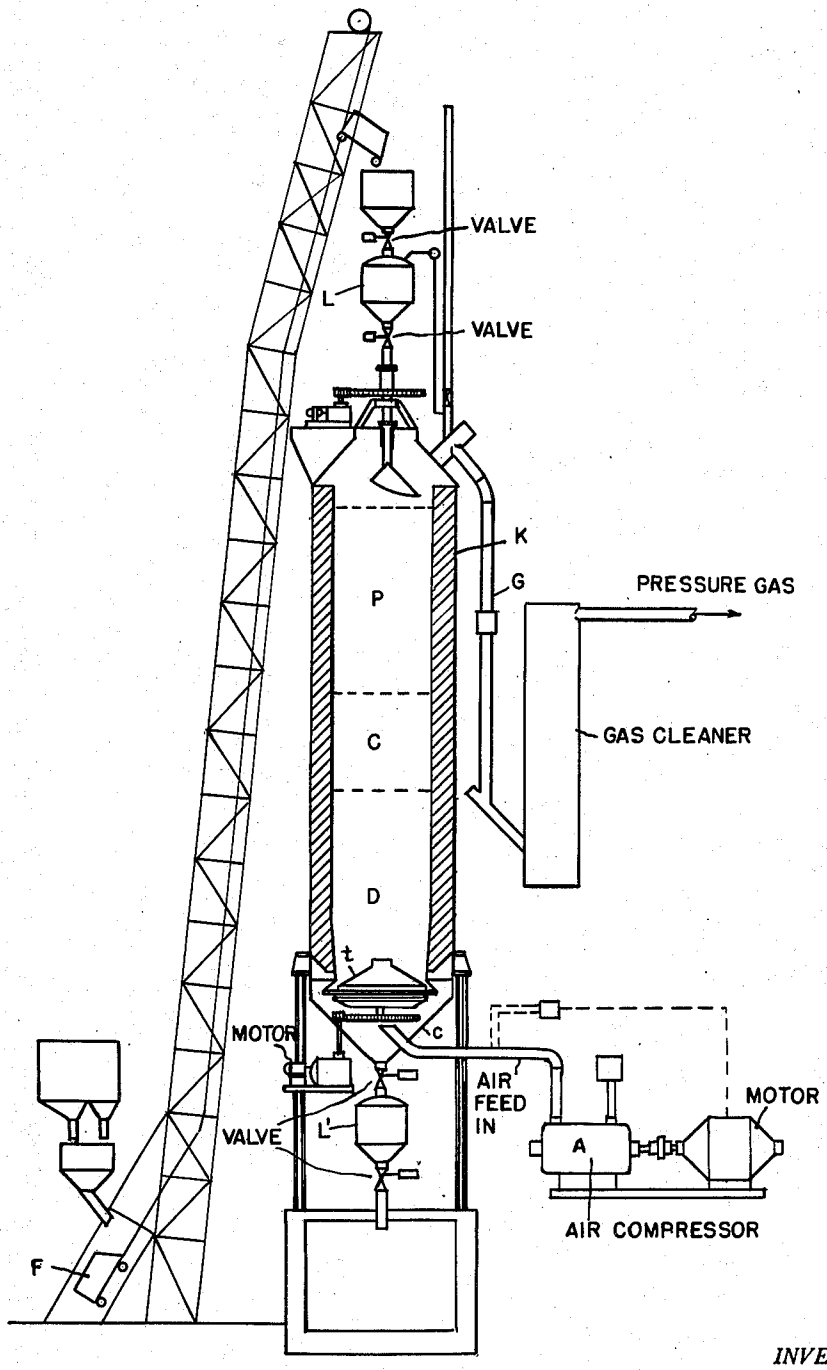
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BURNING LIME AND LIKE CO_2 -YIELDING MATERIALS

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BURNING LIME AND LIKE CO_2-YIELDING MATERIALS

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1 Claim. (Cl. 263—53)

