March 15, 1927. 1,621,222

H. M. ROBERTSON

APPARATUS FOR BURNING OR CALCINING MATERIALS

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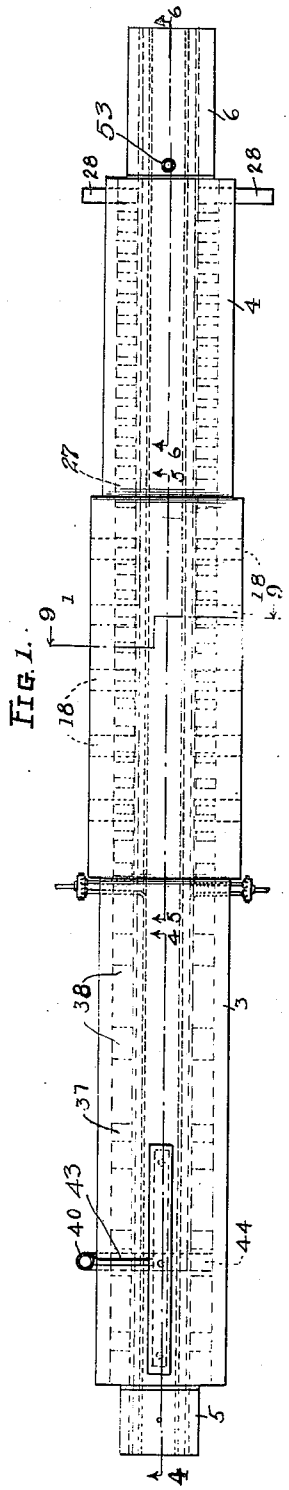


FIG. 1.

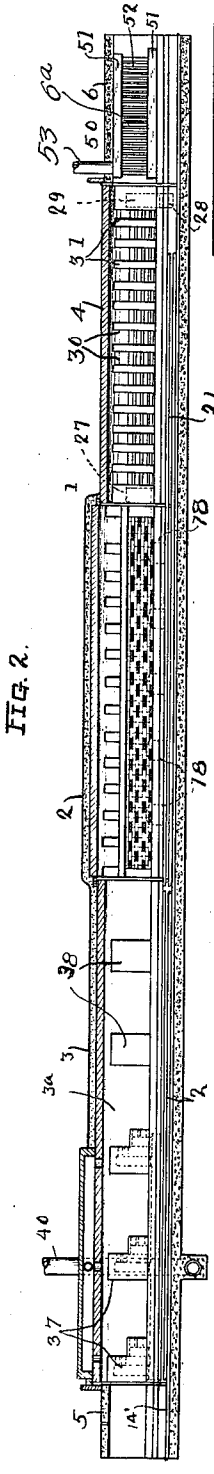


FIG. 2.

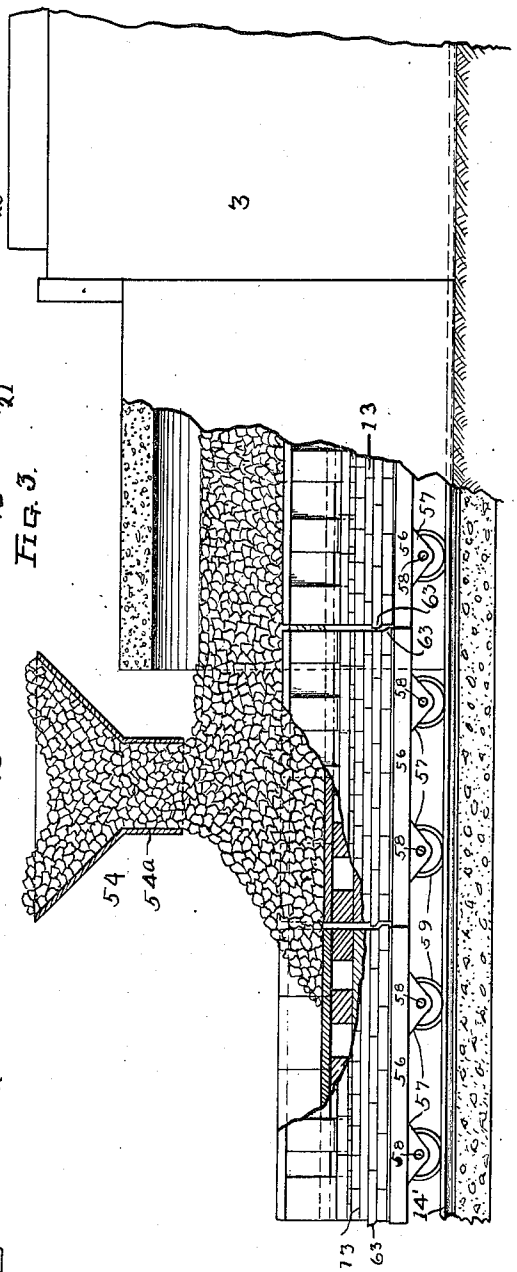


FIG. 3.

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APPARATUS FOR BURNING OR CALCINING MATERIALS

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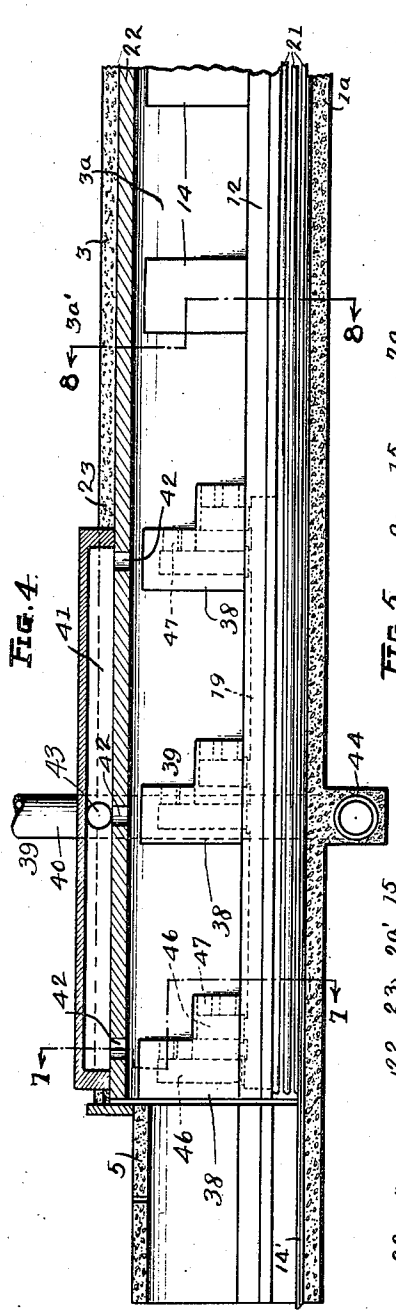


FIG. 4.

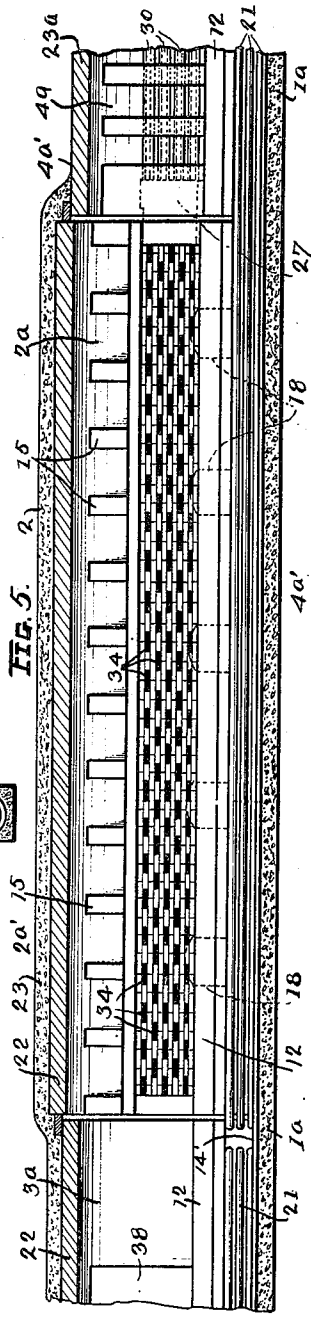


FIG. 5.

