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C. P. DĚBUCH
 PROCESS FOR THE PERFORMANCE OF CHEMICAL REACTIONS,
 SUCH AS ROASTING, CALCINING OR THE LIKE
 Filed Aug. 28, 1933 3 Sheets-Sheet 1

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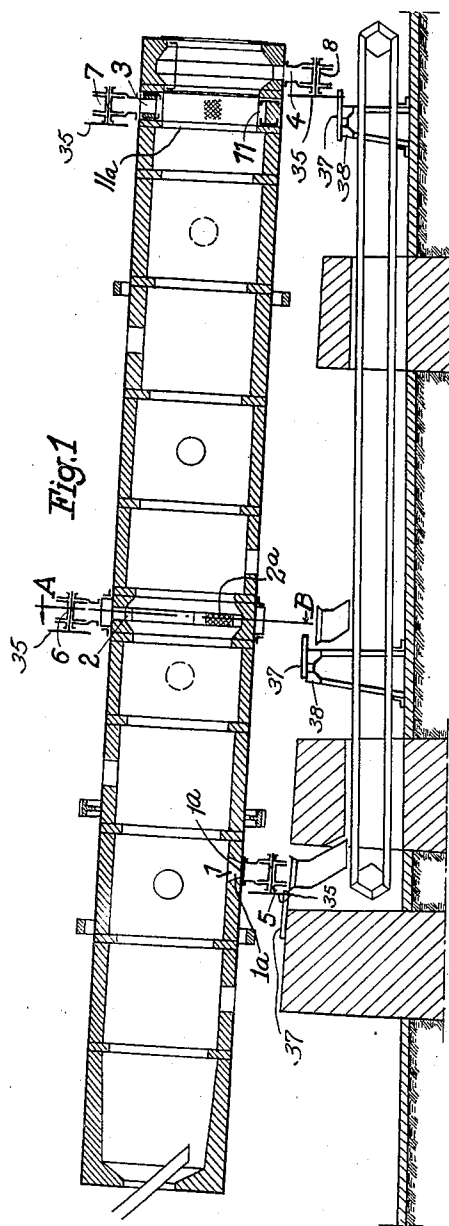


Fig. 1

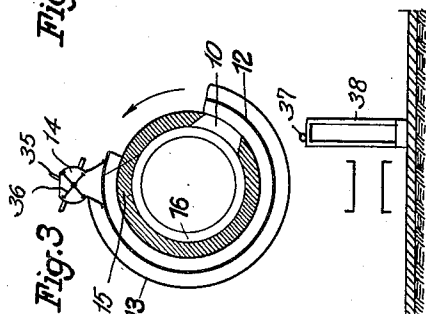


Fig. 3

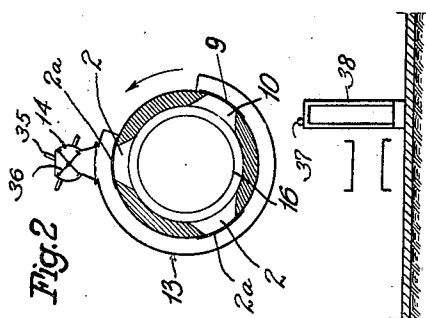


Fig. 2

Fig. 4

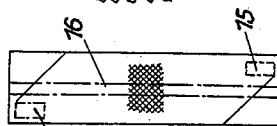
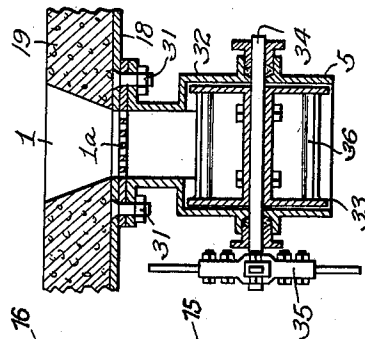


Fig. 8.



