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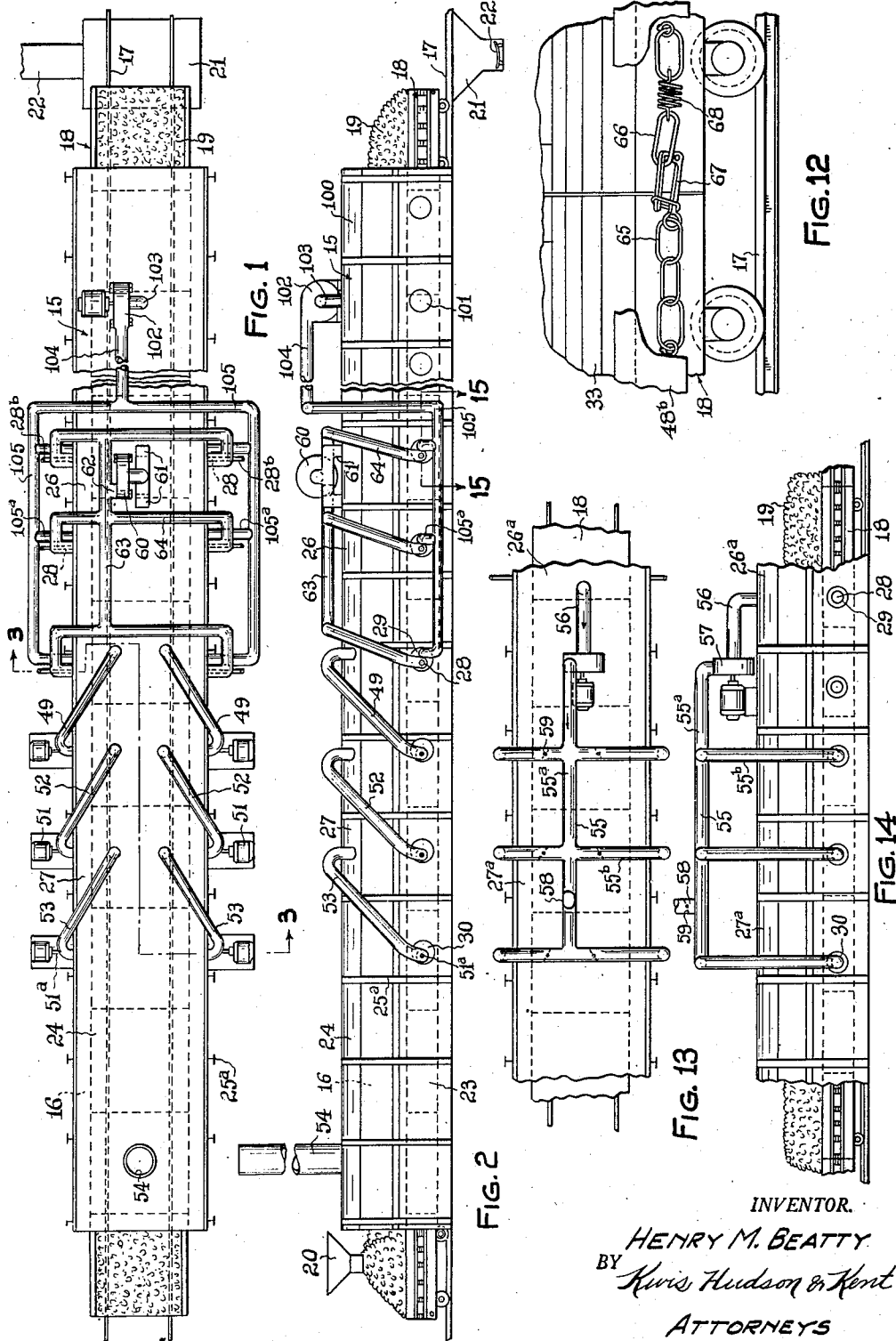
H. M. BEATTY

2,386,835

KILN

Filed July 4, 1942

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H. M. BEATTY

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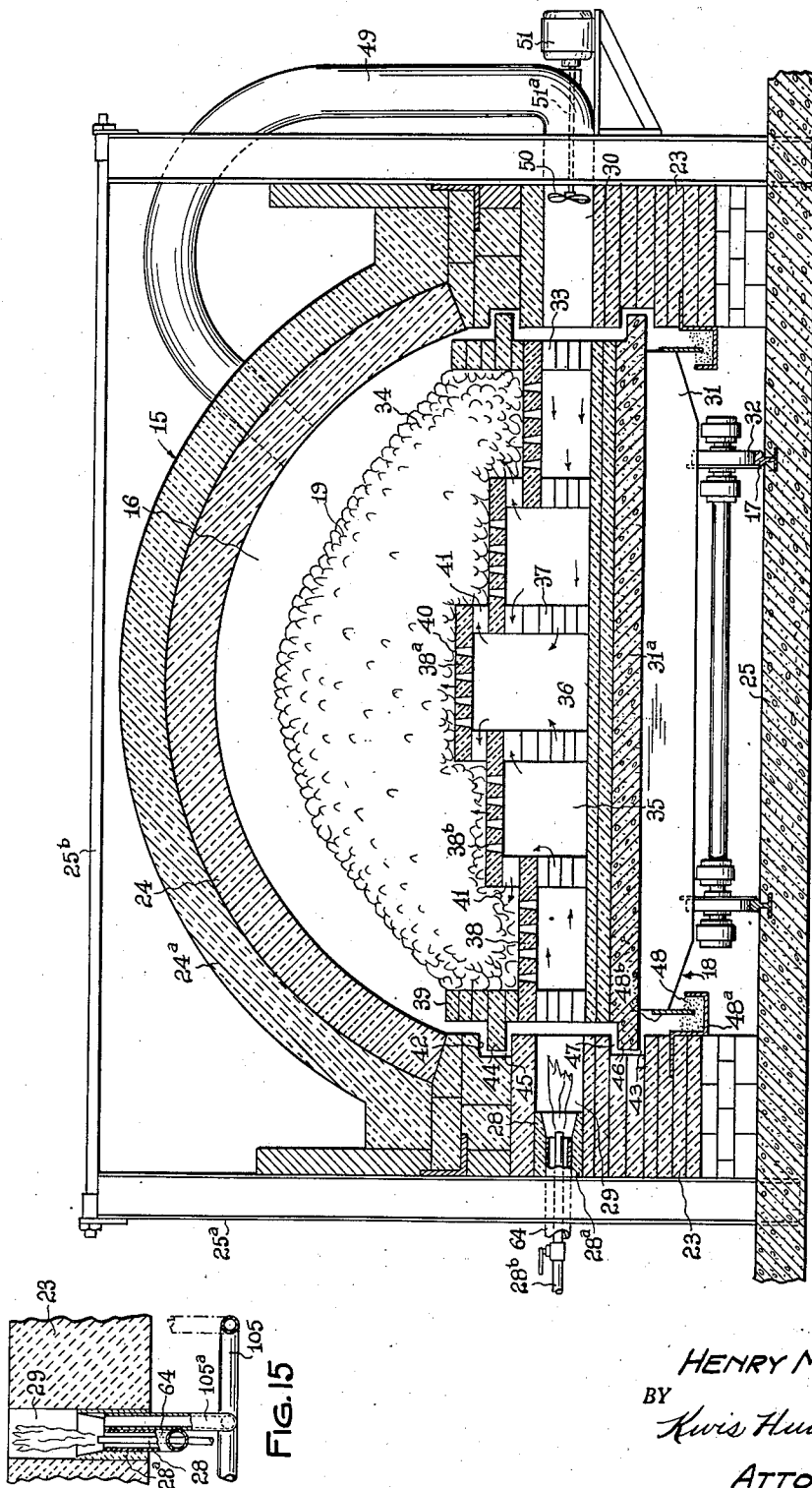


