flue 20 and one branch 21 connected to flues 22 and 31 in the side walls of the treating chamber 6. A butterfly valve 23, situated in pipe 18, has for its purpose to direct the body passing through the hot blast stoves, either through pipe 19 to chimney flue 20 (products of combustion) or when the position of the valve is shifted, through pipe 21 to flues 22 and 31 in the walls of the kiln (hot air currents).

It will be seen by reference to the drawings (Fig. 1) that when the butterfly valve 23 is in the position shown, the two hot blast stoves 10—11 at the left of the figure are delivering products of combustion to the chimney flue 20, while the two hot blast stoves 10ª—11ª, at the right of the figure are delivering air to the flues 22—31.

The operation of the hot blast stoves will be readily understood. Gas and air is introduced through pipes 14, 15 and 16 into the chamber 12, then burned. The products of combustion from the chamber 12 pass upward and then downward through the heating chamber 13, and then out through pipes 18 and 19 to chimney flue 20, heating the structure of the heating chamber 13 during their passage. When the heating chamber has been brought to the required temperature, the butterfly valve is shifted the gas and air shut off through pipes 14, 15 and 16 and valve 17ª in pipe 17 opened, which allows air to enter through the pipe 17. The air entering, passes up the combustion chamber 12, down the heating chamber to pipe 18, through pipe 21 to flues 22—31 in the body of the kiln. In order to aid in heating the heating chamber 13, the top of all the hot blast stoves are connected by a pipe 24 in which are valves 25—26. The pipe 24 is also connected through pipes 27—28 with combustion chambers 29, 29ª, 30, 30ª, located within the body of the kiln and situated in the vicinity of the hot blast stoves. With the butterfly valve in the position shown in Fig. 1, the valve 25 in pipe 24 will be opened and the valve 26 closed. Hence the products of combustion from within the combustion chambers 29, 29ª, 30, 30ª will flow through pipe 27 to pipe 24, thence through the heating chamber 13 to chimney flue 20, the products of combustion aiding to heat the chambers 13.

It is not essential however, to connect the top of the hot blast stoves with the chambers 29, 29ª, 30, 30ª, although it is advisable, as advantage is taken of the heat of the products of combustion leaving the chambers 29, 29ª, 30, 30ª.

The hot dry air delivered from the hot blast stoves 10, 10ª, 11, 11ª, is introduced into the treating chamber 6 of the kiln, through the flues 22, which deliver the heated air behind the combustion chambers 29, 29ª, 30, 30ª and flues 31 located along both sides of the treating chamber, adapted to deliver air into the upper part of the treating chamber through ports 32, the construction of which is best shown in Fig. 3.

Situated in the flues 31—31ª connecting pipes 21 with flues 22, are resistance coils 33 or other electric heating means, adapted to be put in circuit with the dynamo 34. The passage of electricity through the coils disposed along the length of the kiln, may be controlled by hand operated switches 35, as shown in Fig. 5, or a coil or coils may be connected to sectional rails 36—37 arranged along the length of the kiln, so that when truck 8 bridges a pair of rails, it will close the circuit through a coil or pair of coils or groups of coils arranged along any part of the length of the kiln. It will be observed from the drawings, that the combustion chambers 29, 29ª, 30, 30ª are shown as located at about the center of the kiln and these combustion chambers are adapted to be heated by gas and air in combustion, fed through branch pipes 38—39 connected to pipes 14—15. The products of combustion from the combustion chambers 29, 29ª, 30, 30ª are carried off through pipe 27 to pipe 24, and thence through the path heretofore described, to chimney flue 20. The hot air from the hot blast stoves, passes over the combustion chambers 29, 29ª, 30, 30ª, which materially increases the heat of the air, so that the central zone of the kiln is the hottest zone. Manifestly, chambers such as 29 and 29ª, may be located anywhere along the length of the kiln so as to impart heat to the incoming hot air and determine the temperature of any desired zone. What is true of the combustion chambers 29, 29ª, is likewise true of the heating devices 33. The air passing over the heating devices in the flues 31, receives additional heat; in other words, the chambers 29, 29ª,

30, 30ª and heating devices 33 in the flues 31ª and 31 act as heat boosters.

40 represents a flue leading from the bottom of the treating chamber to the induction orifice of a pump 41. The eduction orifice of the pump 41 is connected to a pipe 42 which discharges into the atmosphere, or may be connected to an apparatus (not shown) suitable for drying air and to deliver such air to the pipe 17. Apparatus for drying air is now commonly used in hot blast stoves, and I have not thought it necessary to illustrate such an apparatus in the present application.