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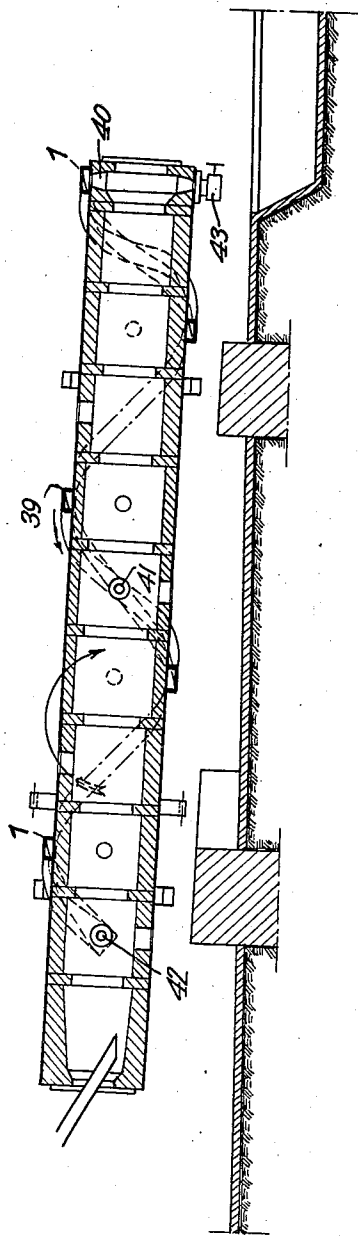
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PROCESS FOR THE PERFORMANCE OF CHEMICAL REACTIONS,
SUCH AS ROASTING, CALCINING OR THE LIKE

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3 Sheets-Sheet 2

Fig. 5



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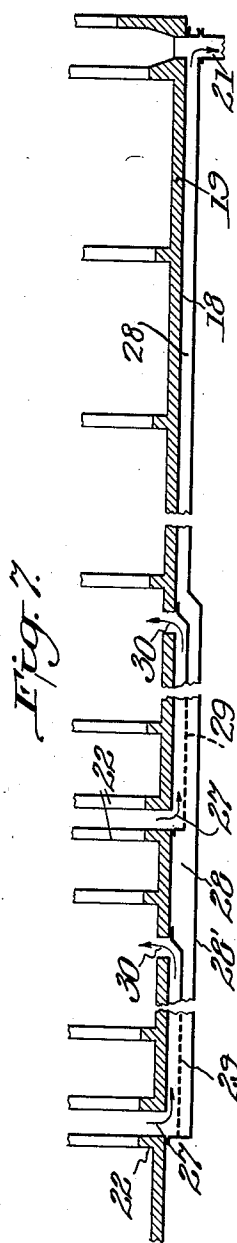
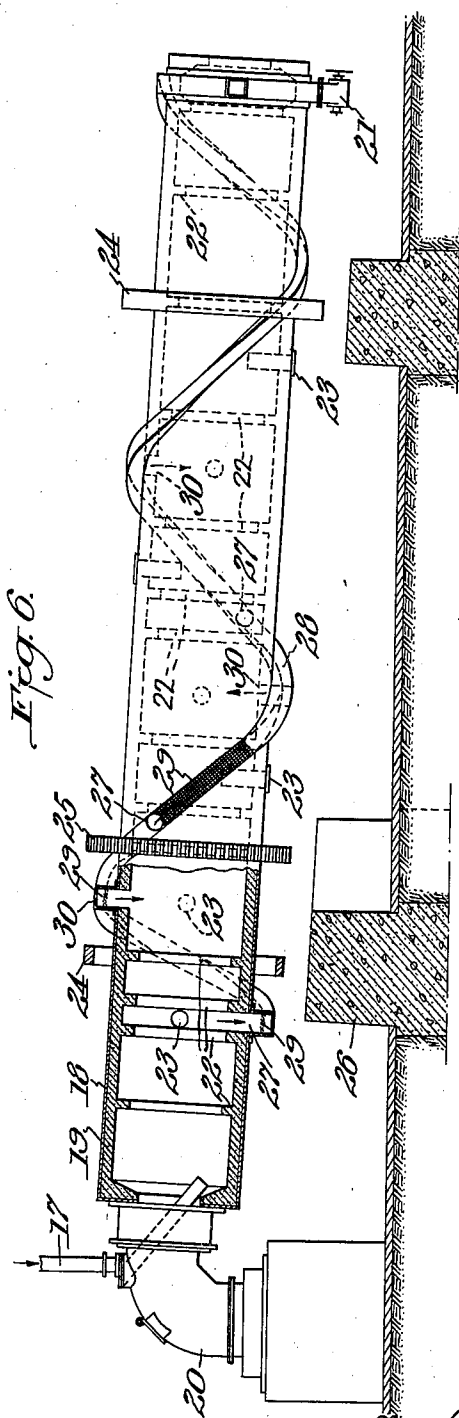
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PROCESS FOR THE PERFORMANCE OF CHEMICAL REACTIONS,
SUCH AS ROASTING, CALCINING OR THE LIKE