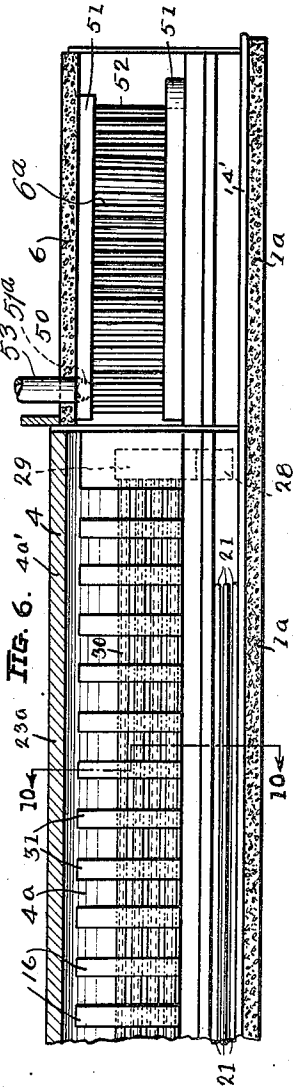


FIG. 6.

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APPARATUS FOR BURNING OR CALCINING MATERIALS

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FIG. 7.

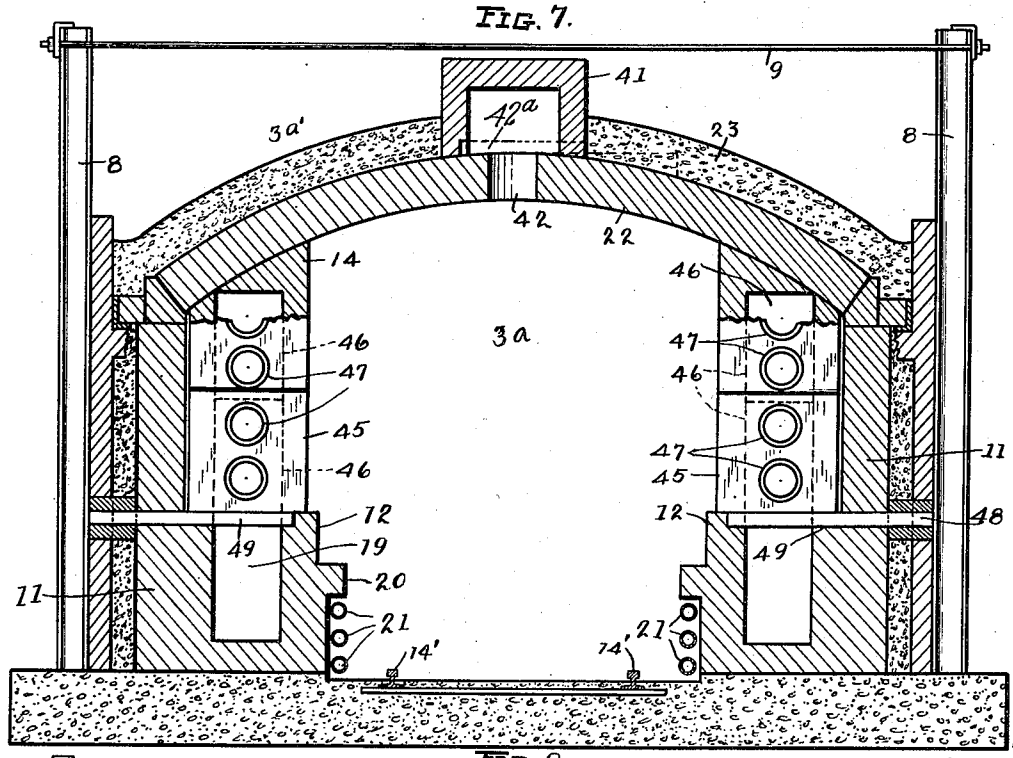
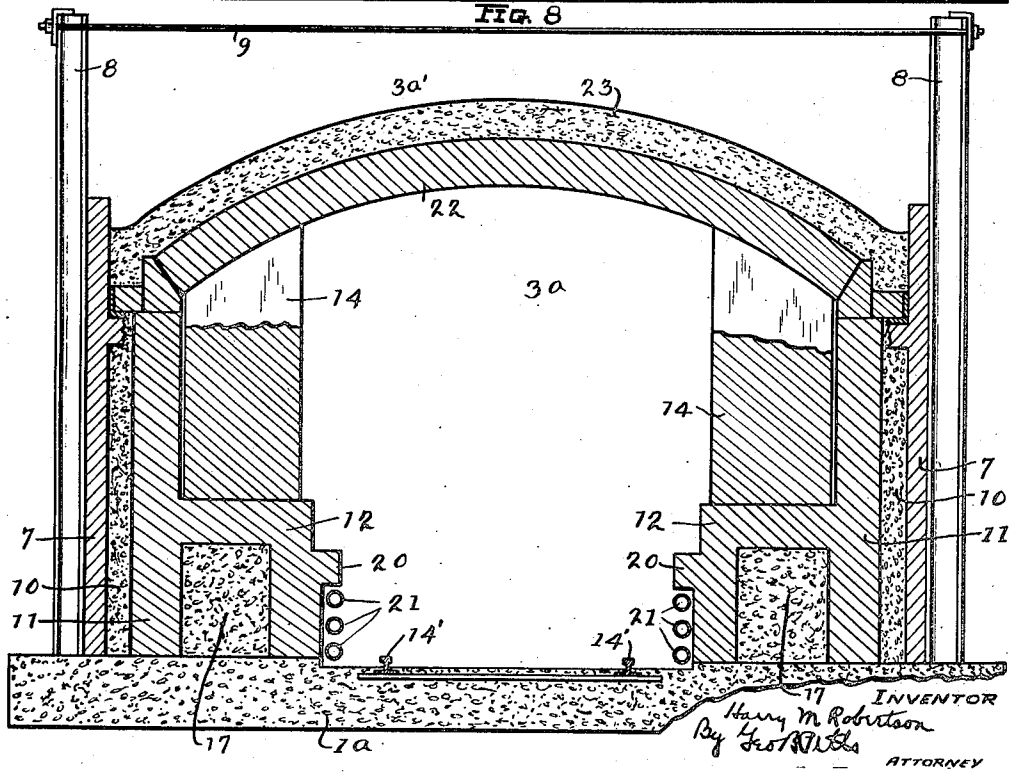