FIG. 3

FIG. 15

INVENTOR.
HENRY M. BEATTY
BY *Kuris Hudson & Kent*
ATTORNEYS

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H. M. BEATTY

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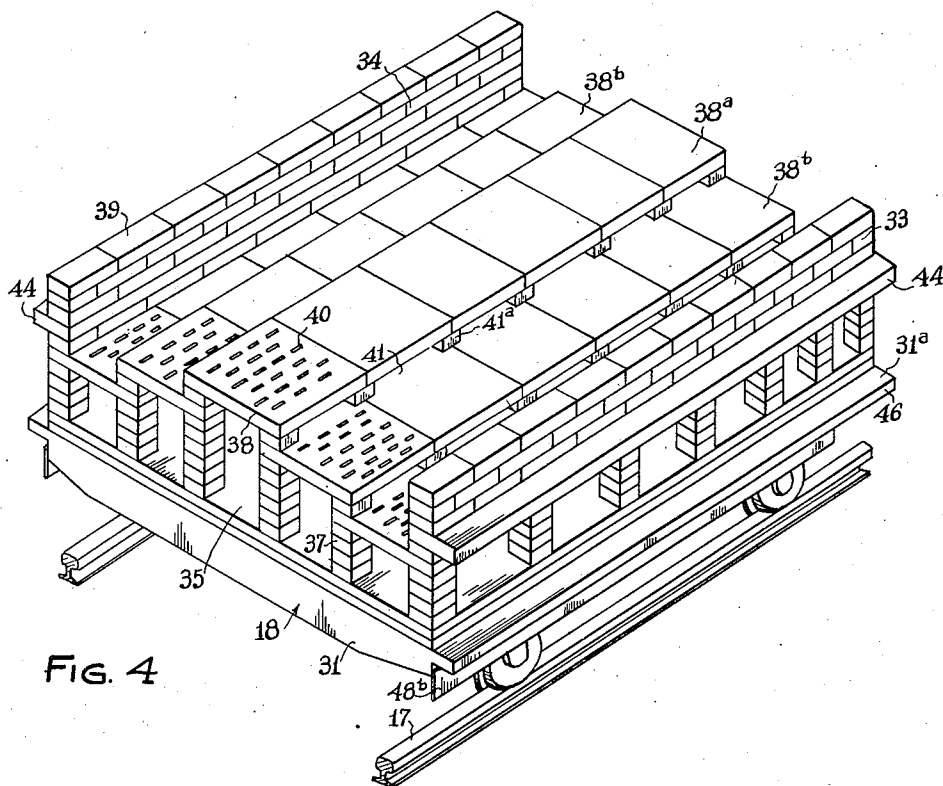