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3 Sheets-Sheet 3



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UNITED STATES PATENT OFFICE

2,039,062

PROCESS FOR THE PERFORMANCE OF
CHEMICAL REACTIONS, SUCH AS ROAST-
ING, CALCINING, OR THE LIKECarl Paul Dëbuch, Frankfort-on-the-Main, Ger-
many, assignor to American Lurgi Corporation,
New York, N. Y., a corporation of New YorkApplication August 28, 1933, Serial No. 687,234
In Germany August 14, 1930

5 Claims. (Cl. 75—60)

This invention relates to a process for the performance of chemical reactions, such as roasting, calcining or the like.

In processes for the performance of chemical reactions, in which the material to be treated is passed through a heated reaction chamber, the said material is mostly lacking in uniformity in respect of its physical character. This is a defect which attempts are made to rectify, in certain cases, by previously classifying the material into different grain sizes, which are treated separately. In this connection, mention may be made of the calcination of lump magnesite in shaft furnaces, and of fine-grained magnesite in rotary-tube furnaces. On the same lines, special types of furnace (lump pyrites furnaces) and processes have been devised for roasting pyrites in the form of large lumps, and special furnaces (fine-pyrites furnaces) and processes for roasting the same ores when in a finely divided form.

The commercial term "fines", as applied to pyrites, comprises for example, all crushed pyrites with a grain size of up to 0.8 to 0.10 mms. According to the requirements of the purpose in view, the classification into grain sizes may of course, differ from that specified. Even in such fine-grained material, the several sizes differ in their behaviour under heat treatment. Owing to its large superficial area and small diameter the fine grain reacts far more quickly than the coarser. Consequently, the intended chemical change during the heat treatment is completed sooner in the case of the fine grain than in that of the coarse. This applies for example, to the roasting of sulphide ores such as pyrites, galena or zinc blende, to calcination, as regards the splitting off of carbon dioxide and water of hydration and also to a whole series of other processes, such as the splitting off of sulphur dioxide from gypsum or heavy spar, and the calcining or sintering of magnesite or the like.

The circumstance that in fine-grained material, the finest grain is more reactive than the coarser, has already been utilized in various ways. Thus, in calcining magnesite, the crushed or ground material has been treated in a rotary-tube furnace, in such a manner as to produce both causticized and dead-burned, or sintered magnesite at one and the same time. At a point where a working temperature of about 900 to 1000° was attained, the rotary-tube furnace was provided with holes through which the caustic magnesite—of uniform grain size if desired—was discharged. The bulk of the charge was dead-burned and discharged at the heated end of

the furnace. In roasting sulphidic zinc ores from which the zinc is to be recovered by hydrolysis, it is found that there is a risk of the finer particles of the ore being over-roasted. In view of this, it was proposed to subdivide the ore, before roasting to completion, into particles of different sizes and to treat each grain size in a special furnace throughout, so that the maximum roasting speed of each grain size could be taken into consideration.