FIG. 8



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APPARATUS FOR BURNING OR CALCINING MATERIALS

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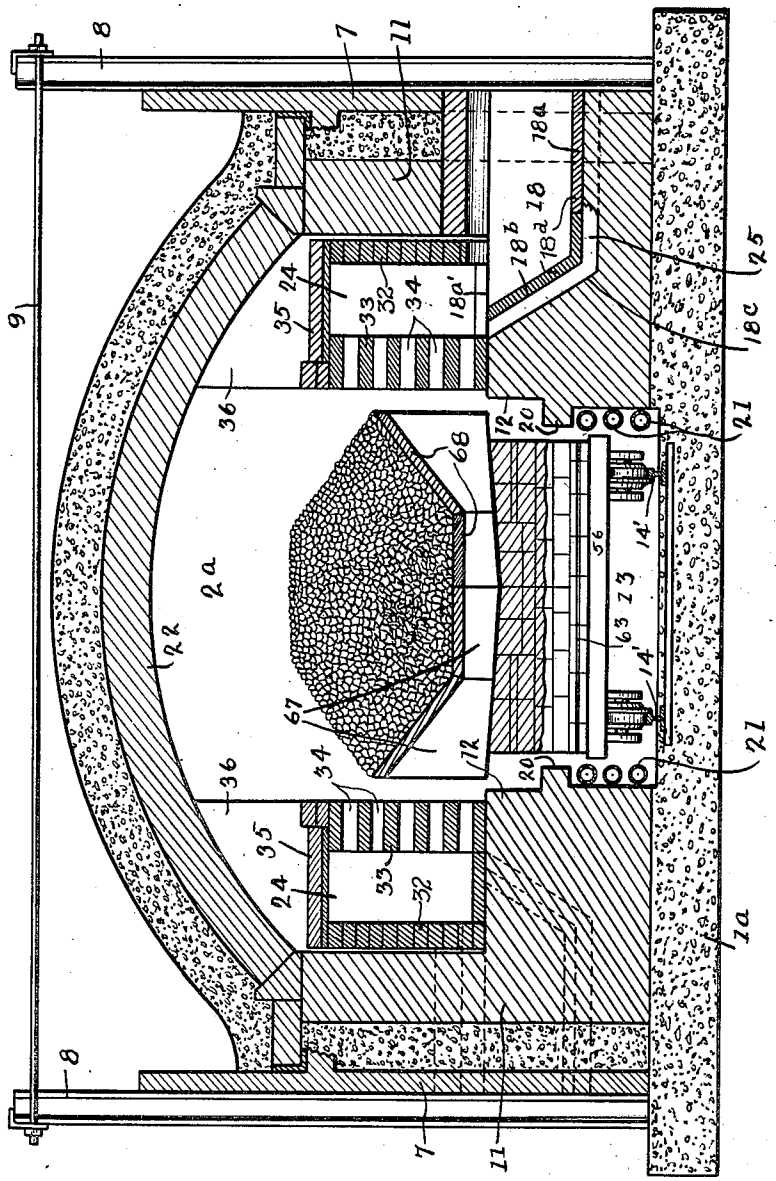


FIG. 9.

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APPARATUS FOR BURNING OR CALCINING MATERIALS

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FIG. 10.

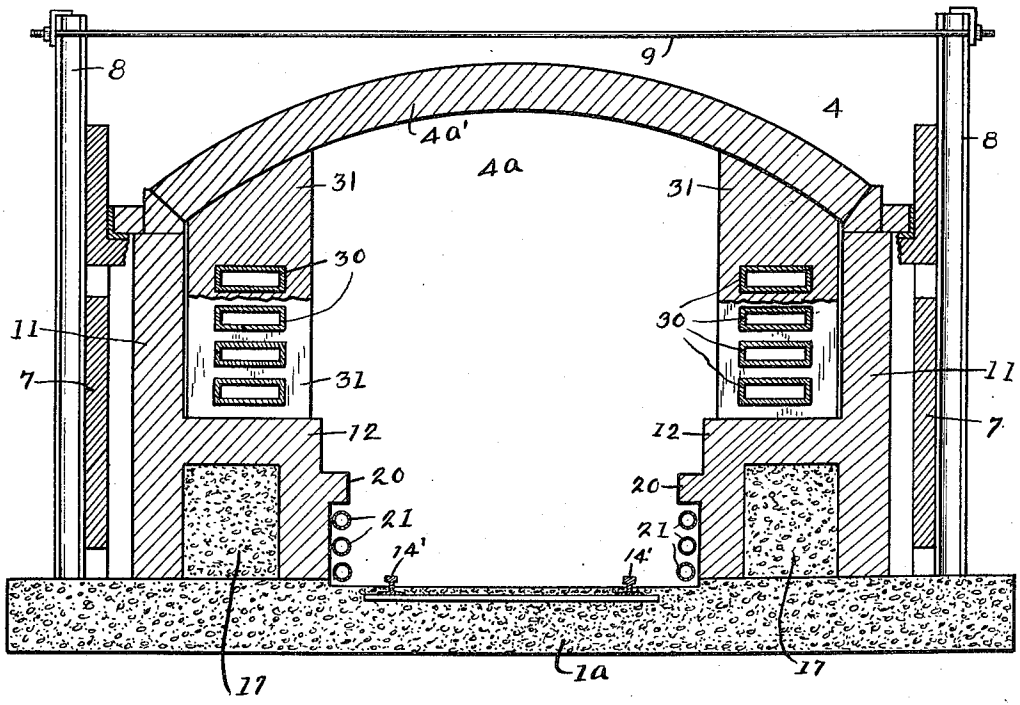
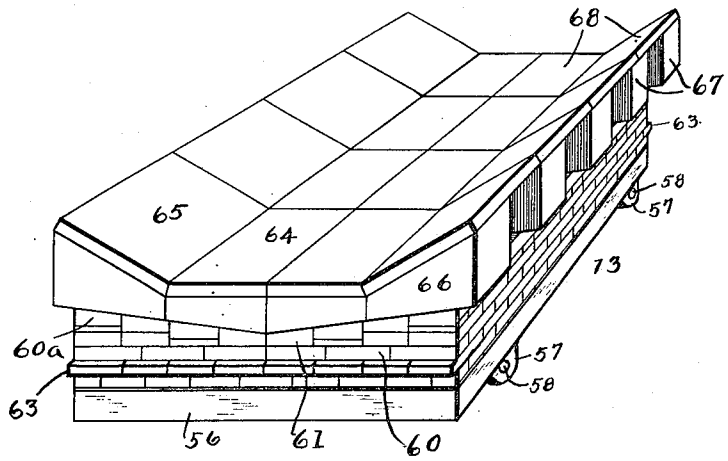


FIG. 11.



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APPARATUS FOR BURNING OR CALCINING MATERIALS

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FIG. 12.

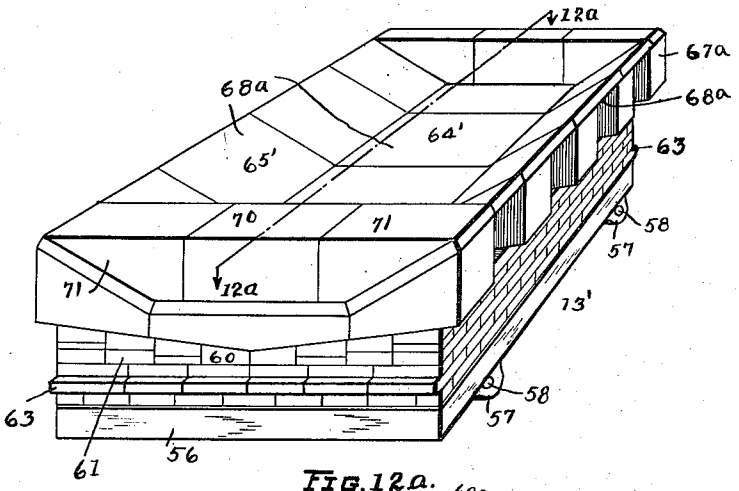


FIG. 12a.