FIG. 4

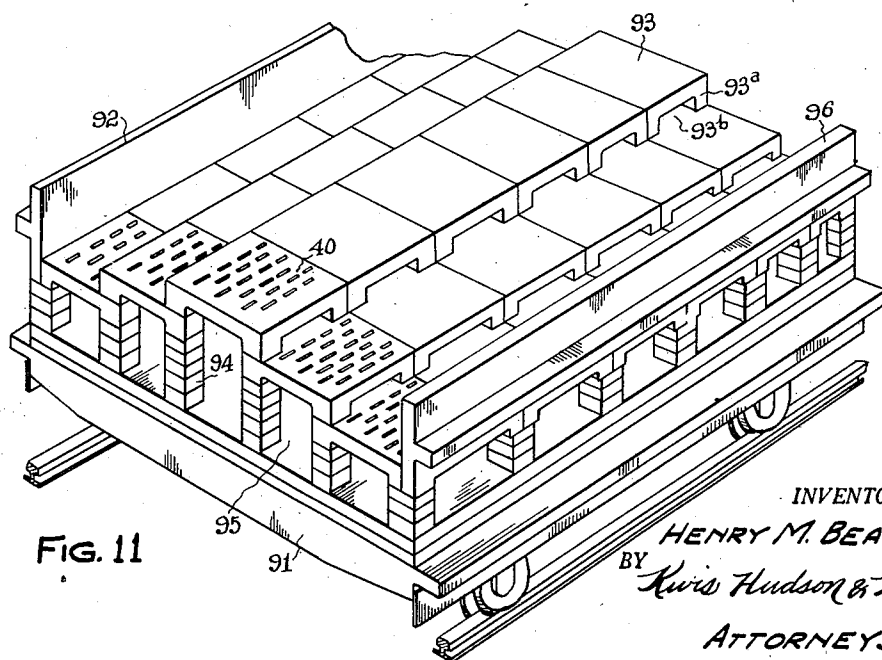


FIG. 11

INVENTOR.
HENRY M. BEATTY
BY *Kewis Hudson & Kent*
ATTORNEYS

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H. M. BEATTY

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5 Sheets-Sheet 4

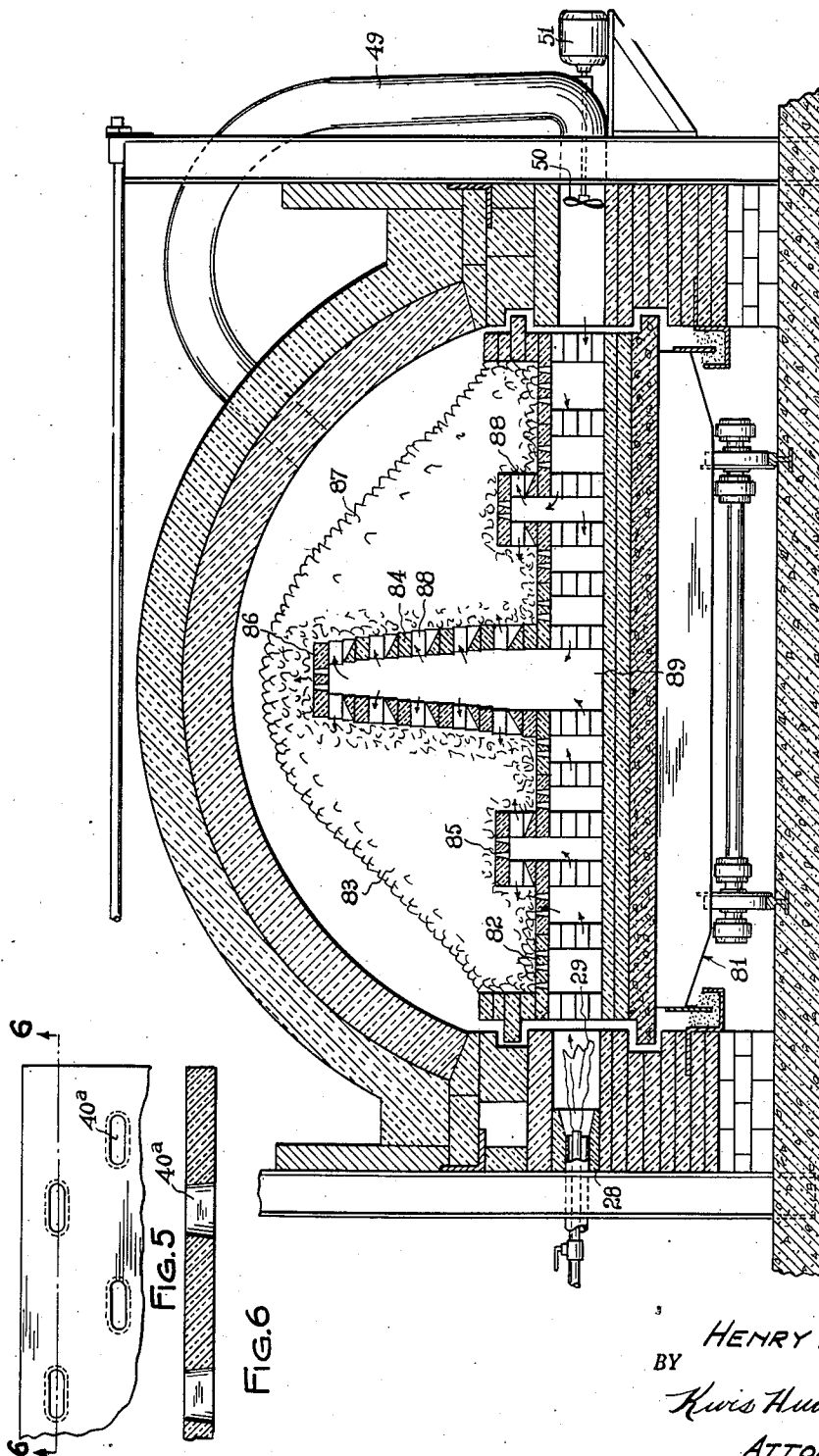


FIG. 10

INVENTOR.

HENRY M. BEATTY

BY

W. H. Hudson & Kent

ATTORNEYS

Oct. 16, 1945.

H. M. BEATTY.

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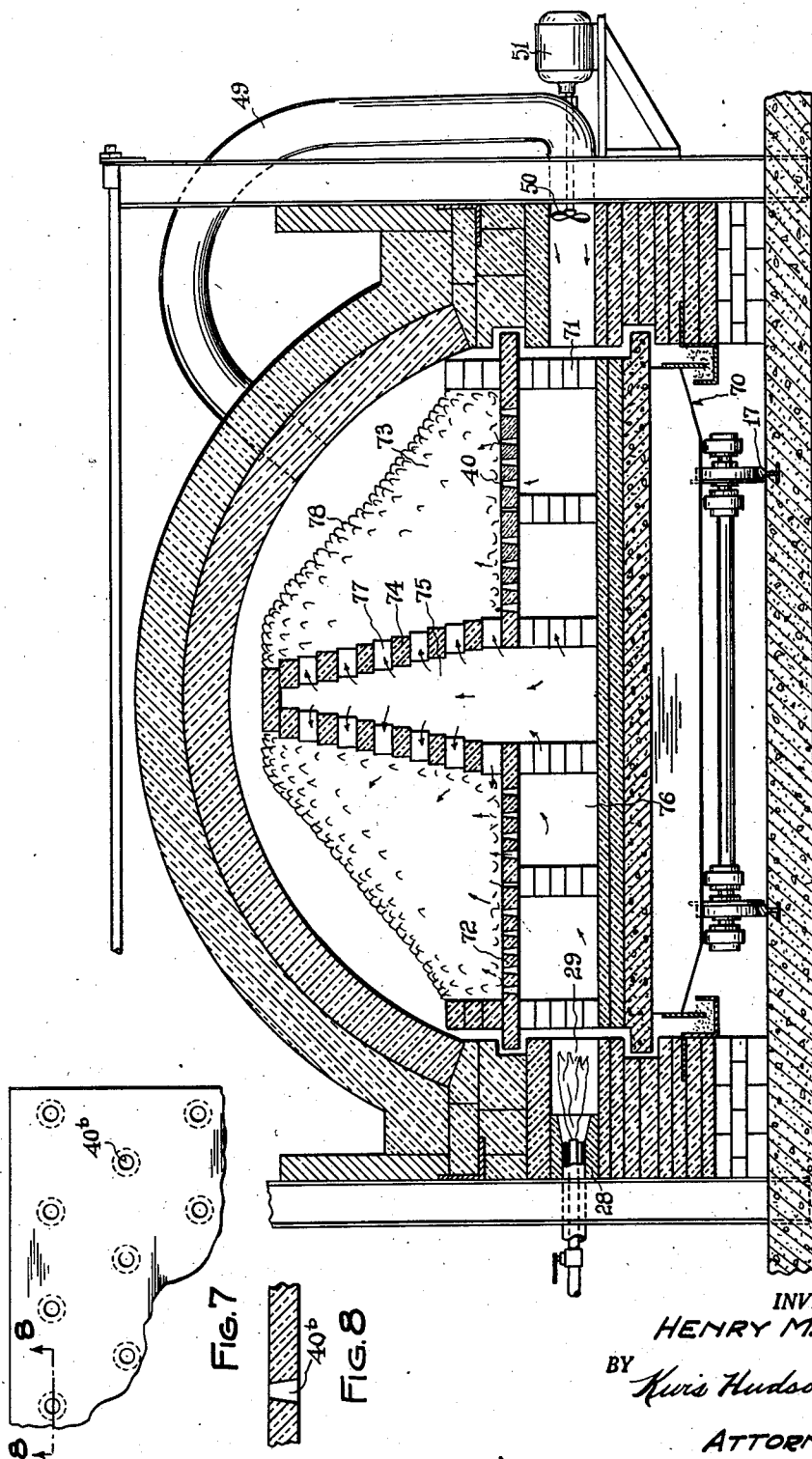