The joint heat treatment of fine material comprising different grain sizes results not merely in the possibility of difference in character between the coarser and finer grains at the completion of the treatment; the finest particles which closely surround the coarser ones, prevent the access of heat and the reaction gases to the latter. Accordingly, the transformation of the coarser particles is retarded and the furnace output is correspondingly lowered. Nevertheless, in many instances, the proposal to roast the various grain sizes of fine material separately in different furnaces, is rendered impracticable on account of the high prime and running costs of a multiplicity of furnaces.

According to the present invention, the chemical alteration of fine-grained material that contains a variety of grain sizes at the outset, or assumes that condition during the treatment, can be effected by passing the material through a heated, elongated reaction chamber—that is to say, for example, in roasting or calcining, without separating the material into different grain sizes—in such a manner that the several grain sizes undergo the same chemical transformation with approximately equal completeness. With this object, the finer grain sizes are removed in succession, separately from the coarser sizes, at two or more points in the elongated reaction chamber, the discharge points being so located that in each case, the individual grades of grain size are discharged when each grade has undergone the desired uniform degree of transformation.

The process of the present invention is not comparable with a known process in which the pulverulent material is introduced at the top of an upright reaction chamber and subjected to the action of gases ascending from below, in order to effect its chemical transformation. The known process proceeds in such a manner that the reaction takes place when the gases meet the materials in a state of suspension, the result being that the materials—insofar as they have taken part in the reaction—become specifically heavier and

descend, out of the reaction zone, through the reaction chamber, while the untransformed materials, which are specifically lighter than those which have been transformed, are seized upon by an ascending suction current and are drawn in the opposite direction, out of the reaction zone. Unlike the process of the present invention, this case does not relate to the treatment of substances that are present in different grain sizes, or are converted into a variety of grain sizes during the reaction treatment, and are jointly moved for a considerable distance through a reaction chamber. Consequently, this process is not attended with the drawback that finer materials, in which the reaction is already completed, retard the coarser and not yet transformed materials in their way through the reaction chamber.

In order more fully to explain the invention, the following example is given, referring to the roasting of pyrites.

The analyses of commercial fine pyrites by screening reveal a remarkable agreement with regard to the percentage proportions of the various grain sizes, the characteristic feature being that by far the greater portion consists of the fine grades of grain size, while the coarser grades are present in merely small amounts.

Fine pyrites with grain sizes between 0 and 8 mm. contain e. g.:

Grain sizes—	Per cent
0-2 mm.....	45-70
2-6 mm.....	15-30
6-8 mm.....	5-15

For the present purpose, it is sufficient to assume a mean composition of:

Grain sizes—	Per cent
0-2 mm.....	50
2-6 mm.....	35
6-8 mm.....	15

The examination of the roasted products from such raw fine pyrites shows, in the first place, that in all cases, a decrease in grain size has occurred in all the grades, that is to say, a percentage increase in the finer grades and a decrease in the coarser grades, has occurred during the treatment. This circumstance is of course, also borne in mind in devising the roasting process according to the invention, but can be left out of consideration here.

Unroasted pyrites have a mean sulphur content of 47-48%, the roasted products one of 1.5%. Examination of these products shows that this sulphur content is distributed among the several grain sizes as follows:

Grain sizes—	
0-2 mm.....	contains... 0.6% S
2-6 mm.....	1.4%
6-8 mm.....	4.7%

According to the present invention, at that point in the furnace at which the roasting of the fine pyrites, grade 0-2 mm. is completed, this grade is removed from the interior of the furnace while the 2-8 mm. grade is left in the furnace for further roasting. It has been ascertained that the sulphur content of the 0-2 mm. grade has been reduced to 0.6% by the time the charge has completed half the distance it has to travel through the furnace. On this account, an outlet with a screening device in direct connection with the furnace, is provided at this point, and the material corresponding to this grain size is discharged.

Since, for economic reasons, a sulphur content of 1.5% is permissible, in the example under consideration, and the 2-6 mm. grade still contains 1.4% of sulphur at the end of the roasting, this product also can be regarded as sufficiently desulphurized and removed, as finished roasted material at a suitable point (for example at 3, Fig. 1). On the other hand, the 6-8 mm. grade contains more than the permissible limit of sulphur. Consequently, this coarse grade which still fails to exhibit adequate roasting, is not regarded as a finished product and according to the invention, is recharged by means of suitable appliances, into the same roasting furnace for the purpose of increasing its travel and therefore the duration of the roasting treatment.