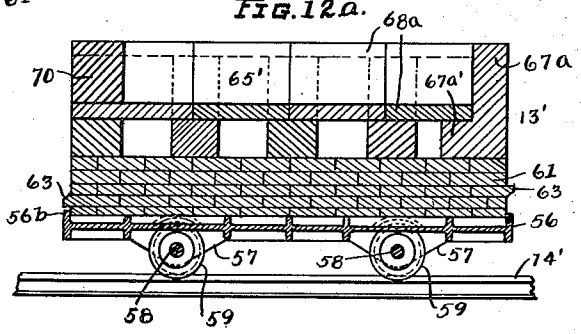
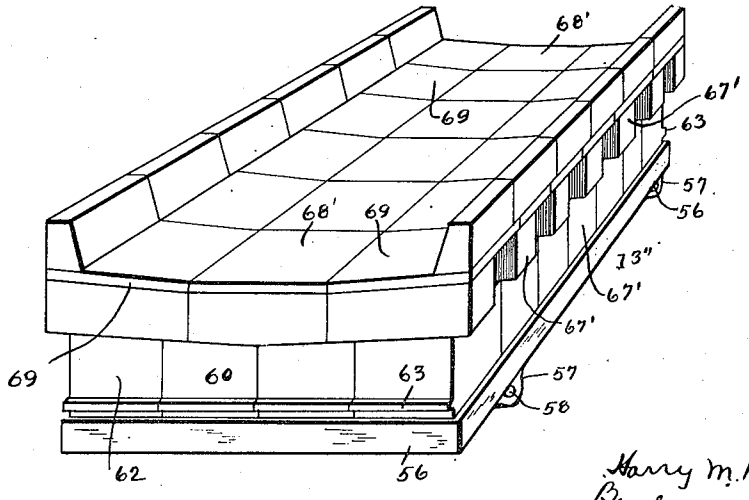


FIG. 13.



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APPARATUS FOR BURNING OR CALCINING MATERIALS

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Fig. 14.

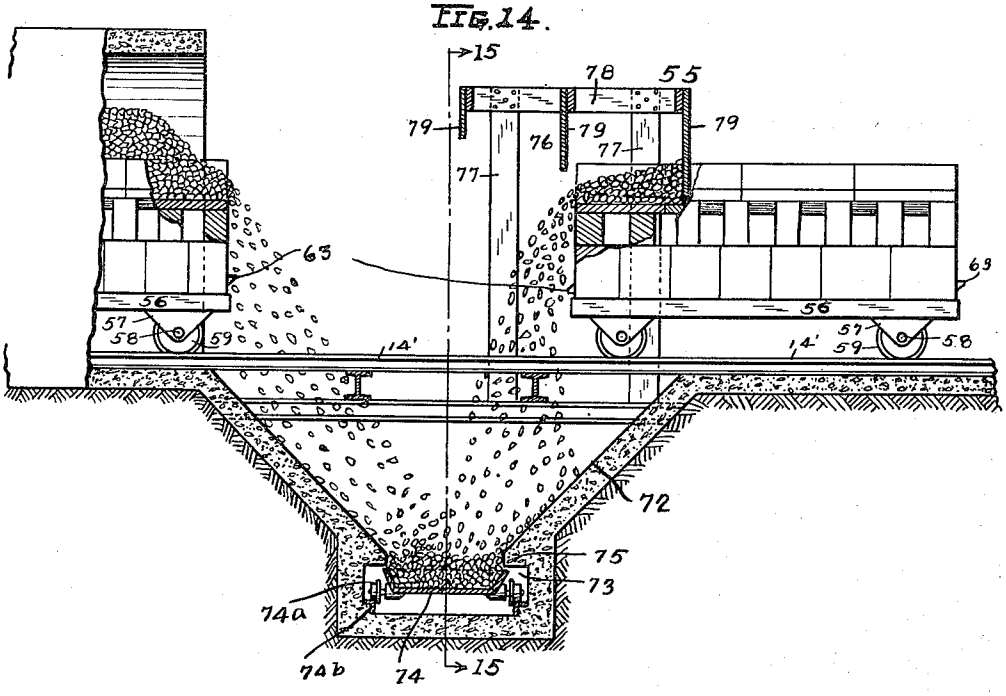
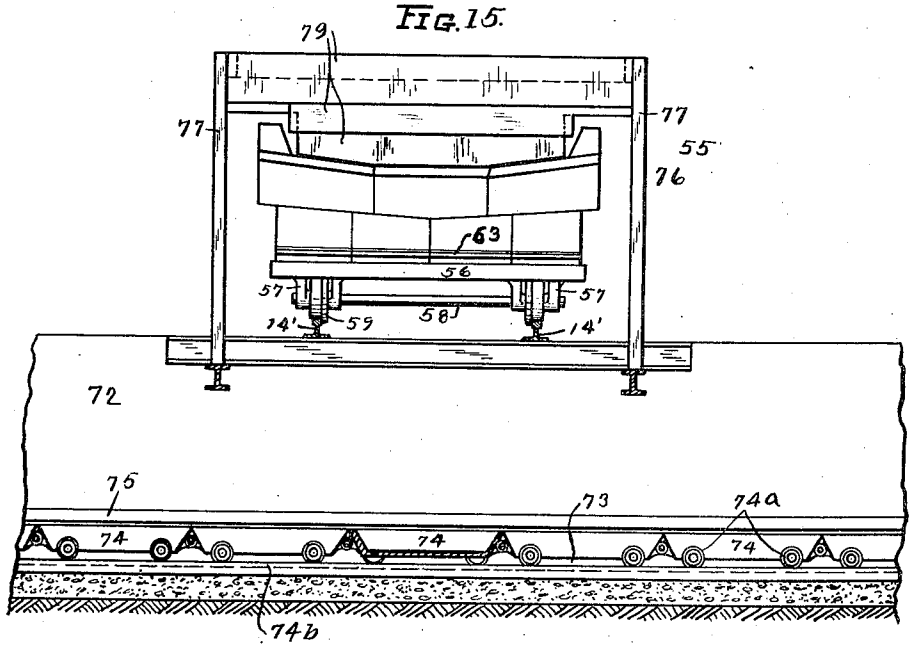


Fig. 15.



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Patented Mar. 15, 1927. 1,621,222

UNITED STATES PATENT OFFICE.

HARRY M. ROBERTSON, OF LAKEWOOD, OHIO.

APPARATUS FOR BURNING OR CALCINING MATERIALS.

Application filed June 20, 1925. Serial No. 38,589.

This invention relates to an apparatus for and process of burning or calcining materials, particularly materials in rock form, such as limestone, shale and the like. The apparatus is of the continuous kiln type.

One object of the invention is to provide an improved apparatus for burning or calcining materials, whereby uniformity of product is insured, greater output results and operating expenses in fuel and labor are decreased.

A further object of the invention is to produce an improved apparatus wherein limestone may be calcined by contact with the products of combustion and complete burning effected so that picking of the calcined material is eliminated.

Another object of the invention is to provide an improved process of calcining limestone capable of producing lime of high quality in a rapid manner.

Another object of the invention is to provide an improved tunnel kiln of simple construction.

Other objects of the invention will be apparent to those skilled in the art to which my invention relates from the following description taken in connection with the accompanying drawings, wherein—

Fig. 1 is a plan view of an apparatus embodying my invention and capable of use in carrying out my improved process.

Fig. 2 is a longitudinal section through the apparatus.

Fig. 3 is a fragmentary view, enlarged, showing the preferred manner of introducing the materials into the apparatus and conveying them therethrough.

Figs. 4, 5 and 6 are fragmentary enlarged sections on the lines 4—4, 5—5 and 6—6, respectively, of Fig. 1.

Figs. 7 and 8 are enlarged transverse sections on the lines 7—7 and 8—8, respectively, of Fig. 4.

Fig. 9 is an enlarged transverse section on the line 9—9 of Fig. 1.

Fig. 10 is an enlarged transverse section on the line 10—10 of Fig. 6.