Fig. 9

Fig. 7

Fig. 8

INVENTOR.
HENRY M. BEATTY
BY *Wesley Hudson & Kene*
ATTORNEYS

UNITED STATES PATENT OFFICE

2,386,835

KILN

Henry M. Beatty, Shaker Heights, Ohio, assignor
to The Kelley Island Lime and Transport Com-
pany, Cleveland, Ohio, a corporation of Ohio

Application July 4, 1942, Serial No. 449,769

20 Claims. (Cl. 263—28)

This invention relates to tunnel kilns of the continuous type for burning or calcining bulk limestone or various other materials and products, and more particularly to a kiln of this type embodying improvements which render the same more satisfactory and efficient than similar kilns heretofore employed.

An object of my invention is to provide an improved kiln of this type in which gaseous medium for heating (or cooling) is made to pass through or permeate the bulk material being treated.

Another object of the invention is to provide an improved construction for a kiln of this type in which the heated gases, after passing through the bulk material in the burning zone of the kiln, are used to preheat the bulk material at a point in advance of the burning zone.

A further object of my invention is to provide an improved kiln in which a car adapted to carry a load of bulk material is constructed with passages or openings for admitting or directing heating (or cooling) gaseous medium through the bulk material and in which sealing means is arranged to confine the gaseous medium to cause the same to pass through the material.

Still another object of this invention is to provide an improved construction for a kiln car adapted to carry material to be treated and in which the body or load-carrying portion of the car has passages or openings therein enabling the heated gases to pass through the material.

The invention also provides an improved tunnel kiln through which cars are pushed, while in an end-to-end abutting relation forming a substantially continuous support for bulk material to be treated, and wherein coupling means is provided for the cars for substantially maintaining such abutting relation.

The invention may be further briefly summarized as consisting in certain novel combinations and arrangements of parts hereinafter described and particularly set out in the appended claims.

In the accompanying sheets of drawings,

Fig. 1 is a plan view of a tunnel kiln embodying my invention;

Fig. 2 is a side view thereof;

Fig. 3 is a transverse sectional view, on a larger scale, taken through the kiln as indicated by line 3—3 of Fig. 1;

Fig. 4 is a perspective view of one of the kiln cars;

Fig. 5 is a partial plan view of one of the floor slabs of the car;

Fig. 6 is a partial sectional view through the slab as indicated by section line 6—6 of Fig. 5;

Fig. 7 is a partial plan view showing a similar floor slab provided with round holes instead of slots;

Fig. 8 is a sectional view taken through the slab as indicated by line 8—8 of Fig. 7;

Fig. 9 is a transverse sectional view similar to Fig. 3 but showing a modified construction;

Fig. 10 is also a transverse sectional view similar to Fig. 3 but showing another modified construction;

Fig. 11 is a perspective view showing a kiln car similar to that of Fig. 4 but representing a further modification;

Fig. 12 is a partial side elevation showing coupling means connecting the abutting ends of adjacent kiln cars;

Fig. 13 is a partial plan view showing another arrangement of ducts for supplying heated gases to the preheating section of the kiln;

Fig. 14 is a partial side elevation of the kiln showing such modified duct arrangement; and

Fig. 15 is a partial longitudinal sectional view taken through one of the burner ports as indicated by line 15—15 of Fig. 2.

In the embodiment of the invention illustrated in Figs. 1 to 4, inclusive, I show a tunnel kiln 15 having a longitudinal passage or tunnel 16 in which is a track 17 for the movement of wheeled cars 18 through the tunnel. As will be explained more in detail hereinafter, the cars 18 are designed to carry a quantity of bulk material 19 to be treated or calcined and which may be limestone or any one of various other materials. As indicated in the drawings, the bulk material 19 is a loose material in lump form having numerous voids or passages therein between the lumps and through which high temperature combustion gases, or cooling gases as the case may be, can pass as hereinafter explained. As shown in Figs. 1 and 2, a number of the kiln cars 18 is provided and they extend through the kiln in a series in abutting end-to-end relation with each other. By pushing the cars in succession past a loading station or hopper 20 and into the kiln, a more or less continuous movement of the bulk material through the kiln may be obtained. The cars emerging from the opposite end of the kiln move past an unloading station having a hopper 21 into which the treated material is discharged or dumped to be carried to a desired point by the conveyor 22.

The kiln 15 may be constructed with longitudinal side walls 23 and an arched roof 24 which define or enclose the longitudinal passage or tunnel 16. The side walls 23 and the track 17 may

be supported by a suitable floor or foundation 25. Rows of columns 25a may be provided along the side walls 23 and may have their upper ends connected by tie rods 25b. The side walls and the arch 24 are constructed largely of firebrick or other suitable refractory material. A cover or layer 24a of heat insulating material may extend over the arch 24.

As shown in Figs. 1 and 2, the kiln 15 includes a burning section 26 in which the main portion of the burning or calcining of the bulk material 19 takes place, and may also include a preheating section 27 in advance of the burning section and in which some of the heated gases are utilized for preheating the bulk material. A number of burners 28 are provided at longitudinally spaced points in the side walls of the burning section 26 for supplying the heat used in treating the bulk material. These burners may be arranged to extend through suitable burner blocks 28a located in the outer ends of the burner ports or openings 29. Oil or other suitable fuel may be supplied to the burners 28 by the pipes 28b. The preheating section 27 of the kiln is also provided with longitudinally spaced ports or openings 30 in the side walls 23. The ports 30 occupy a location similar to the burner ports 29 and, as will be explained more fully hereinafter, serve as gas inlet ports for the reintroduction of the heated gases which are used in preheating the material 19.

