No. 836,187. PATENTED NOV. 20, 1906.

J. HICKEY.

AUTOMATIC DRYING APPARATUS FOR ORES, &c.

APPLICATION FILED DEC. 4, 1903.

5 SHEETS—SHEET 1.

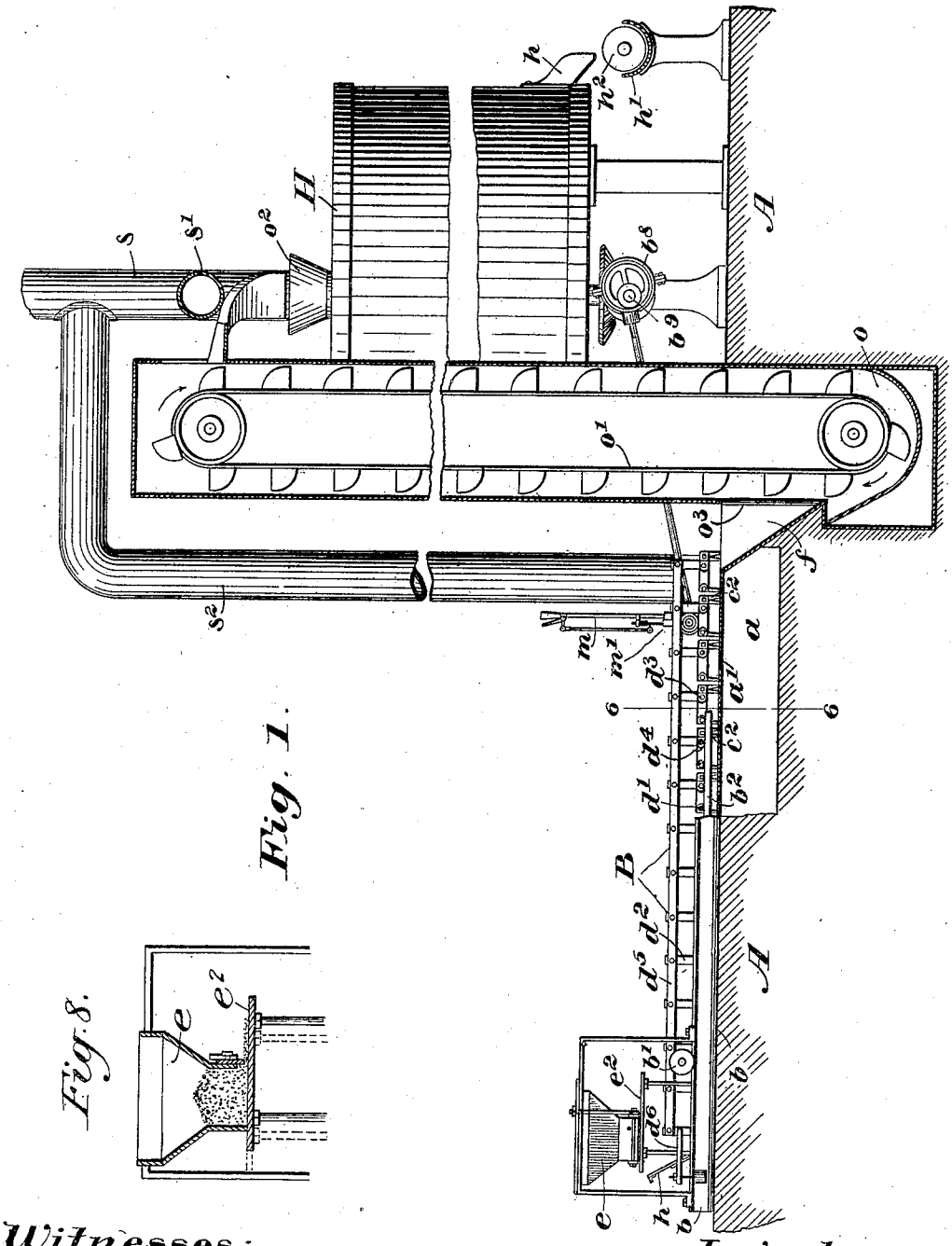

Fig. 1.

Fig. 8.

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5 SHEETS—SHEET 2.

Fig. 2.

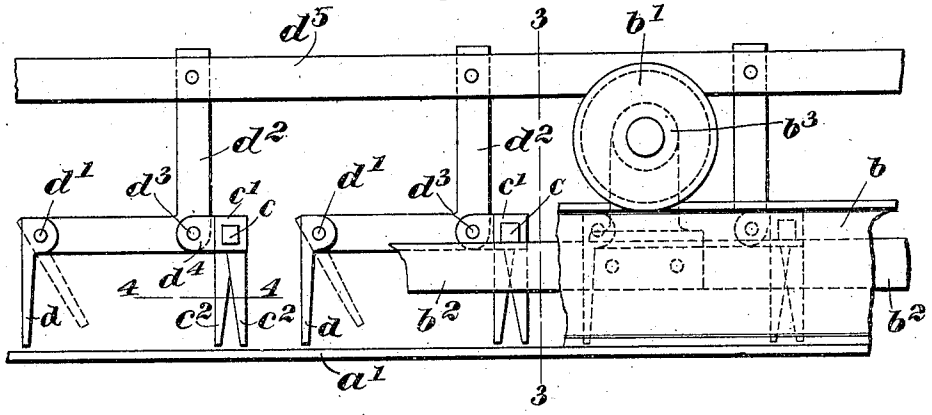


Fig. 3.