The screening outlet naturally varies in design according to the type of the furnace. In the case of multi-stage furnaces, an entire stage for example, may be arranged as a screen or segmental screens can be disposed in suitable hearth openings in a stage. Rotary-tube furnaces afford specially suitable conditions.

In order more clearly to understand the invention, reference is made to the accompanying drawings, which illustrate diagrammatically and by way of example, several embodiments of rotary-tube furnace suitable for carrying out the present process.

Fig. 1 is a longitudinal vertical section of a rotary tube furnace embodying features of the invention;

Fig. 2 is a section on line A—B of Fig. 1;

Fig. 3 shows a special form of construction of a screening and discharge device which may be substituted for that shown in Fig. 2;

Fig. 4 is a development of the screen 12 of Fig. 3;

Fig. 5 represents a rotary tube furnace provided with means for returning roasted material from the discharge end of the furnace to other points thereon that are located nearer the charging end thereof;

Fig. 6 is a fragmentary sectional elevation of a rotary-tube furnace illustrating a further modification of the invention;

Fig. 7 is a development of the screening and conveying passage, encircling the furnace, shown in Fig. 6; and

Fig. 8 is an enlarged section through the discharge device 14.

The furnace (Fig. 1) is provided about one-third the way along, with the first discharge opening 1, the openings 2 being disposed about midway along the furnace and other openings 3 and 4 at the end. In order to prevent any undesired access of air, the discharge openings are fitted with discharging devices 5, 6, 7, and 8 whose structure is more clearly shown in element 14 of Fig. 8. By the employment of these devices solids may be removed from the furnace without material admission of air at the discharge points. The screens at the discharge openings may be arranged in various ways. At the first openings 1 and 2, screens 1a, 2a, respectively, are interposed between the shell of the furnace and the discharging devices. At the discharge opening 3, the screen 11 is a continuous cylindrical screen, situated inside the furnace, the charge material being caused to pass over it, on the way to the last discharge opening 4, by the expedient of locating cylindrical screen 11 adjacent the low side of barrier ring 11a, the cylindrical screen having substantially the same diameter as barrier ring 11a. None of the charge material ex-

cept such as has passed through the screen 11 can reach the discharge device 7. This manner of arranging the screens comes under consideration especially in the case of such points in the furnace and such processes where or during which, a smaller liberation of heat has to be reckoned with.

Fig. 2 represents the manner in which a plurality of discharge openings distributed over the perimeter of the furnace and provided with screens can be fitted with a single discharging device.

In this case a plurality of openings 2, 2, 2, are located about the periphery of the furnace, communicating with a conduit 13 which encircles at least the major portion of the circumference of the furnace in the plan of the openings. Secured to this conduit and communicating therewith is a discharge means 6 for ejecting solids without admitting a substantial amount of outside atmosphere to the structure. At the mouth of each of the openings 2, 2, 2, is positioned a screen 2a adapted for retaining larger pieces of charge while passing smaller pieces. With rotation of the furnace, the smaller pieces of charge which have passed into the conduit 13 through the openings 2, 2, 2, by way of the screens 2a, 2a, 2a, are moved to and discharged by discharge means 6.

It will be appreciated that the material which falls through the screen 1a, or 2a, into the passage formed by the casing 13 cannot go back into the furnace again through the screen 1a, or 2a, when the operations during rotation of the furnace are imagined with reference to Fig. 2. In the position shown in Fig. 2, the material can leave the furnace through the right screen 2a: when the furnace rotates further the right screen 2a ascends and moves out of the layer of material. The screen 2a that is at the lower left in Fig. 2 therefore enters into operation. The material which falls through one of the screens 2a slides on the casing 13 so that it is always adjacent the lowest point. It therefore travels over the casing 13 during rotation of the furnace and reaches the discharge chute when the latter, during the rotation, passes through the lowest position which it can assume. At this moment, the screen 2a which is in the highest position in Fig. 2 enters into operation: the material passing through this screen 2a falls directly into the discharge chute 14. Upon further rotation, the cross arm 35 of the discharge chute reaches the stop 37 and the discharge chute is turned one or two chambers so that the material which it has taken up meanwhile is shut off from the passage formed by the casing 13 and cannot fall back again into the passage.