The kiln cars 18 are substantially identical in construction, and, as best shown in Figs. 3 and 4, may comprise a quadrangular truck or frame 31 having flanged supporting wheels 32 arranged to run on the rails 17. The upper portion of the truck or frame 31 is in the form of an imperforate slab or platform 31a on which is constructed a car body 33 adapted to carry the bulk material 19. The body 33 may be constructed of heat conducting refractory material in the form of bricks or slabs arranged to define a bin or container 34 for the bulk material 19 with a space 35 between such bin and the platform 31a for receiving the flames and heated gases from the burners 28. In constructing the car body 33 one or more layers 36 of heat insulating refractory brick may be laid on the platform 31a and a suitable number of piers 37 may then be erected to support refractory slabs 38 which form the floor of the bin 34. The body 33 may also include upright longitudinal side walls 39 formed by laying refractory brick or the like along the edges of the outermost floor slabs 38.

As already indicated above and as shown in drawings an important feature of my invention consists in providing for the passage of hot gases through the bulk material 19, preferably combustion gases of a sufficiently high temperature for calcining the bulk material. This is accomplished by confining the relatively high temperature combustion gases obtained from the burners 28 so that these gases must pass through the bulk material in order to reach the free space in the upper part of the kiln. To this end I construct the kiln cars 18 so that the gas receiving or combustion space 35 thereof will be substantially opposite the burner ports 29, and I also provide numerous openings 40 in the floor of the bin or container 34 through which the heated gases may pass from the space 35 upwardly into the bulk material 19. I have found that by causing the heated gases to pass through the bulk material in this manner the burning of limestone to produce lime or the calcining of other materials will be accomplished more efficiently and satisfactorily

than if the heated gases were merely passed over the surface of the material.

The openings in the floor of the bin 34 may be either in the form of spaced slots 40a, as shown in Figs. 5 and 6, or in the form of round holes 40b, as shown in Figs. 7 and 8. To prevent these slots or holes from becoming clogged with pieces of the bulk material being treated I give the slots or holes a shape such that they will be self-clearing. In this instance I obtain this result by tapering the slots or holes so that they are of downwardly increasing width which permits any pieces which enter the slots or holes to drop freely therefrom.

In addition to the openings 40 extending through the floor slabs 38, I may provide rows of longitudinally extending ports or passages 41 which also admit heated gases from the space 35 into the bulk material. The passages 41 may be obtained by constructing the piers 37 of varying heights and arranging the rows of slabs 38 in tiered or stepped relation, as shown in Figs. 3 and 4. With this arrangement for the floor slabs 38, it will be seen that the center row of slabs forms a relatively elevated floor section 38a and that the intermediate rows of floor slabs, that is the rows on opposite sides of the center row, also form relatively elevated floor sections 38b which are of somewhat lesser height than the section 38a. With the slabs arranged in this stepped relation, the edges of the slabs of the center row overlap the slabs of the intermediate rows and the slabs of the intermediate rows overlap the slabs of the outer rows, but in each case the overlapping slab portions are separated by blocks 41a which are spaced apart longitudinally of the car body to leave the passages 41 therebetween.

In order to confine the high temperature combustion gases obtained from the burners 28 so that they must pass through the bulk material, I provide longitudinally extending heat seals or gas seals 42 and 43 between the cars and kiln at points above and below the burner ports 29. The upper heat seal 42 may be formed by extending a portion of the wall 39 of the car body laterally to form a longitudinal flange 44 which extends into a longitudinal groove 45 formed in the side wall of the kiln. This upper seal may be located adjacent the level of the floor of the bin 34 or somewhat above the floor level, as shown in Fig. 3. The lower heat seal 43 may be formed by extending the longitudinal side edge 46 of the truck platform 31a so as to extend into a longitudinal groove 47 of the side wall of the kiln.

These longitudinally extending heat seals 42 and 43, being located respectively above and below the burner ports 29 and the openings into the space 35 of the car body, will serve to restrict the heated gases from passing upwardly or downwardly between the sides of the car and the kiln walls. By confining the heated gases to the space 35, it will be seen that the gases will be made to pass upwardly into the bulk material through the openings 40 and the passages 41. Although I have described the floor of the bin 34 as having both the openings 40 and the passages or ports 41, it will be understood that either set of openings can be omitted if the other set is found to be sufficient.

To protect the car wheels and related parts from the heat of the burners 28, I may provide the usual longitudinally extending sand seals 48 at opposite sides of the car truck. These seals may comprise longitudinally extending troughs 48a containing a quantity of sand and depending

plates 48b carried by the trucks and extending downwardly into the sand contained in the troughs.

It may be desirable to utilize some of the hot gases which have passed through the bulk material 19 for preheating the material in advance of the burning section 26. For this purpose I may provide more or less spirally extending ducts 49 which receive heated gases from the upper portion of the burning section 26, preferably at a point adjacent the first pair of burners, and carry such gases backwardly and downwardly along the kiln for reintroduction into the preheating section 27. The ducts 49 may be of a length to carry these heated gases a distance approximately equal to the length of one car so that the heated gases which have passed through the material carried by one car will be reintroduced into the preheating section 27 at a point to be passed through the material of the next adjacent car. The discharge end of the ducts 49 may connect with the inlet ports 30, which, as shown in Fig. 3, are located substantially opposite the space 35 of the cars 18. For accelerating the flow of heated gases through the ducts 49, I may provide propeller type fans or blowers 50 driven from electric motors 51 by shafts 51a. The fans 50 cause the heated gases to be withdrawn from the burning section 26 through the ducts 49 and to be forced through the inlet ports 30 into the space 35 and then upwardly through the openings 40 and ports 41 into the bulk material 19 for preheating the same.

The preheating of the bulk material as just described may be carried out in several stages, as represented in Figs. 1 and 2. In this instance I show two additional pairs of spirally extending ducts 52 and 53 by which the heated gases can be withdrawn from the top of the preheating section 27 and reintroduced therein at an earlier point for producing preheating of the bulk material in the manner already described. A stack 54 may be provided adjacent the loading end of the kiln for the discharge of heated gases which have passed through the preheating section 27.