As it is sometimes desirable to introduce moisture or a gas into the air currents entering the kiln, I provide the pipe 43 connected to the flues 21. The moisture or gas introduced into the flues 21, is distributed to the interior of the kiln in connection with heated air, through the flues 22 and 32. By slightly modifying the construction of the kiln, that is, the position of the flues, controlling valves, etc., they may be arranged to deliver, in connection with the air, moisture or gases at one section of the length of the kiln, as for instance the first section, and heated air without additional moisture or gases in the second section, and so on to the end of the kiln. As this is an obvious change in construction, I have not thought it necessary to illustrate it.

The operation of the kiln of the type described, will be readily understood. The hot air from the hot blast stoves is discharged into the treating chamber, and assuming that the heat boosters are not in operation, the air passes through the treating kiln, over the material in the kiln, and thence by flue 40 to blower 41, by pipe 42, to any suitable device which will heat and dry the air introduced into the hot blast stoves through the pipe 17. Manifestly the temperature of the air introduced is highest at the point of location of the hot blast stoves and lowest at the inlet and outlet of the kiln. If it is desired that the temperature of the kiln at the central zone shall be higher than that of the air delivered from the hot blast stoves, gas and air is introduced into the combustion chambers 29, 29ª, or 30, 30ª, which boosts the temperature of the air. If, on the other hand, it is desired that the temperature of the air shall be highest at the inlet end of the kiln, the heating devices 33 in flues 31 near the inlet of the kiln are coupled with the dynamo 34, which boosts the temperature at the inlet end. If it is desired that the temperature of the air shall be varied along the length of the kiln, *i. e.*, higher at one point and lower at the other, and again higher and lower, etc., the heating devices 33 located along any section of the length may be connected with the dynamo, the coils of the next section unconnected with the dynamo and the next section connected and so on.

It will be seen that the boosting devices provided are such that the temperature at any section of the length of the kiln, or adjacent sections, can be determined to suit requirements. In Fig. 6 means are shown for automatically throwing the heating devices 33 into operation by movement of the truck 8 as it closes the circuits connected to sectional rails arranged at different portions of the length of the kiln.

It will be observed from the drawings, that the hot air introduced into the kiln in the vicinity of the combustion chambers, enters at the bottom of the kiln and passes over the combustion chambers to be delivered into the kiln, passes over the material 9 under treatment, and out of the kiln under the action of the blower 41, whereas the hot air introduced into the kiln through the flues 31 and ports 32, is delivered into the top of the treating chamber and out of the treating chamber under the action of the blower 41.

The drawings show that valves are provided for controlling the various gas and air pipes. These I have not numbered, as their position and function will be sufficiently plain from the drawings. I wish it understood that I do not limit myself in any wise to the type of hot blast stoves illustrated. Any suitable device may be employed to heat the air introduced into the treating chamber. I prefer to use hot blast stoves, as experience with such devices, where heated and dry air is introduced through them (as in blast furnace work) has shown them to be highly efficient and economical. Further, I do not limit myself to the particular type of electric heating device used. I have shown in the drawings, simply coiled resistance wire. Any well known type of electric heating device may be substituted for the wire coils. Such heating device likewise may be coupled in any suitable manner with the source of energy, so that any pairs of coils or groups of coils at any part of the length of the kiln, may be employed, as desired, in accordance with the temperatures which are required within the kiln structure. By reason of such auxiliary supplemental heating devices, the temperature at any section of the length of the kiln can be regulated to a nicety, which condition is not possible in any kiln heretofore constructed. Further, by reason of the auxiliary electric heating devices, the temperature at any section of the length of the kiln can be defined and held at that particular temperature; thus by putting into operation the electric heating devices at the front end of the kiln, leaving the heating devices at the next section of the kiln out of operation, and put-

ting into operation the next group of heating devices along the length of the kiln, the temperature created in zone at the mouth of the furnace, will not affect the temperature of successive zones toward the center, the low temperature between heated and unheated zones acting as an air shield to confine the temperature to the particular zone where it is desired. This is a new result in kilns, as in the ordinary construction, where the heated air is introduced at the center of the kiln, the tendency is for the heat to diffuse itself equally throughout the length of the kiln, which interferes materially with the temperature effects which it is desired to obtain.

It is well known in practice, that in treating certain material, it is necessary to subject them first to a low humid temperature to gradually heat the body, then to a higher drier temperature to set up exudation of the moisture, then to a lower temperature to cool down the body to prevent the body checking, then to a quickly applied high dry temperature to vitrify the surface, the temperatures again being varied from the vitrifying point to the cooling point at the rear end of the furnace.

I have made the above explanation to bring out the functional operation of the heat boosters, not only as regards their value in increasing and defining the temperature, but in confining the temperature, or otherwise regulating the temperature along sections of the length of the kiln.

I further wish to point out that through the use of the supplemental electric boosters, the temperature of the kiln at any moment may be automatically regulated by the passage of the material through the kiln, and confined to a certain zone for the time and thus effect a considerable saving of heat energy.

Having thus described my invention, I claim:

1. In a tunnel kiln, the combination of a treating chamber, means for heating air located exterior to the chamber and adapted to discharge heated air into the chamber, means for drawing the heated air out of the chamber, and means within the chamber for adding to the heat of the introduced heated air.