Fig. 3 represents another embodiment of a discharging device. In this case, the material issues through an outlet 10, and drops, irrespective of grain size, through the wide-open outlet, on to the screening jacket 12 surrounding the shell of the furnace. The fine material passes through said screen and falls on to the inner surface of the external casing 13, which delivers it to the outlet 14. The coarse material remains inside the screen 12 and is raised thereby and dropped back into the furnace through a second opening, 15, (shown in dotted lines at the top of Fig. 3) when the said second opening is in top position.

In Fig. 8 it can be seen how the screen 1a, which covers the whole opening 1, is secured to the cylinder 18 by bolts 31. The bolts 31 like-

wise serve for securing the discharge chute 5 to the furnace casing. Chute 5 comprises a housing 32 and a cell wheel 33 which is secured to and rotates with a shaft 34, which latter carries cross arms 35 outside the housing. The vanes 36 of the cell wheel 33 divide the cylindrical chamber inside the housing 32 into a plurality of cells and, by contact of their edges with the wall of the housing, seal the separate cells off from each other. Upon rotation of the furnace, the arm of the cross-arms 35 then in the suitable position strikes against a stop 37 carried on a suitable support 38 or by a part of the foundation of the furnace: in this way the cross arms cause the cell wheel to be turned one (or more) cells. The cells passing by the discharge opening of the housing empty thereby, while the cells that reach the neighborhood of the upper charge opening of the housing are filled again. Discharge chutes of this kind are already known per se; they can be used at all discharge openings of the furnace, 5, 6, 7, and 8.

In Fig. 4 a plane projection of the screen 12, with the discharge opening, 10, and the return opening, 15, into the furnace, are shown. The baffle ring 16, separating the two openings from each other, likewise is indicated.

The rotational movement of the furnace effects the screening of the material that has fallen into the screen 12. The fine material which has passed through the screen into the external casing 13, travels along the latter and is discharged through the opening 14, while the coarse material left on the screen drops back into the furnace by way of the return opening 15. In order to ensure that the whole of the material coming within the scope of a discharge opening during a complete revolution will pass through said opening and out of the furnace, the invention provided inside the furnace and beyond the discharging device, a barrier ring 16 disposed in known manner and of sufficient height to prevent the accumulated material from trickling over it in the course of a revolution. The arrangement is also such that the material in front of the ring issues from the furnace and is returned thereto immediately behind the ring. The arrangement of a channel, formed by two rings, inside the furnace is preferable for practical reasons and is just as effective as a single ring.

With respect to the action of the discharge device shown in Figs. 3 and 4, it will be appreciated that material falls through the opening 10 on the screen 12 during the interval at which the opening 10 moves through the lowest position. When the furnace turns further, the right end of the screen gradually moves up and the discharge device 14 travels downwards: the material which has fallen on the screen does not stick to the screen but falls down over the same to the degree that the screen moves upwards. The material, therefore, is always adjacent that part of the screen 12 which travels at the time through the lowest point. The material which has passed through the screen slides along on the casing 13 in the same way. This traveling of the material over the screen and the casing continues during rotation of the furnace until the discharge device reaches its lowest position: in this position the material which has passed through the screen 12 falls into the discharge chute. The latter is turned one chamber by the stop 37, and the material which has entered the discharge chute is, in this way, prevented from falling back again into the passage formed by the casing 13.

The material which has been retained on the screen cannot travel farther when it reaches the end of the screen passage in the lowest position of the discharge chute. Upon further rotation of the furnace, therefore, said material is lifted up until the discharge chute again reaches its highest position. In this position, the material, which meanwhile rests on the screen at the end next to the discharge chute, falls back into the furnace through the opening 15.