Fig. 11 is a perspective view of a truck (wheels for the truck being omitted) having a holder for the material.

Fig. 12 is a perspective view of a truck (the wheels therefor being omitted) having a holder of slightly different form from that shown in Fig. 11.

Fig. 12ª is a longitudinal sectional view of the truck and holder shown in Fig. 12, on the line 12ª—12ª thereof.

Fig. 13 is a perspective view of a truck (the wheels therefor being omitted) having a holder slightly different in construction from that shown in Figs. 11 and 12.

Fig. 14 is a fragmentary view, partly in section, of the discharge end of the apparatus showing the automatic means for discharging the materials.

Fig. 15 is a section on the line 15—15 of Fig. 14.

My apparatus may be used for burning various kinds of materials, including shale and limestone, but I have particularly adapted it for the burning or calcining of the latter. In my apparatus and according to my process the limestone rocks are subjected to heat at a predetermined temperature for a predetermined period of time without contact or mixture with the fuel, so that lime devoid of ash and other products is obtained. In carrying out my process, I use an apparatus of the continuous kiln type, whereby the introduction of the material into the kiln, its treatment and the discharge thereof may be effected readily and substantially continuously.

1 indicates as an entirety a kiln having a burning section 2, a preheating section 3 and a cooling section 4; and by preference the preheating section is provided with an inlet section 5 and the cooling section 4 is provided with a supplemental or auxiliary cooling section 6, all of these sections being in line with each other, whereby the material is passed through a zone 3ª of gradually rising temperature, then through a zone 2ª having a fixed, predetermined temperature to effect the burning of the material, then through a zone 4ª, whereby cooling is permitted; then through a zone 6ª where a further cooling is provided for.

The kiln is built on a suitable bed 1ª preferably formed of cement. The outer walls of the kiln 1 may be built of bricks 7 or other materials. These walls may be braced by studs 8, tied together by rods 9, the studs being spaced any desired distances and fixed at their lower ends in the bed 1ª. The walls 7 are lined with insulation, as shown at 10, to properly insulate the inner walls 11, which are preferably formed of fire bricks. The walls of the inlet section 5 and supplemental cooling section 6 may be formed from cement. All of the walls that

are formed from cement may be reinforced in any manner desired. The inner wall 11 is widened at its lower portion to form benches 12 which extend from end to end of the kiln 1 and form between them a space for the conveying means for the limestone rock, such conveying means in the present instance comprising trucks indicated as an entirety at 13, to which reference will later be made. As will later appear, the trucks 13 fit between the benches and run on tracks 14' and cooperate with the benches to form above the latter the zones 3^a, 2^a, and 4^a, whereby the heat and products of combustion and carbon dioxide and other vapors may be controlled and readily discharged or exhausted from the kiln and the products of combustion utilized to the best advantage in preheating the material as it passes through the zone 3^a. The benches 12 also serve as supports for baffles 14, 15, 16, in the zones 3^a, 2^a and 4^a, respectively, the purpose of which will later be set forth. The benches 12 may be variously constructed from fire bricks; for example, each may be made to form an interior space that is filled with cement, as shown at 17; while portions of the benches 12 may be constructed otherwise to provide for the primary combustion chambers, indicated as an entirety at 18 or for outlet conduits 19 (see Figs. 4 and 7). The opposing side faces of the benches 12 are provided with ledges 20 which co-operate with the sides of the trucks 13 to prevent the heat and products of combustion from flowing down below the truck bodies 13^a and causing damage to the truck wheels, their axles and axle bearings. To maintain the space below the ledges 20 relatively cool, I provide piping 21, preferably three lines of pipe, against or adjacent each bench side face below the adjacent ledge 20 (being mounted on the side face in any desired manner) and circulate through such piping cold air by means of a suitable blower (not shown) connected to the inlet ends of the pipes 21. As will be understoood from Figs. 1, 2 and 5, there are two sets of pipes 21 on each bench side face, one set extending from the inner end of the preheating section 3 to its outer end and the other set extending from the inlet end of the burning section 2 to or a point adjacent the discharge end of the cooling zone 4^a. The outer and inner ends of the pipes 21 are bent outwardly and project through the walls of the kiln 1. The inner ends of the sets of pipes are connected by a pipe 21^a with a suitable blower (not shown), which forces cold air through them, the radiation from the pipes serving to maintain the space between the benches 12 and below the ledges 20 and truck bodies relatively cool for the purpose already set forth. By this arrangement of the pipes and their connection with the cold air supply, the cold air is introduced substantially centrally of the kiln and at the point of maximum temperature. The zones 3^a, 2^a and 4^a are covered by roofs $3^{a'}$, $2^{a'}$, $4^{a'}$, respectively, each of the roofs $3^{a'}$, $2^{a'}$, preferably each comprising an arch of suitable fire bricks 22 covered with insulation 23 and the roof $4^{a'}$ comprising an arch of suitable fire brick 23^a.

The burning or calcining of the limestone is effected while passing from one end to the other end of the furnace section 2 or in passing through the burning zone 2^a, wherein a predetermined temperature, preferably of 1,700 to 2,400 degrees Fahrenheit dependent upon the quality and nature of the limestone is maintained, although a higher or lower temperature may be maintained if desired, I having found that within certain limits, a relatively high temperature is desired to burn out the impurities in the material being treated to produce what is commonly known as white lime. The heating means comprises a pair of combustion chambers 24 extending from end to end of the furnace section 2 preferably on or above the level of the benches 12 at each side of the burning zone 2^a (see Fig. 9), the primary combustion chambers 18 (already referred to) and air supply conduits 25, 26, arranged to supply heated air to the combustion chambers 24, as will later appear. As shown in dotted lines in Figs. 1, 2 and 5, there are a plurality of primary combustion chambers 18 having openings extending through the outer walls 7 at either side of the burning section 2. Each primary combustion chamber 18 is provided by constructing in the adjacent bench 12 and wall 7 an opening of the desired shape to form the chamber having side walls, a bottom wall 18^a and a rear wall 18^b that is upwardly inclined, these walls forming an opening $18^{a'}$ at their inner portions that leads into the bottom of the adjacent combustion chamber 24. By preference the walls 18^a and 18^b of each primary combustion chamber are cut away to form a groove or space 18^c of any desired width leading inwardly through the wall 7 and the walls 18^a and 18^b are provided with a lining 18^d, preferably formed from slabs of suitable refractory material, to protect the walls of the benches 12. As shown in Fig. 9, the lining 18^d extends over and along the groove 18^c and co-operates with its walls to form the air supply conduit 25. By this arrangement the air in the conduit 25 is heated by the burning fuel in the chamber 18 and delivers it to the combustion chamber 24 at a point adjacent the opening $18^{a'}$. The primary combustion chambers shown are adapted to receive gas or oil burners, but by provision of a grate they may be utilized to burn coal as the fuel. Each air supply 26 comprises a manifold 27, which opens

into the adjacent combustion chamber 24 preferably at that end adjacent the discharge end of the burning section 2. The air supplied by each manifold 27 is heated in the following manner: 28 indicates a conduit or pipe incorporated in each side wall of the cooling section 4, preferably adjacent its discharge end. The pipe 28 has an inlet end which extends through the wall 7 (see Fig. 1). Its opposite end connects with a manifold 29 to which are connected a series of pipes 30, preferably of rectangular shape in cross section, extending longitudinally of the cooling section above the benches 12 and connected at their opposite ends to the adjacent manifold 27. The air in the pipes 30 is heated by the heat radiating from the material passing through the cooling zone 4^a, the transfer of the heat from the material to the air in the pipes serving to gradually cool the material and to heat the air, so that the latter may be used for combustion purposes in the combustion chambers 24 to supplement the heated air supplied by the conduits 25. The pipes 30 are mounted in openings formed in the spaced piers or baffle members 16, which are supported on and extend from the benches 12 to the arch $4^{a'}$. The piers 16 tend to cause the heat to radiate inwardly and outwardly relative to the pipes 30 due to a draft which is set up within the kiln 1, as will be later described. The pipes 30 may be formed from fire clay or other suitable fire resisting material. By making them of rectangular shape, maximum area of exposed pipe walls is provided between the inner and outer edges of the piers 16, or at either side of the space required for the passage of the material.