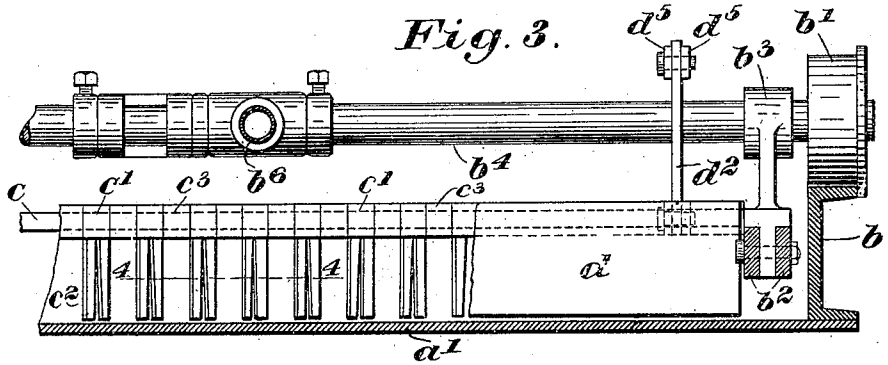
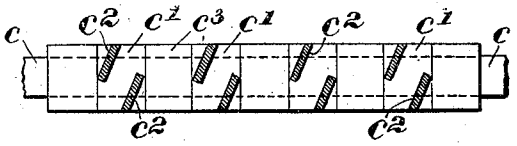


Fig. 4.



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5 SHEETS—SHEET 3.