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In burning lime, a well-known procedure involves charging the stone, in size of two-inch pieces or larger, together with coke, into the top of a vertical kiln, while air for combustion is supplied by a blower at the bottom. This procedure has the disadvantage of tending to yield products lacking in desirable uniformity and freedom from unconverted cores. Another very serious disadvantage where the off carbon dioxide is utilized is the requirement of pick-up compressors to take the gas leaving the kiln and compress it up to a sufficient pressure head for feeding to apparatus such as carbonators, etc., for its use. In such practice, the characteristic is operation of the calcining zone at atmospheric pressure. In accordance with the present invention, the calcining and the discharge of carbon dioxide is carried on under super-atmospheric pressure, and with advantages in operation and products as will appear from the following description.

To the accomplishment of the foregoing and related ends, the invention, then, comprises the features hereinafter fully described and particularly pointed out in the claim, the following description and the annexed drawing setting forth in detail certain illustrative embodiments of the invention, these being indicative, however, of but a few of the various ways in which the principle of the invention may be employed.

The sole figure is a schematic vertical section view of an illustrative equipment in which the process may be carried out.

In calcining in accordance with the present invention, the apparatus employed may vary. One form of apparatus, shown in the drawing, involves a vertical shaft kiln K to which crushed stone and fuel are fed, as by a skip hoist F, through a coordinated seal-off lock L having valves at both ends so as to provide succession valved gas-lock zones at the top of the kiln K. The kiln provides a preheating zone P, a combustion zone C where the admixed fuel burns, and a discharge zone D in which the hot calcined product is progressively cooled to discharge by a rotatable table *t* in a cone bottom *c* to a coordinated seal-off lock L' having valves at both ends, so as to provide succession valved gas-lock zones at the bottom of the kiln K, and then discharged. Super-atmospheric pressure is maintained in the kiln, compressed clean and cool air being forced by compressor A into the bottom, and there being no release, the combustion gas proceeds under pressure through its pipe G to a cleaner and under pressure to a storage point or point of usage. It is of course required to be

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capable of withstanding the operating pressures involved, and in general may include a metal jacket with refractory lining, and in upright placement, and having air compressing means for forcing air into the bottom at a rate to determine the operating pressure which is to be maintained in the calcining chamber or kiln, and since the lime or calcined product must be discharged from the high pressure container to the outside atmosphere, an intermediate discharge chamber with a cut-off valve leading to the calcining chamber and another cut-off valve at the discharge point to the atmosphere includes the generally suitable equipment to permit the calcined material to be passed out of the calcining chamber into the discharge compartment, and by appropriate alternate operation of the valves to discharge the product to the outside. At the top of the kiln or calcining chamber, again a separate compartment with a valve between the calcining chamber and a valve at the inlet of such compartment, permits feed of raw material, and with appropriate alternate operation of such valves, movement of the material without interfering with the high pressure maintenance in the calcining chamber. In engineering practice, the general construction of such gas-locks is known and may be adapted variously. One form of apparatus which may be employed in carrying out the process is set forth in my patent application Serial No. 782,099, filed October 25, 1947.

While the burning of lime and dolomite is most commonly contemplated, it is to be seen that the present process also involves other materials yielding carbon dioxide in calcination. The stone to be calcined is crushed to desired size, and in general this is considerably smaller than in the practice heretofore. While in some apparatus installations gaseous fuel may be employed, most commonly a solid carbonaceous fuel, preferably coke, is to be employed, and in mixture along with the crushed stone. Depending upon general conditions, the proportion of such coke or the like may be varied, but usually it is preferred to employ about an equal number of stone and fuel particles. With the valve between the calcining chamber and the charging compartment closed and the valve at the inlet of the charging compartment open, the pressure zone in the calcining chamber is duly maintained, but the stone charge can be introduced into the charging compartment. Then, on closing the inlet valve and opening the valve to the calcining chamber, the material may be emptied thereinto.