The combustion chambers 24 extend from end to end of the burning section 2, each being disposed above the adjacent bench so as to be on an approximate level with the material passing through the zone 2^a. Each chamber 24 has a rear refractory wall 32 to protect the inner wall 11, and a front wall 33 having a plurality of uniformly spaced openings 34 through which the flame and products of combustion project and flow to effect burning of the material. The chamber 24 is provided with a top 35, which comprises slabs of suitable refractory material supported on the upper ends of the walls 32 and 33, as shown in Fig. 9. The baffles or partitions 15 extend from the tops 35 to the arch 22, have their front edges in a plane coincident with the front or inner face of the wall 33. The baffles 15 are preferably arranged one opposite the other and uniformly spaced from end to end of the zone 2^a (see Fig. 5) and primarily serve to prevent the products of combustion and the heat generated thereby from finding a straight path of exit through the zone 2^a; on the other hand, the baffles 15 serve to cause these elements and other gases or vapors to flow inwardly and outwardly in a successive manner as they are drawn through the zone 2^a to the zone 3^a by the induced suction, to which reference will later be made; accordingly it will be seen that the products of combustion and other heated gases and vapors are caused to circulate into and through or between the material and out again.

The heated air and gases, consumed products of combustion, carbon dioxide and other vapors given off from the material as it passes through the zone 2^a flow into and through the preheating zone 3^a and contact with the material being moved forwardly therein, the effect of which is to dry out all moisture in the material and gradually heat it up to approximately the temperature of the zone 2^a. To more effectively cause these heated elements to penetrate the material as it moves through the zone 3^a, I provide therein a plurality of pairs of piers or baffle elements 14, (already referred to), disposed in spaced relation preferably equal distances from each other. As understood from Fig. 1, the baffle elements 14 constituting each pair are positioned opposite each other on the benches 12, the effect of which arrangement is to cause the heated elements to flow inwardly around these baffle elements and then outwardly into the spaces between them, and thus prevent these elements from forming into a current and flowing in a path leading directly through the zone 3^a; these baffles therefore insure the circulation of these elements into and through the material or the spaces between the rocks constituting it.

38 indicates a draft inducing means connected with the zone 3^a and serving to set up a suction effect therein and thus draw all of the heated air and gases, products of combustion or gases resulting therefrom, and vapors from the material through the zone 2^a into the zone 3^a and through the latter whereby they are discharged either into the open, or to some suitable apparatus where it is desired to re-claim, as by-products, any of the materials combined or mixed with the limestone or other material that is being calcined. The draft inducing means is regulated to insure flow of all the heat and gases and products of combustion and prevent any portion thereof entering the cooling zone 4^a.

39 indicates as an entirety mechanism for regulating the discharge of the heated air and gases, vapors and consumed products of combustion from the zone 3^a. As the draft inducing means and the regulating mechanism are in combined or associated relation, I will describe them as follows: 40 indicates a discharge pipe or conduit at

one side of the preheating section and leading to a suitable point of discharge. Interposed in this conduit is a suitable suction device, such as a power driven fan (not shown) having sufficient suction effect to induce the maximum draft in the zones 3^a and 2^a. 41 indicates a conduit mounted on the roof $3^{a'}$ and extending longitudinally and centrally thereof so as to receive the heated ingredients and elements of the character referred to through one or more ports 42 formed in the roof $3^{a'}$. The ports 42 may be opened and closed independently of each other by suitable dampers 42* (see Fig. 7). The ports 42 are spaced from each other any desired distance and extend from the inlet end of the zone 3^a toward its discharge end so that through the regulation of their dampers, the discharge of the heated ingredients at one or several points can be effected. The conduit 41 preferably comprises an inverted hollow member which sets into a slot or opening formed in the roof section 23 as shown in Fig. 4. 43 indicates a pipe connecting the conduit 41 with the conduit 40. As will be understood from Figs. 1 and 4, the conduit 41 extends downwardly to a point below the bed 1^a, where it is connected to a transverse pipe 44, which in turn is connected by risers with the chambers or outlet conduits 19 (see Figs. 4 and 7). The chambers 19 preferably extend longitudinally of the benches 12 from the inlet end of the zone 3^a to a point below the third pair of baffle elements 14. Each of the baffles 14 above the adjacent conduit 19 has a stepped rear end wall 45 for a purpose which will later appear. 46 indicates a plurality of vertical pipes or conduits formed in each of the baffle elements just referred to and extending from the adjacent chamber 19 upwardly and each pipe 46 is connected to one or more inlet pipes or openings 47 leading inwardly from the end wall 45 whereby the conduit 19 receives the heated ingredients from points at different levels within the zone 3^a. 48 indicates dampers for closing the pipes 46, each damper preferably comprising a plate slidably fitting a guide way 49 formed in the adjacent bench 12 and walls 11 and 7—see Fig. 7. By pulling one or more of the dampers out, the flow of the gases can be controlled through any one or more of the pipes 46 and at a high or low level in the zone 3^a, as desired. By providing each of the baffle elements with a larger number of pipes 46 or controlling the openings into the pipes 47, the discharge of the heated gases can be taken off at intermediate levels.

From the foregoing description it will be seen that I provide for the discharge of the heated gases either at the top of the zone 3^a or at different levels in the zone, and also at different points longitudinally of the zone through either of these discharge openings. Accordingly, the suction effect of the fan can be regulated dependent upon the conditions existing within the kiln or the nature of the material or speed with which it becomes heated after it enters the zone 3^a.

The supplemental cooling section 6 may be provided with supplemental means 50 for cooling the material rapidly, since the material after passing through the cooling zone 4^a has cooled sufficiently to permit the application of any sort of cooling without danger of affecting the material or the holder 13 carrying it. The supplement cooling means 50 comprises a pair longitudinally arranged upper and lower manifolds 51 connected by a plurality of pipes 52, arranged adjacent each side wall of the section 6. The upper manifolds 51 are connected by pipes 51^a to a pipe 53 which extends upwardly through the roof of the section 6. A suitable blower (not shown) is interposed in the pipe 53, the purpose of which is to blow or suck cold air through the manifolds 51 and pipes 52, openings being formed in the lower manifolds to permit of this operation (see Fig. 6).

The limestone may be loaded onto trucks carrying holders of the type shown generally at 13′ in Figs. 12 and 12^a and the trucks moved successively through the kiln 1, preferably in abutting relation; but I prefer to use trucks having holders of the type shown at 13 in Fig. 11 or of the construction shown at 13″ in Fig. 13, since a number of advantages result in the use thereof, to wit, (1) the holders can be continuously loaded without waste of material; (2) the holders, by reason of their continuity while being moved through the kiln, have an increased carrying capacity and provide for the movement of a continuous stream of material into and through the kiln; and (3) they permit of the automatic discharge of the material from the holders.