2. In a tunnel kiln, the combination of a treating chamber, means for heating air located exterior to the chamber and adapted to discharge heated air into the chamber, means for drawing the heated air out of the chamber, and means located within the chamber and at separated points along the chamber for adding to the heat of the introduced heated air.

3. In a tunnel kiln, the combination of a treating chamber, means for heating air located exterior to the chamber and adapted to discharge heated air into the chamber, means for drawing the heated air out of the chamber, and separately controlled means located within the chamber for adding to the heat of the introduced heated air.

4. In a tunnel kiln, the combination of a treating chamber, means for heating air located exterior to the chamber and adapted to discharge heated air into the chamber, means for drawing the heated air out of the chamber, and electrically heated means within the chamber and located along the chamber for adding to the heat of the introduced heated air.

5. In a tunnel kiln, the combination of a treating chamber, means for heating air located exterior to the chamber and adapted to discharge heated air into the chamber, means for drawing the heated air out of the chamber, and means located about the center of the kiln and heated by the combustion of gas and air, and means located along the length of the kiln and heated by electric current, for adding to the heat of the introduced heated air.

6. In a tunnel kiln, the combination of a treating chamber, means for heating air located exterior to the chamber and adapted to discharge heated air into the chamber, means for drawing the heated air out of the chamber, and means consisting of two sets of heating devices heated by different means and separately controlled, and located within the chamber, for adding to the heat of the introduced heated air.

7. In a tunnel kiln, the combination of a treating chamber, means for heating air located exterior to the chamber, said means consisting of hot blast stoves arranged in pairs and located on opposite sides of the chamber, means whereby one of each pair of stoves may be connected with the interior of the kiln to deliver hot air therein or to the chimney flues to direct the products of combustion passing through such stoves and after heating them to the chimney flue, means for feeding gas and air to said stoves at intervals, and means for feeding dry air to said stoves at intervals.

8. In a tunnel kiln, the combination of a treating chamber, means for heating air located exterior to the chamber consisting of two pairs of hot blast stoves located on opposite sides of said chamber and situated about midway of the length of the chamber, means for supplementing the heat of the air currents derived from said hot blast stoves located within the combustion chamber and in proximity to said stoves, and flues through which the hot air is delivered communicating between the hot blast stoves and the interior of the kiln.

9. In a tunnel kiln, the combination of a treating chamber, a series of air flues and air discharge ports located in the walls of

the chamber and communicating with the interior of the chamber, means for introducing heated air into said flues and discharging it into the chamber, and means in said flues for supplementing the heat of the introduced air.

10. In a tunnel kiln, the combination of a treating chamber, two pairs of reversible hot blast stoves located exterior to the treating chamber, flues introduced between the hot blast stoves and the interior of the chamber and between the hot blast stoves and the chimney flue, means for directing the hot air passing through two of the stoves at the time into the interior of the kiln and the products of combustion passing through the other two of the stoves at the time to the chimney flue, means for heating the hot blast stoves, and means for introducing dry air into the hot blast stoves according to whether the hot blast stoves are connected with the chimney flue or the interior of the kiln.

11. In a tunnel kiln, the combination of a treating chamber, a series of flues arranged in the walls of the chamber, said flues having port openings into the chamber, said port openings arranged to discharge into the upper portion of the chamber along certain portions of its length and into the lower portion of the chamber along other portions of its length, together with means for introducing hot air and means for withdrawing the hot air from the kiln.

12. In a tunnel kiln, the combination of a treating chamber, a series of combustion chambers arranged in line at each side of the chamber and located approximately at the center of the kiln, means for heating said combustion chamber, and means for introducing hot air into the treating chamber near the bottom of and behind the combustion chambers.

13. In a tunnel kiln, the combination of a treating chamber, a series of combustion chambers arranged in line at each side of the combustion chambers, means for heating the combustion chambers, means for conveying the products of combustion of the combustion chambers away from the combustion chambers, two pairs of hot blast stoves located at each side of the combustion chamber, means introduced between the combustion chambers and the hot blast stoves whereby the products of combustion from the combustion chambers will at intervals be directed through one of each oppositely disposed pair of hot blast stoves, a chimney to which the hot blast stoves are connected and means controlling the direction of flow of the products of combustion from the combustion chambers to the respective pairs of hot blast stoves.

14. In a tunnel kiln, the combination of a treating chamber provided with a series of ports and passages arranged along each side of the chamber and adapted to introduce air into the chamber, electric heating devices located in each of said air passages, means for feeding electric current to said heating devices, and means whereby the heating devices may successively be brought into operation to heat incoming air.

In testimony whereof I affix my signature in the presence of a witness.

GEORGE HILLARD BENJAMIN.

Witness:

LESTER BEARDSLEY.