Any desired refinements of feed distributors may be availed of if desired. None is required in small kilns. In the calcining chamber, with progressive feed as indicated and with supply of compressed air forced in at the bottom, three general zones of action are maintained. In the upper portion, the incoming stone and fuel passes progressively downward and hot combustion products from below pass countercurrently and result in a heat exchange whereby the stone and fuel is progressively heated up to the point of combustion in the central zone of the calcining chamber, while the gas passing from the top under high pressure has given up substantially all of its heat and is fed into scrubbers or other cleaning means and then to point of use, e. g. carbonators, or storage. Exit gas temperatures not much above atmospheric are thus readily attained. Simultaneously, since compressed air at high pressure is being forced into the bottom of the calcining chamber, in proceeding counter-concurrently through the calcined product coming from the center combustion zone, a heat exchange zone on the calcined product is thus effective to progressively heat up the air to the combustion zone and progressively cool the calcined lime or magnesia or like product such that it may be passed to the discharge compartment, the outlet valve of the latter being closed and its inlet valve next to the calcining chamber being opened, and then on closing the inlet valve and opening the outlet valve the calcined product having given up its heat to the incoming air is discharged to the atmosphere at a temperature relatively low and permitting easy handling.

As the operating pressure maintained on the kiln is determined by the pressure of the compressed air forced in at the bottom, it is seen that the control is relatively simple, and since no compressors are required operating on the discharge gases from the kiln, notable advantages result. Cool clean air is handled by the compressing plant, and the volume is considerably less than would have to be handled by compressors to operate on the exit gas made up of the produced carbon dioxide both of the calcination and the fuel combustion plus the residual nitrogen from air supplies for combustion. In an illustrative equipment thus, the power required to operate the air compressors in the present process is only about 72% of what would be required to operate the kiln at customary atmospheric pressure and compression pick-up of the exit gas. Additionally, the present procedure eliminates the difficulties and high costs of maintenance of compressors operating on exit gas. Such gas, even after going through cleaner-means, carries condensate substances and sulphur dioxide from the fuel, which are destructive on compressor equipment.

In the customary operation at atmospheric pressure, the stone fed for calcining must be relatively large, two inches and more, because the draft through a mass of stone is progressively cut down as the stone size is decreased, and such size is the minimum practicable in atmospheric pressure operation. However, in super-atmospheric pressure as in the present invention, since pressure drop of the gas through a bed of broken solids is proportional to the density of the gas and the square of the gas velocity, as the total pressure of the gas is increased the density increases and the linear velocity decreases and the over-all effect of increasing the operating pressure is to reduce the pressure loss proportionately; and since the pressure loss is also inversely proportional to the size of the stone, it is seen that for a given drop through the stone charge, the size of stone can be reduced proportionately to the increase in total pressure. Thus, in operating, for example, at 60 lbs. p. s. i. abs., the stone can be one-quarter the size of that for a process operating at atmospheric pressure, and yet the power required to force the air and gases through the kiln is approximately one-quarter that required when operating with the top at atmospheric pressure, since it would be required to compress only one-quarter the air volume to provide for the pressure loss through the kiln. For the same reason, if it be assumed that the same amount of power is to be used to drive the gases through a kiln operating at 60 lbs. p. s. i. abs. as is used for atmospheric pressure operation, the size of the stone can be one-sixteenth smaller; or it would vary inversely to the square of the operating pressure.

The stone for the present process may thus be sized in accordance with the operating pressure which is to be maintained, and in general may be less than one-half inch. Conveniently, an operating pressure of at least 50 lbs. p. s. i. abs., preferably around 60 lbs., may be employed. The advantages of the invention, however, may be realized in proportion, with lower or higher pressures, all super-atmospheric.

An important result of this use of smaller size stone in the charge is the improvement of the uniformity of calcining, the amounts of unburned cores and over-burned stone being proportionally reduced. And, it becomes possible to calcine stone which is too small to be handled by customary atmospheric-pressure calcining. As the stone size is reduced, the size of the solid fuel or coke also can be reduced, and operation becomes possible for instance with even coke breeze, which is of very low cost compared with lump coke. Economies in fuel cost result.