Instead of using the arrangement of spirally extending ducts 49, 52, and 53 for reintroducing heated gases into the preheating section 27, I may use an arrangement of ducts as shown in the modified construction illustrated in Figs. 13 and 14. In these views I show a preheating section 27a to which heated gases are supplied at a plurality of points by the piping 55. This piping may include an intake section 56 which connects with the upper portion of the burning section 26a and supplies heated gases therefrom to the blower 57. This blower forces the heated gases through the main pipe 55a and the branch pipes 55b into the preheating section 27a through the inlet ports 30 with which the branch pipes 55b are connected. A stack 58 may be connected with the main pipe section 55a for discharging excess gas to the atmosphere. Dampers 59 located in the branch pipes 55b and in the stack 58 may be adjusted to regulate the amount of heated gases desired to be reintroduced into the preheating section 27a.

Certain advantages can be obtained in the operation of my improved kiln by withdrawing heated gases from the upper portion of the burning section 26 and reintroducing the same through the burner ports 29. When the bulk material being treated is limestone, these gases will consist largely of carbon dioxide, and the reintroduction of the same through the burner ports

tends to produce a longer flame at the burners. When longer flames are obtained, they extend farther into the space 35 and even into the bulk material 19 and thus cause the heat to be applied more effectively to the material. For withdrawing such gases from the top of the burning section and reintroducing the same through the burner ports, I may provide a blower 60 having intake connections 61 at spaced points in the top of the burning section 26 and a connection 62 for discharging such gases into a main duct 63 having branches 64 leading to the burner ports 29.

The kiln 15 may also include a cooling section 100 through which the cars 18 pass after traversing the burning section 26 and before they arrive at the unloading hopper 21. This cooling section is provided with a plurality of spaced cold air inlet ports 101 which correspond substantially in location with the burner ports 29 and the inlet ports 30 of the preheating section. That is to say, the cooling ports 101 are located substantially opposite the space 35 of the cars so that cool air will be directed into this space and can be made to pass through the material being treated.

For causing a flow of cool atmospheric air into the kiln through the ports 101 I may provide a blower 102 which has an intake connection 103 communicating with the upper portion of the cooling section of the kiln. The blower 102 draws cool air in through the ports 101 and causes such air to pass through the openings 40 and 41 in the floor of the car into the bulk material 19. The air passing through the bulk material cools the same and is itself heated during such passage. This heated air can be discharged to atmosphere by the blower 102 or preferably, as shown in Figs. 1 and 2, can be discharged into a duct 104 having branches 105 extending along the burning section of the kiln and provided with connections or nozzles 105a for directing the heated air into the burner ports 29 and secondary air. During this cooling operation the seals 42 and 43 between the cars and kiln, and particularly the upper seals 43, restrict the flow of the cool air so that it must pass through the material before it can reach the blower 102.

As I have stated above in a general way, the cars 18 extend in a series through the tunnel of the kiln with the ends of adjacent cars in abutting relation. The bodies of the cars are constructed so that the bins 34 thereof are without end walls, as shown in Fig. 4, and when the ends of the cars are in abutting relation, the cars form a substantially continuous support upon which the bulk material is carried as a more or less continuous pile. It will therefore be seen that if the ends of the cars were permitted to separate from each other by even a small distance, such as might result from the passage of the cars over irregular portions of the track 17, some of the material would drop into the space between the adjacent car ends and might result in displacement or other damage to portions of the refractory materials forming the car body. This difficulty can be avoided by substantially preventing such separation between the car ends, and for this purpose I provide coupling means on opposite sides of the cars and adjacent the ends thereof which, when connected, will span the joint formed by the car ends and will hold such ends in abutting relation. Any suitable form of coupling means may be employed, such as the chains 65 and 66 shown in Fig. 12. A hook 67 of the

toggle or pelican type carried by the chain 65 may be used to connect this chain with the chain 66. A spring 68 suitably incorporated in the chain 66 acts to continuously draw the car ends toward each other but is adapted to yield somewhat to afford enough flexibility to prevent breakage.

In Fig. 9 I show a modified form of kiln in which the car 70 differs from the car 18 in that the body 71 is constructed with the floor slabs 72 lying in substantially the same horizontal plane so that the bin 73 has a substantially flat floor or bottom. The car body may be provided along the center line thereof with a relatively elevated section 74 forming a longitudinally extending hollow partition or chimney having therein a chamber or passage 75, the lower end of which is in communication with the space 76 beneath the floor of the bin. The elevated section 74 may be formed of refractory material such as brick laid up in the form of checker-work so as to provide a number of ports or openings 77 for the passage of heated gases (or cooling air) into the bulk material 78. The relatively elevated section 74 may be constructed so that the walls thereof converge upwardly to thereby obtain a desired distribution of the heated gases through the ports 77 in relation to the length of the path which the gases are required to travel through the bulk material. In addition to the ports 77 of the relatively elevated section 74, I may also provide openings 40 through the floor slabs 72 for directing heated gases (or cooling air) upwardly through the bulk material from the space 76. In other respects the car and kiln correspond substantially with the construction illustrated in Fig. 3 and described in detail above.

In Fig. 10 I show another modification in which the kiln car 81 represents a combination of features contained in the car 18 and in the car 70. The body of the car 81 is constructed with slabs 82 arranged to form a generally flat floor for the bin 83 but has a longitudinally extending relatively elevated hollow section or partition 84 at the center thereof and relatively elevated sections 85 extending longitudinally on opposite sides of the center section 84 and lower in height than the latter. The center section 84 is preferably not as high as the section 74 shown in Fig. 9, and the top thereof may be formed by a longitudinal row of slabs 86 over which the bulk material 87 extends. The side walls of the elevated sections 84 and 85 may have ports or openings 88 therein for the passage of heated gases (or cooling air) from the space 89 into the bulk material 87. In addition to the ports or passages 88 I may provide openings 40 in the floor slabs 82 and in the slabs forming the tops of the elevated sections 84 and 85 for directing heated gases (or cooling air) into the bulk material. In other respects the kiln and the kiln car shown in Fig. 10 are similar to the construction illustrated in Fig. 3.

In Fig. 11 I show still another form of kiln car having the same general shape as the car 18 but in which the floor and side walls of the bin of the car body are constructed of metal. In this modified kiln car 91 the body 92 is constructed with the bottom thereof formed by slabs 93 made of a suitable metal or heat resisting alloy. These slabs may be supported by piers 94 and may be arranged in the stepped relation above described for the floor slabs of the kiln car 18. The metal slabs 93 have short legs or projections 93a thereon with gas ports or passages 93b between the pairs of legs and leading from the space 95 be-

neath the floor of the bin. The sides of the body may be formed by elongated plates or slabs 96 also made of a suitable metal or heat resisting alloy and which may be suitably connected to the floor slabs 93. If desired, the floor slabs 93 may be provided with a number of openings 40 which, together with the ports 93b, permit the heated gases (or cooling air) to pass from the space 95 into the bulk material. Since metal is a good conductor of heat, it will be readily seen that the use of metal in forming the floor and side walls of the bin portion of the body 92 will permit heat to pass directly to the bulk material by conduction as well as by being carried into the bulk material by the heated gases.