The effect of a baffle ring 16, in combination with an opening, 10, for the discharge of the material becomes clear when it is taken into account that in traveling downwards in the furnace the material accumulates in front of the baffle ring until the pile of material becomes as thick as the height of the baffle ring. It is only then that material passes on over the baffle ring. When an opening in the furnace casing is provided before the baffle ring, considerable amounts of material fall constantly through this opening. The height of the baffle ring is selected so that the amounts of material that fall through the opening in the furnace casing are so large that the layer of material directly in front of the baffle ring can no longer attain the height of the baffle ring.

Fig. 5 represents an arrangement by means of which the material—even screened material, if desired—discharged from the end or from any other point of the furnace, can be automatically recharged into an anteriorly situated portion of the furnace. This arrangement consists of a worm 39—for example of rectangular cross section fixed to the furnace structure and so disposed as to result in a turning effect in the opposite direction to the rotational direction of the furnace and connected with the interior of the furnace at convenient points 40, 41, 42. The rotation of the furnace causes the material to travel inside the worm in a direction, in this instance, opposite to that taken by the charge in the furnace, so that by means of the worm, material can be conveyed from a lower part of the furnace to a higher part. The worm 39, although shown as rectangular, may be of any convenient cross section. It may be constructed of any convenient suitable material, such as iron or other metal, that is not attacked by the material to be treated. A discharge device is shown at 43.

The arrangement can also be applied to cases in which material is to be conveyed from the anterior portion of the furnace to rearward portions of the latter as more fully described with reference to Figs. 6 and 7. In such cases the rotational direction of the arrangement must of course, be modified accordingly.

The return transport of the coarser material screened off at the end of the furnace may be of twofold importance in the process according to the invention.

In the first place, coarse-grain material, the chemical transformation of which has not attained the desired degree can be returned, for the purpose of retreatment, to the head end of the furnace, or to any other suitable point, such as the main reaction zone. Under the single or repeated treatment of the coarse-grain material in the furnace, it then acquires the desired character. On the other hand, the return of a portion of the charge material from a cooler into a proposed hotter zone of the furnace, lowers the temperature in said hotter zone.

It will be assumed that a certain kind of pyrites attains a permissible roasting temperature of

1000° C. and that the product at the end of the furnace still has a temperature of about 200° C. If now, 20–25% for example, of the roasted product in the cooled condition, be returned to the main reaction zone, this latter will be cooled to the extent of about 200–250° C., that is, to 800–750° C. Experience has shown that the efficiency of the furnace depends on the amount of the charge, which is in direct proportion to the heat liberated by the combustion of the sulphur. Consequently, in the case of the example, the charge of raw pyrites can be increased by the amount required to restore to 1000° C. the temperature of the charge from the 800–750° C. to which it has been lowered.

According to the invention, the screen placed round the furnace shell in Figs. 3 and 4, can be disposed, with equal effect, in the worm passing round the furnace. The discharge openings serving to remove the roasted material from the furnace can also be employed at the same time for the admission of air. In some cases, it is also advisable to connect the outlets together for example by means of channels or the like arranged as a worm passing around the furnace. The material from several outlets will therefore be then collected and discharged at a single point from the collecting channel which of course, is integrally connected to the furnace. In such case, the device required for the reception of the charge from the furnace can be of a substantially simpler character. The channels can be provided with interior classifying screens, so that the material is separated in accordance with its grain size, during its passage through the channel, as is shown in greater detail in Figs. 6 and 7. This is particularly advisable when the various grain sizes are to be put to different uses, one grade, the coarse for example, being subjected to a secondary treatment, for example by returning it to the furnace by means of the arrangement shown in Fig. 5 or if the finest screenings are unsuitable for the subsequent further application and are to be transformed into a coarser condition by known processes.