So far as I am aware, I am the first to construct a holder for material which may be introduced into a chamber that is heated to a high temperature, moved through and discharged from the chamber whereby it is subjected successively first to a high temperature and then to normal temperature without damage or deterioration of any sort. As shown, the trucks carrying the holders are moved into filling position, as shown in Fig. 3, preferably below a loading hopper 54, then they are moved into and through the zones 3^a, 2^a, 4^a, successively, then they are moved past a discharging or unloading mechanism indicated as an entirety at 55; then the trucks are returned by a return track (not shown) to position ready to be moved to a point below the loading hopper 54. The movement of the trucks may be continuous or intermittent,

as desired, power being applied to the first end truck at the inlet end of the kiln and it in turn pushing the trucks in front of it forwardly.

The truck body comprises a frame 56 (preferably a casting 56[a] having strengthening ribs and a flange 56[b] extending along its sides and ends—see Fig. 12[a]) and bearing boxes 57 for axles 58 which carry the wheels 59, the peripheries of which are shaped to engage the tracks 14'. 60 indicates a base portion supported on the frame 56 and formed of refractory blocks, such as bricks 61, as shown in Figs. 11, 12 and 12[a] or tile 62, as shown in Fig. 13. The bricks or blocks rest on the frame and fit within the flange 56[b]. The upper surface of the base portion 60 is shaped to form inclined bases 60[a], 60[a], extending from the longitudinal side edges of the base portion downwardly to a longitudinal line extending centrally thereof. The purpose of this construction will later appear. At 63 the end walls of the base portion 60 are provided with transversely extending ribs arranged to close the spaces between the trucks and thus prevent heat from radiating downwardly. As shown in Fig. 3, the ribs on the front and rear end walls of each truck are off-set one relative to the other so that the ribs on adjoining trucks will overlap each other for this purpose.

The holder 13 comprises a bottom 64, side walls 65 and supporting members 66 all of which are constructed from blocks 67 and slabs 68 each formed from suitable fire clay capable of resisting the high temperature required in the kiln 1 in burning the limestone or other material and exposure to the air at normal temperature without danger of breakage. The blocks 67 preferably extend transversely of the base portion 60, being arranged in rows each row spaced from the other row to permit the heat to circulate beneath the bottom 64 and side walls 65; also, the blocks in each row constitute a series so that their lower surfaces may engage the incline bases 60[a] and their upper surfaces support the slabs 68 in the manner shown. The side walls 68 are inclined inwardly and downwardly, thus serving to increase the carrying capacity of the truck, at the same time leave a large area of the material exposed to the heat and products of combustion as well as permit the ready escape of the carbon dioxide and other vapors from the material. The bases 60[a] being inclined downwardly and inwardly, they prevent lateral sliding of the blocks 67 on the base portion, and hence insure the assembly of the slabs in position. The slabs 68 forming the side walls 65 are inclined sufficiently to maintain a maximum load without affecting the accessibility of the heat and products of combustion to the material or free escape therefrom of the vapors given off incident to the burning action. It will be seen from Figs. 3 and 11 that the bottom 64 and side walls 65 extend from end to end of the truck body 56 or base portion 60, so that they substantially abut the corresponding walls of the adjacent trucks. As a result, the loading of the trucks may be carried on continuously and the holders may co-operate one with another to form a continuously moving stream of material which is continually moving into and through the kiln, as will be understood from Fig. 3. The holder may be modified so that the outermost slabs thereof will be but slightly inclined, as shown at 69 in Fig. 13, in which form of construction I prefer to provide flange sections 70 extending along the side edges of the slabs 69. As will be understood, the flange sections are formed of the same material as the other sections of the holder; also, that the blocks 67' are shaped to support the slabs 68' and 69 in the position shown. Fig. 13 also shows a further modification which may be used in connection with either form of holder, in that the base portion is constructed of fire-clay blocks instead of bricks.

Where it is desired to provide the holder with end walls I construct it as shown at 13'—see Figs. 12 and 12[a]. In these views, I provide blocks 70, 71, shaped to fit the slabs 68[a] forming the bottom 64' and side walls 65'. The blocks 70, 71, may rest on the slabs 68[a] or they may be formed integrally with the end row of blocks 67[a], in which event the blocks have an off-set portion 67[a]' to form a seat for the adjacent slabs 68[a]. By fitting the base portion 60 of the holders within the flange 56[b], the latter will lie beyond the refractory base portion and thus engage each other to effect movement of the trucks through the kiln 1 without contact with the refractory walls. Danger of breakage of these walls is therefore eliminated.

In my process of burning limestone, the material is first introduced into and passed through a zone where the temperature is gradually increased from approximately atmospheric temperature to the temperature at which the burning is effected, then the material enters and passes through a zone of a predetermined temperature so that for a predetermined period the material is subjected to the desired temperature to insure complete burning, and finally the material passes into and through a cooling zone where its heat is utilized to heat air which is supplied to the combustion chamber. During the passage of the material through these zones, it is continuously subjected to a draft induced at or near the entrance end of the kiln, the effect of which is to carry off the vapors resulting from the burning of the material to draw the products of combus-

tion and heat rearwardly and through the zone 2^a to prevent it passing into the cooling zone 4^a and to direct it into and upon the material being moved forwardly in the zone 3^a. From the foregoing description it will be seen that in my form of construction and in carrying out my process, I provide for a continuous supply of material and movement thereof through the kiln, and finally discharge it from the holders outside of and beyond the exit end of the kiln, preferably as shown in Figs. 14 and 15.

The holders are preferably loaded from a hopper having a suitable chute 54^a controlled by a valve (not shown). The bottom or delivery end of the chute 54^a may be so positioned that it will level over the material discharged into the holders at such height as to prevent overloading thereof.

Of the discharging means 55, 72 indicates a collecting hopper countersunk in the ground below the tracks 14′ and bed 1^a. This hopper may have its wall built of cement and its lowermost portion may be shaped to form a chamber 73 through which an endless conveyor 74 runs, the walls of the chamber having guide members 75 to direct the burnt material into the buckets. The conveyor buckets may carry rollers 74^a, engaging suitable tracks 74^b. The conveyor 74 leads to a suitable discharge place or station. 76 indicates frames disposed on opposite sides of the tracks 14′, each frame preferably comprising uprights 77 and connecting members 78, 79 indicates the discharging elements comprising a series of scraping members extending between the frames 76 and arranged with their lower free edges at different levels, the first being arranged to scrape off a portion of the material as a holder 13 is moved below and past the scraping member, the next being arranged to scrape off a further portion of the material as the movement of the holder continues and the last scraping member being arranged to scrape close to the bottom of the holder and thus effect discharge of all of the material. It will be obvious that the holders could remain stationary and the scraping members moved relative thereto, in which event the uprights 77 could be mounted on wheels, but I prefer to continue the tracks 14′ outwardly beyond the kiln section 6 and hopper 72 and to move the truck thereover as shown in Fig. 14. In moving the truck and its holder in this manner, I propose to provide at some suitable point a winch for a cable carrying a hook which may be connected to each truck, as they exit from the kiln, and to move it away from the succeeding truck to effect the discharge as shown in Fig. 14. While I have shown in Figs. 14 and 15 three scraping members 79, I may increase or decrease the number as desired.

In the burning of limestone to produce lime according to my process and by means of an apparatus such as disclosed, limestone containing calcium or magnesium may be readily calcined since the temperature can be regulated according to the chemical characteristics of the limestone. As will be noted very accurate control of the temperature may be made, so that a better quality or a higher grade of lime can be produced than with apparatus now in use. The period of burning depends upon the length of the heating section, which will be determined by the available limestone at the place of erection of the kiln. Since the material is moved through a burning zone and only the gases of the products of combustion come in contact therewith, and the temperature of these gases may be controlled by regulation of the fuel and air, it will be seen that relatively high efficiency is obtained without danger of overheating.