The capacity, or the tonnage of stone that can be calcined in a given kiln volume, depends on the stone surface area and on the mass or weight of air and gases flowing through it. Operating under a pressure of several atmospheres and with stone size thus materially reduced, the stone area per given volume is increased, thereby increasing the capacity of the kiln, since the heat transfer rate from the gases to the stone is increased. The heat transfer rate and kiln capacity increase also as the weight or mass flow for a given cross-sectional area is increased, and as the gas pressure is increased the density or mass per volume increases. For a given linear gas velocity and pressure loss through the kiln, by operating under pressures above atmospheric, an increase in kiln capacity results. The rate of combustion of fuel also increases with the pressure, being a function of the partial pressure of oxygen.

It is interesting that the calcination of calcium and magnesium carbonates follows the thermo-dynamic properties of boiling water, that is to say, the temperature remains constant during calcination, just as it remains constant during the boiling of water. The calcination temperature is a function of or depends on the partial pressure of the resulting gas or vapor, in this case CO_2. Also it is significant that as the pressure and temperature of CO_2 are increased, the heat required for the calcination of the carbonates decreases, and finally reaches zero, very much in the same manner as with water, which

at a pressure of 3206.2 p. s. i. abs. at a temperature of 705.4° F., the liquid and the saturated vapor contain the same total heat (no heat of vaporization). Thus, as the calcining reaction is carried on at pressures substantially above atmospheric, the heat required for the reaction decreases, with a corresponding decrease in fuel requirement. Since also a pressurized kiln is considerably smaller for the same capacity, it follows that the heat loss from the shell is less than that for a kiln for atmospheric pressure operation, and a reduction in fuel requirements results.

As a result of decrease in amount of fuel required per ton of stone calcined, the per cent of CO_2 in the exit gas increases, since less air is required per ton of stone decomposed and consequently the amount of diluent nitrogen is proportionately reduced. With the present process, richer CO_2 gas is obtained, and this becomes of importance for many kinds of usages.

From the standpoint of lime or magnesia products, it is seen that a calcining process operating under super-atmospheric pressure as here contemplated, provides a uniformity which has long been desired, and from the standpoint of carbon dioxide produced, it provides a product of high content and directly available in carbonating operations or other usages. At the same time, in the total operation the only compressor action required to maintain the kiln pressure and discharge the exit gas at desired pressure is at the inlet of the equipment and operating on cool, clean air. Correspondingly there is a very substantial saving in compressor maintenance and upkeep as compared with any system having compressors operating on off-gas which causes deposits in the cylinders and valves and which also contains more or less sulphur dioxide from the fuel combustion.

Other modes of applying the principle of the invention may be employed, change being made as regards the detail described, provided the features stated in the following claim, or the equivalent of such, be employed.

I therefore particularly point out and distinctly claim as my invention:

In a process of calcining, passing a mixture of fuel and material to be calcined having a particle size of about one-half inch or less through succession-valved gas-lock zones, then passing the whole mixture as a unitary substantially vertical, continuously downwardly sinking column of particles substantially maintaining their positions relative to each other through a first heat exchange zone in which hot product gases wholly passing countercurrently to the column preheat the mixture, then through a second lower contiguous combustion zone in which the calcined product is formed, and then through a third still lower contiguous heat exchange zone in which the heat of the calcined product preheats countercurrently incoming air, and simultaneously with passage of the continuously downwardly moving column, feeding low velocity compressed clean and cool air into said third zone substantially directly countercurrently to the downwardly moving column so as to cool the calcined product and to maintain super-atmospheric pressure within the three zones and proper combustion in the second zone, without upsetting the non-turbulent downward flow of particles, drawing off the calcined cooled product through succession-valved air-lock zones below the column, and passing the cooled product gases from the first heat exchange zone under its maintained super-atmospheric pressure.

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