In the various forms of kiln cars illustrated and described herein, it will be understood that the number, size, and arrangement of openings or ports through the floor slabs and in the relatively elevated sections of the car floor will be such that a desired distribution of the heated gases (or cooling air) will be obtained to all portions of the load of bulk material. A substantially uniform distribution of the heated gases to all portions of the load of bulk material is desirable so that the burning or calcining of the material will be carried out with uniformity. It will also be understood that in all of the above described kiln cars the floor of the car body and the relatively elevated sections of the floor are of substantially the same length or plan dimension as the slab or platform 31a of the car truck.

From the foregoing description and the accompanying drawings it will now be readily understood that I have provided an improved construction for tunnel kilns and kiln cars with which a more satisfactory and efficient treatment of limestone or other bulk material can be obtained.

While I have illustrated and described my improved apparatus in more or less detail, it will be understood, of course, that I do not wish to be limited to the particular details and embodiments herein disclosed, but regard my invention as including such changes and modifications as do not constitute a departure from the spirit of the invention and the scope of the appended claims.

Having thus described my invention, I claim:

1. In apparatus of the character described, a kiln having a tunnel therein, a car movable along said tunnel and having a body including a floor and upright walls defining a bin adapted to carry loose bulk material in lump form to be treated, the floor of said body having openings therein for the passage of high temperature combustion gases through the bulk material, burners located to deliver such high temperature combustion gases into the kiln, and means providing seals extending longitudinally between the car and kiln adjacent the level of said floor for confining said high temperature combustion gases to cause the same to pass through said openings and bulk material.

2. In apparatus of the character described, a kiln having a passage therethrough, a car movable along said passage and having a body including a floor and upright walls defining a bin adapted to carry loose bulk material in lump form to be treated, the floor of said body having openings therein for admitting high temperature combustion gases to said bulk material from beneath said floor, burners located to deliver such high temperature combustion gases into the kiln at a point below the level of said floor, and means providing seals extending longitudinally between said car and kiln adjacent the level of

said floor for confining said high temperature combustion gases to cause the same to pass upwardly through said openings and through said bulk material.

3. In calcining apparatus, a kiln having a passage therethrough, a wheeled car movable along said passage and having thereon a structure including a floor and upright walls defining a bin adapted to carry a load of loose bulk material in lump form to be calcined, burners in said kiln arranged to direct high temperature combustion gases toward the car, said car having a space therein beneath said structure for receiving said high temperature combustion gases from said burners and openings leading from said space for directing said high temperature combustion gases through the bulk material, and means providing seals between the car and kiln at points above and below said burners for confining said gases to cause the same to flow through said openings and bulk material.

4. In calcining apparatus, a tunnel kiln having a longitudinal passage and burners in its side walls, a series of cars substantially in abutting end-to-end relation in said passage and providing a substantially continuous support for a load of loose bulk material in lump form to be calcined and including upright walls extending above said support for retaining the bulk material thereon, each of said cars having a space therein beneath said support for receiving the high temperature combustion gases from said burners and openings leading from said space for directing said high temperature combustion gases through said bulk material, and means providing seals extending longitudinally between the cars and kiln at points above and below said burners.

5. In apparatus of the character described, a tunnel kiln having a longitudinal passage therein, a track in said tunnel, a car comprising a truck having wheels operable on said track and an imperforate slab supported by said truck, a body including a floor and upright walls defining a bin adapted to carry loose bulk material in lump form to be treated, said body being mounted on the truck with a space between said floor and slab and said floor having openings for the passage of high temperature combustion gases from said space into the bulk material, and burners in the side walls of the kiln arranged to direct such high temperature combustion gases into said space.

6. In apparatus of the character described, a tunnel kiln having a longitudinal passage therein, a track in said tunnel, a car comprising a truck having wheels operable on said track and an imperforate slab supported by said truck, a body including a floor and upright walls defining a bin adapted to carry loose bulk material in lump form to be treated, said body being mounted on the truck with a space between said floor and slab and said floor having openings for the passage of high temperature combustion gases from said space into the bulk material, burners in the side walls of the kiln arranged to direct such high temperature combustion gases into said space, and means providing seals extending longitudinally between the car and kiln at points above and below said space.

7. In calcining apparatus, a truck having an imperforate slab thereon, a body constructed on said slab and including a floor and upright walls defining a bin adapted to hold loose bulk material in lump form to be calcined, said body having substantially its entire floor spaced from said

slab to permit the passage of high temperature combustion gases therebetween, said floor having a relatively elevated section provided with laterally opening passages for admitting the high temperature combustion gases to the bulk material from the space beneath the floor, said passages being of an area to admit a sufficient volume of said high temperature combustion gases to said bulk material to calcine the same.

8. In calcining apparatus, a truck having an imperforate slab thereon, a body constructed on said slab and including a floor and upright walls defining a bin adapted to hold loose bulk material in lump form to be calcined, said body having a floor spaced from the slab to permit the passage of high temperature combustion gases therebetween, said body having an upstanding hollow partition in said bin and substantially co-extensive with one plan dimension of the body, the chamber in said hollow partition being in communication with the space beneath the floor of said body to receive said high temperature combustion gases therefrom and the walls of the partition having openings for directing said heated gases into the bulk material, said chamber and openings being of an area to supply a sufficient volume of said high temperature combustion gases to said bulk material to calcine the same.

9. In calcining apparatus, a car having an imperforate slab thereon, a body constructed on said slab and including a floor and upright walls defining a bin adapted to hold loose bulk material in lump form to be calcined, said body having substantially its entire floor spaced from the slab to permit the passage of high temperature combustion gases therebetween, said body having an upstanding hollow partition in said bin and substantially coextensive with one plan dimension of said floor, said hollow partition having an upwardly converging chamber therein which at its lower end is in communication with the space beneath the floor of the body to receive said high temperature combustion gases therefrom and the walls of the partition having openings for directing said gases into the bulk material.

10. In apparatus of the character described, a tunnel kiln having a passage therethrough, a series of cars movable along said tunnel and each car having upright walls and a floor defining a bin adapted to carry loose bulk material in lump form to be treated, the floors of said cars having openings for directing high temperature combustion gases through said bulk material, refractory means providing seals extending longitudinally between said cars and kiln, burners in a wall of the kiln for delivering said high temperature combustion gases thereinto at a point below said seals, and means for withdrawing from the kiln at a point above said seals combustion gases which have passed through said material and reintroducing said gases into the kiln at a point below said seals.