As my apparatus maintains the limestone and fuel separate, the lime may be used for chemical purposes and furthermore a limestone which breaks up under the influence of heat may be calcined.

In my construction, the material is conveyed through the kiln and calcined without contact with the walls thereof. Accordingly no abrasive action takes place. As a result, the inner exposed walls of the kiln may be constructed from various materials capable of withstanding the various temperatures existing in the pre-heating, burning and cooling zones without regard to their hardness or to the chemical characteristics of the limestone to be calcined or the amount of impurities contained in it. Not only does this construction economize the cost, but simplifies the building of the kiln and eliminates the renewal of and repairs to the lining required in other types of kilns.

From the foregoing description it will be seen that I provide for complete regulation of the induced draft so that (1) the burning conditions are properly controlled to prevent the heat and gases from entering the cooling zone to effect their flow toward the exhaust port or ports; and (2) the temperature in different portions of the pre-heating zone 3^a may be changed at will to meet varying conditions.

I have found that in a continuous tunnel kiln of the construction herein disclosed, very material reduction in fuel and labor may be attained. Furthermore, the apparatus is capable of calcining limestone rock material that is relatively small or fine in size. As a result I may produce lime from limestone which heretofore has been wasted and not used because of its size.

To those skilled in the art to which my invention relates, many changes may be made and widely differing embodiments and applications of my invention will suggest

themselves without departing from the spirit and scope thereof. My disclosures and description herein are purely illustrative and are not intended to be in any sense limiting.

What I claim is:

1. In a tunnel kiln for calcining material, the combination of a pre-heating section and a burning section, the burning section comprising an elongated central portion through which material is conveyed and a plurality of secondary combustion chambers disposed in each side wall of the burning section and opening into the said central portion from end to end thereof, a plurality of primary combustion chambers disposed within the side walls of said burning section and having exit openings leading into the lower portion of said secondary chambers, air inlets for the latter chambers, and means for conveying material through said sections.

2. In a tunnel kiln, the combination of a pre-heating section and a burning section, the burning section comprising an elongated central portion through which material is conveyed and a plurality of secondary combustion chambers disposed in each side wall of the burning section and opening into said central portion from end to end thereof, a plurality of primary combustion chambers disposed within the side walls of said burning section and having exit openings leading into the lower portion of said secondary combustion chambers, means for supplying air to said secondary combustion chambers, holders for conveying material through said sections, and means at the discharge end of said kiln for discharging the material from said holders.

3. In a tunnel kiln for calcining material, the combination of a pre-heating section, a burning section and a cooling section, the burning section comprising an elongated central portion through which material is conveyed and a plurality of secondary combustion chambers disposed in each side wall of the burning section and opening into the said central portion from end to end thereof, a plurality of primary combustion chambers disposed within the side walls of said burning section and having exit openings leading into the lower portion of said secondary combustion chambers, air conduits extending from the discharge end of said cooling section inwardly to and connected with the secondary combustion chamber adjacent the discharge end of said burning section, and means for conveying rock material through said sections.

4. In a tunnel kiln for calcining material, the combination of a pre-heating section and a burning section, the burning section comprising an elongated central portion through which material is conveyed and a plurality of secondary combustion chambers disposed in each side wall of the burning section and opening into the said central portion from end to end thereof; a plurality of primary combustion chambers disposed within the side walls of said burning section and having exits for communicating with said secondary combustion chambers, means for supplying air to said secondary combustion chambers, means for conveying material through said sections, and means spaced along said pre-heating section adjacent its inlet end for regulating the exhaust of gases and vapors from said pre-heating section.

5. In a tunnel kiln for calcining material, the combination of a pre-heating section and a burning section, the burning section comprising an elongated central portion through which material is conveyed and a plurality of secondary combustion chambers disposed in each side wall of the burning section and opening into the said central portion from end to end thereof; a plurality of primary combustion chambers incorporated in the side walls of said burning section and having inlets communicating with said secondary combustion chambers, means for supplying air to said combustion chambers, means for conveying material through said sections, and means spaced along said pre-heating section adjacent its inlet end for regulating the exhaust of gases and vapors from said pre-heating section, said regulating means including a plurality of valved outlets in the upper portion of said section.

6. In a tunnel kiln for calcining material, the combination of a pre-heating section and a burning section, the burning section comprising an elongated central portion through which material is conveyed and a plurality of secondary combustion chambers disposed in each side wall of the burning section and opening into the said central portion from end to end thereof; a plurality of primary combustion chambers incorporated in the side walls of said burning section and having inlets communicating with said secondary combustion chambers, means for supplying air to said secondary combustion chambers, and means spaced along said pre-heating section adjacent its inlet end for regulating the exhaust of gases and vapors from said pre-heating section, said regulating means including a plurality of valved outlets having intake openings disposed at different levels in said pre-heating section.

7. In a tunnel kiln, the combination of a pre-heating section and a burning section, the burning section comprising an elongated central portion through which material is conveyed and a plurality of secondary combustion chambers disposed in each side wall of the burning section and opening into the said central portion from end to end thereof; a plurality of primary combustion chambers incorporated in the side walls of

said burning section and having inlets communicating with said secondary combustion chambers, means for supplying air to said secondary combustion chambers, means for conveying material through said sections, and means spaced along said pre-heating section adjacent its inlet end for regulating the exhaust of gases and vapors from said pre-heating section, said regulating means comprising a plurality of valved outlets in the upper portion of said pre-heating section and a plurality of valved outlets having intake openings disposed at different levels below the upper portion of said pre-heating section.

8. In a tunnel kiln for calcining material, the combination of a pre-heating section and a burning section, means for conveying material through said sections, the burning section comprising an elongated central portion through which material is conveyed and a plurality of secondary combustion chambers disposed in each side wall of the burning section and opening into the said central section from end to end thereof, a plurality of primary combustion chambers incorporated in the side walls of said burning section and arranged to hold fuel to be burned, each said primary combustion chamber comprising a chamber having side walls and a refractory bottom extending rearwardly to direct the flame into the adjacent secondary combustion chamber, and a conduit communicating with the atmosphere and extending below said refractory bottom of each primary combustion chamber and communicating at its inner end with the lower portion of the adjacent combustion chamber, whereby the heat from the fuel burning in said primary combustion chamber heats the air in said conduit supplied thereby for combustion purposes in said secondary combustion chamber.

9. In apparatus of the class described, the combination of a tunnel kiln for calcining materials having an inlet and outlet, trucks carrying holders for material having open ends, means for moving said trucks through said kiln, and discharge means disposed beyond the outlet end of said kiln and in line therewith and acting on the material due to relative movement between said means and each truck to scrape the material therefrom.

10. An apparatus as claimed in claim 9 in which the discharging means comprises a scraping device disposed in the path of the material as the truck is moved outwardly from said outlet.

11. An apparatus as claimed in claim 9 in which the discharge means comprising a scraping device disposed at right angles to the movement of the truck and in the path of movement of the material as the truck moves outwardly from said outlet.

12. An apparatus as claimed in claim 9 in which the discharging means comprises a plurality of scraping devices disposed at right angles to the movement of the truck outwardly from said outlet, said devices having their lower edges in stepped relation downwardly from the first device to the last device.

13. In apparatus of the class described, the combination of a tunnel kiln for calcining materials having an inlet and an outlet, trucks carrying holders having bottom and side walls, means for moving said trucks through said kiln, and a plurality of scraping devices arranged to engage successive portions of the material and discharge it rearwardly from said holder as the truck moves outwardly from said outlet.

14. An apparatus as claimed in claim 13 in which the rearmost scraping device is shaped to fit the bottom and side walls of said holders.

In testimony whereof, I have hereunto subscribed my name.

HARRY M. ROBERTSON.