The rotary-tube furnace according to Fig. 6 has the ordinary charging device 17, the furnace casing 18 and the wall 19 and also the gas flue 20 that joins onto the upper end of the furnace. The discharge device 21 for the material treated in the furnace is located at the lower end of the furnace. In addition the furnace is provided with barrier rings 22 and air inlets 23. The rotary crowns are designated by 24, the drive by 25 and the foundation by 26. Between every two barrier rings, or directly in front of a barrier ring, openings 27 are provided in the casing of the furnace. These openings open into a conduit passage 28 encircling the furnace casing helically, and divided a portion of its length by the screens 29 concentric to the furnace. Each screen extends from one opening 27 nearly to one of the return openings 30 in the furnace wall.

The material which has traveled through a part of the furnace, or a portion of this material, falls through the opening 27 and enters the passage 28 and then reaches the screen 29. On this screen it is shaken forward due to the rotation of the furnace, the fine material thereby falling through the screen and passing along on the outside wall 28' of the passage to the discharge opening 21. The portion of the material remaining on the screen passes through the openings 30 into the furnace again. This portion of the

material is then treated in the furnace again until it reaches another opening 27 being then exposed in the same way and with the same means to a second and possibly to a third or fourth screening.

5 It is possible in some instances to provide the screening devices only in one part of the furnace, e. g. the upper half, and to use the rest of the furnace for the uninterrupted further treatment
10 of the coarser grained material.

As already mentioned, it is not essential to employ a rotary-tube furnace for the process of the present invention. All other kinds of furnace are also applicable in which the material traverses an elongated path during the heat treatment.
15 It is not necessary that the grades of grain size that are successively removed from the furnace should be the same in all cases. Both these grades and the screening devices serving for their removal may be adapted to a far reaching extent
20 to the reaction conditions prevailing in the furnace, especially as regards temperature. Nevertheless, it is possible in all cases to distribute the several points of discharge in such a manner on
25 the perimeter of the furnace that the discharge portions have all undergone the same chemical transformation.

I claim:—

30 1. Process for the chemical alteration of material which contains different grain sizes during a thermal treatment of such material, which comprises passing a body of the material in continuous flow through a heated reaction chamber, removing the several grades of grain size present
35 in the material in succession from the reaction chamber when each grade has undergone substantially identical chemical transformation, and returning a part of the material which has passed

through the entire treatment to the body of material undergoing thermal treatment and at an intermediate stage of the treatment, thereby increasing the total throughput of the chamber.

2. The process defined in claim 1, characterized 5 in that material of small grain size is removed from the chamber at an intermediate stage of the treatment and already treated material of coarse grain size is returned to the body of material in the chamber at an intermediate stage of treatment.
10

3. Process for roasting material which contains different grain sizes during this treatment, which comprises passing a body of the material in continuous flow through a heated reaction chamber, 15 removing the several grades of grain size present in the material from said chamber, at different points, when each grade has undergone substantially identical chemical transformation, and returning a part of the material which has passed
20 through the entire roasting treatment to the body of material undergoing roasting treatment.

4. Process for roasting material which contains different grain sizes during this treatment, which comprises passing the material in continuous 25 flow through a heated reaction chamber, removing the several grades of grain size present in the material from said chamber at different points, when each grade has undergone identical chemical transformation, and returning dead- 30 burned material to the material that is to be roasted.

5. Process defined in claim 4, distinguished therefrom in that the returned material is added to the body in the chamber at a point anterior 35 to that at which it was removed.

CARL PAUL DÉBUCH.

Certificate of Correction

Patent No. 2,039,062.

April 28, 1936.

CARL PAUL DĚBUCH

It is hereby certified that error appears in the above numbered patent requiring correction as follows: In the drawing, Sheet 1, Fig. 1, strike out the reference numeral "1a" and its lead line to the opening space 1; and in Fig. 2, for the reference numerals "9" and "10" read *2a* and *2*, respectively; and that the said Letters Patent should be read with these corrections therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 4th day of August, A. D. 1936.

[SEAL]

HENRY VAN ARSDALE,
Acting Commissioner of Patents.