11. In apparatus of the character described, a tunnel kiln having a burner section and a preheating section, burners in a wall of said burner section, gas inlet ports in a wall of said preheating section, a series of cars in said tunnel each car having a body including a floor and walls defining a bin adapted to support bulk material to be calcined, the floors of said cars being at an elevation above said burners and inlet ports and the body of each car having a space therein beneath its floor adapted to receive high temperature combustion gases from said burners and inlet ports, said floors having openings therein leading from

said spaces for directing the high temperature combustion gases through the bulk material, and ducts connected with the upper portion of said tunnels so as to receive combustion gases which have passed through the bulk material and to redeliver the same into the kiln through the inlet ports of said preheating section.

12. In apparatus of the character described, a tunnel kiln having a burner section and a preheating section, burners in a wall of said burner section, gas inlet ports in a wall of said preheating section, cars in said tunnel, each car having a body including a floor and walls defining a bin adapted to support bulk material to be treated, the body of each car having a space therein beneath its floor adapted to receive high temperature combustion gases from said burners and inlet ports and the floor of each car having openings therein leading from said space for directing the high temperature combustion gases through said material, means providing seals extending longitudinally between the cars and kiln at a point above said burners and ports for confining the gases to cause the same to pass through said openings and through said bulk material, and means for withdrawing from the kiln at a point above the seals combustion gases which have passed through said material and reintroducing the same through said ports into the preheating section of the kiln below said seals.

13. In apparatus of the character described, a tunnel kiln having a burner section and a preheating section, burners in the walls of said burner section, gas inlet ports in the walls of said preheating section, a series of cars in said tunnel, each car having a body including a floor and walls defining a bin adapted to support bulk material to be calcined, the body of each car having a space therein beneath its floor adapted to receive high temperature combustion gases from said burners and inlet ports, the floor of each car having openings therein leading from said space for directing the high temperature combustion gases through the bulk material, means providing heat seals between the cars and kiln at points above and below said burners and ports, and means for withdrawing from the kiln combustion gases which have passed through the bulk material and forcing the same through said ports into the preheating section of the kiln at a point between said seals.

14. In apparatus of the character described, a kiln having a cooling section provided with inlet ports for cooling air, a car movable in said cooling section and having a body provided with a floor at a level above said ports, said body having walls defining a bin adapted to carry a loose bulk product to be treated and said floor having openings for the passage of cooling air in contact with said bulk product, means providing seals extending longitudinally between the car and kiln adjacent the level of said floor, and power driven means for withdrawing gaseous medium from the upper portion of the cooling section for inducing a flow of cooling air through said inlet ports and through said floor openings in contact with said bulk product.

15. In apparatus of the character described, a kiln having a burning section and a cooling section, burners in said burning section, air inlet ports in said cooling section, a car movable in said kiln and having a body provided with a floor at a level above said burners and ports, said body having walls defining a bin adapted to carry loose bulk material to be treated and said floor having

openings therein for the passage of gaseous medium through the material, power driven means for withdrawing gaseous medium from the upper portion of the cooling section for inducing a flow of cooling air through said inlet ports, said body openings and said material, and means for delivering at least a portion of the withdrawn gaseous medium to said burners.

16. In apparatus of the character described, a tunnel kiln having a longitudinal passage therein, a track in said passage, a car comprising a truck having wheels operable on said track and an imperforate slab on said truck, a body on said truck including a floor and spaced walls defining a bin adapted to carry bulk material to be treated, said car having a space between said floor and slab and which extends for substantially the full length of the car and is open along at least one side thereof, and a burner in a wall of the kiln located to direct high temperature combustion gases into said space substantially continuously during movement of the car past said burner, said floor having openings therein for directing said high temperature combustion gases from said space into the bulk material.

17. In apparatus of the character described, a tunnel kiln having a longitudinal passage therein, a track in said passage, a car comprising a truck having wheels operable on said track and an imperforate slab on said truck, a body on said truck including a floor and spaced walls defining a bin adapted to carry bulk material to be treated, said car having a space between said floor and slab and which extends for substantially the full length of the car and is open along at least one side thereof, means providing seals extending longitudinally between the car and kiln and located to confine gas in said space, and a burner in a wall of the kiln located to direct high temperature combustion gases into said space substantially continuously during movement of the car past said burner, said floor having openings therein for directing said high temperature combustion gases from said space into the bulk material.

18. In apparatus of the character described, a tunnel kiln having a longitudinal passage therein, a track in said passage, a car comprising a truck having wheels operable on said track and an imperforate slab on said truck, a body on said truck including a floor and spaced walls defining a bin adapted to carry bulk material to be treated, said car having a space between said floor and slab and which extends for substantially the full length of the car and is open along the sides thereof, and burners in the side walls of the kiln located to direct high temperature combustion gases into said space from opposite sides thereof substantially continuously during movement of the car past said burners, said floor having openings therein for directing high temperature combustion gases from said space into the bulk material.

19. In apparatus of the character described, a kiln having a tunnel therein, a series of cars movable along said tunnel and each comprising a wheeled truck having thereon an imperforate slab and a body provided with a floor and spaced walls defining a bin adapted to carry bulk material to be treated, each car having a space between its floor and slab and which extends for substantially the full length of the car and is open along the sides thereof, said cars having their ends substantially in abutting relation so that said floors provide a substantially continuous

support for said material with a substantially continuous space between such support and said slabs, and burners in the side walls of the kiln located to direct high temperature combustion gases into said space from opposite sides thereof substantially continuously during movement of the cars along the tunnel, said floors having openings therein for directing said high temperature combustion gases from said space into the bulk material.

20. In apparatus of the character described, a kiln having a passage therein, a series of wheeled cars movable along said tunnel and having bodies thereon adapted to carry bulk material to be treated, said bodies including floors and side walls

and having open ends substantially in abutting relation so that said floors form a combined transverse partition in the kiln and a substantially continuous support for the bulk material, said floors having openings therein permitting the passage of high temperature combustion gases through the bulk material, burners in the wall of the kiln for delivering such high temperature combustion gases thereinto on one side of the bulk material and beneath said partition, and means for withdrawing gases from the kiln on the other side of the bulk material and partition for inducing a flow of the gases through said openings and bulk material.

HENRY M. BEATTY.