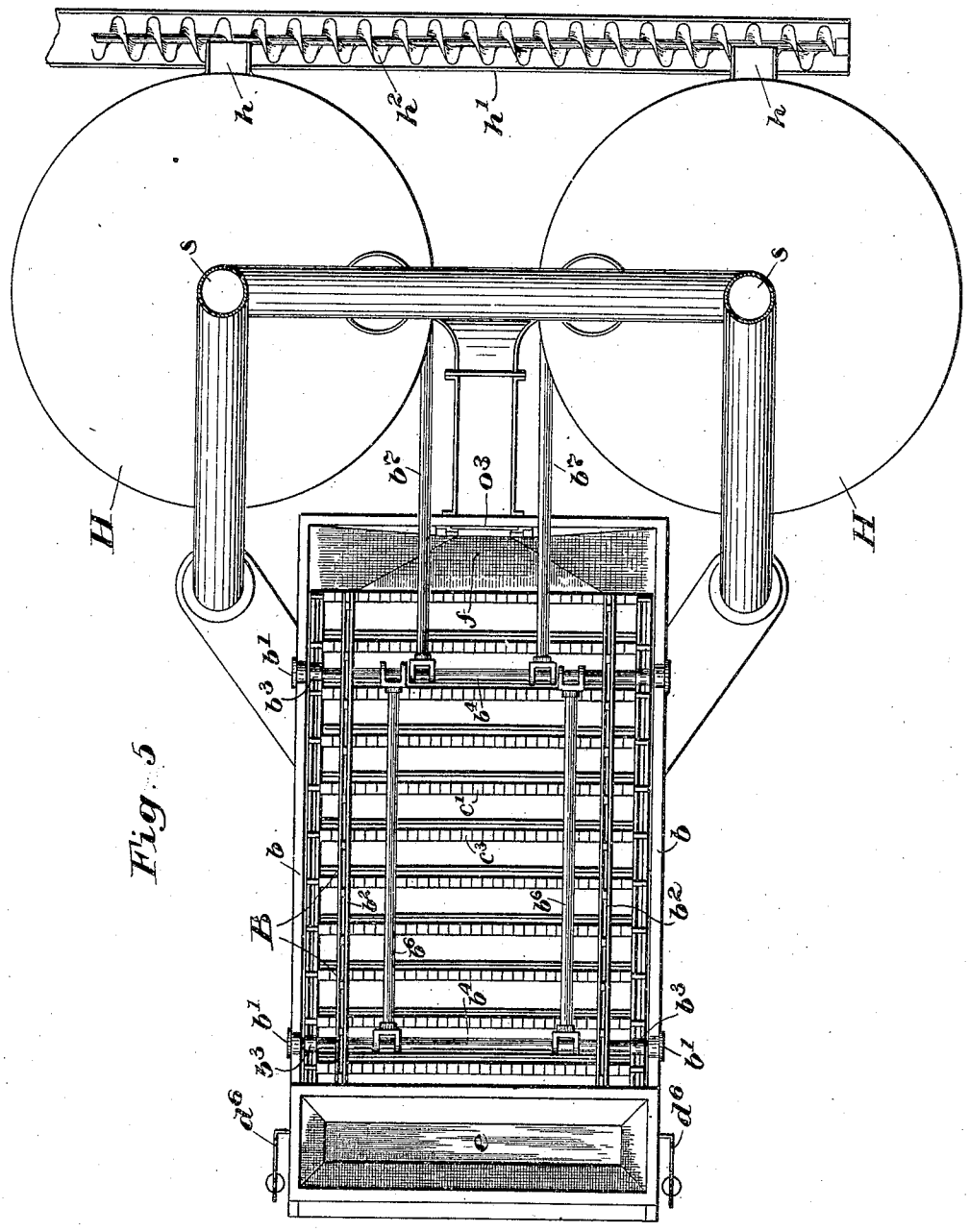

Fig. 5

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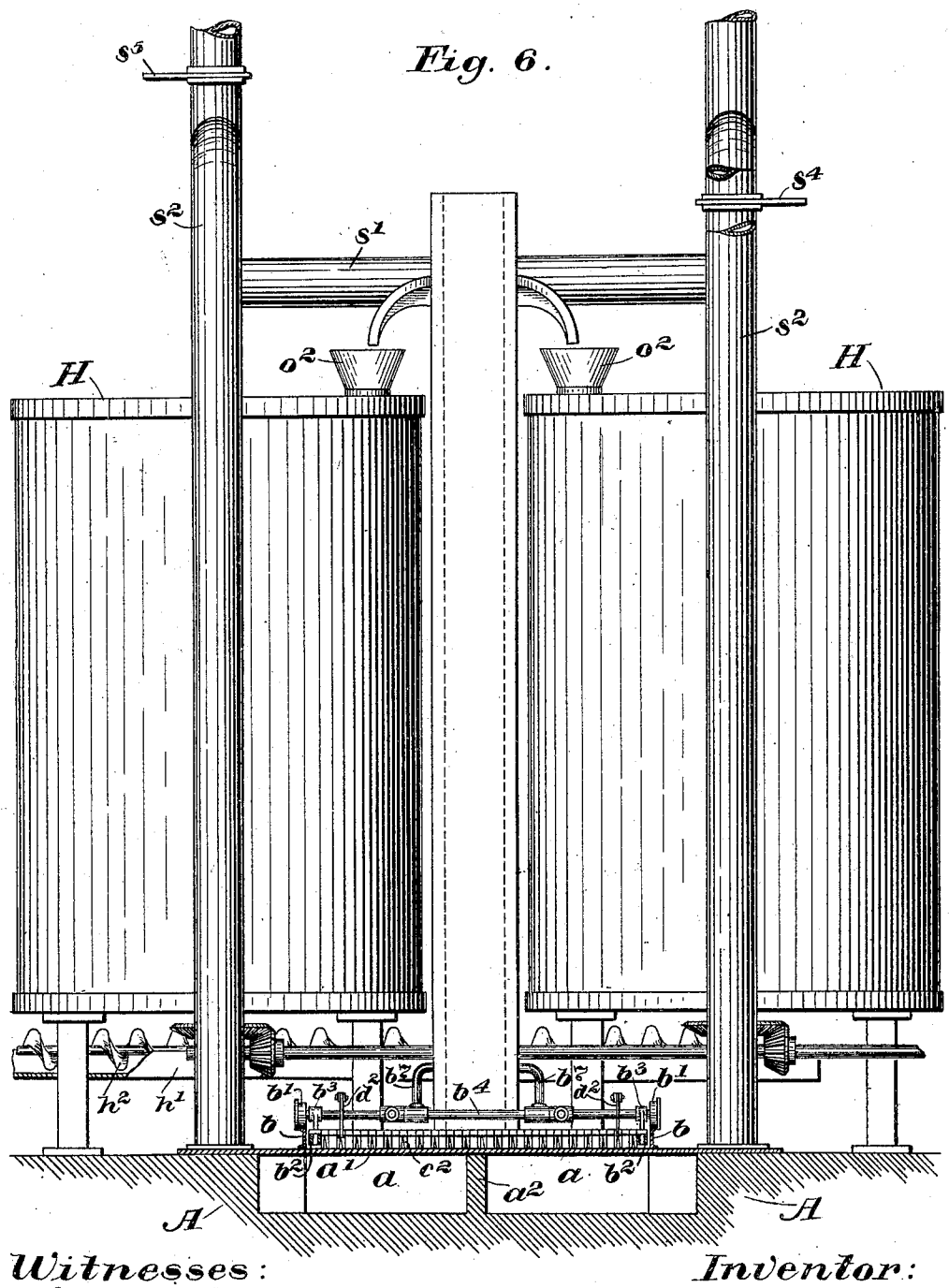
5 SHEETS—SHEET 4.

Fig. 6.



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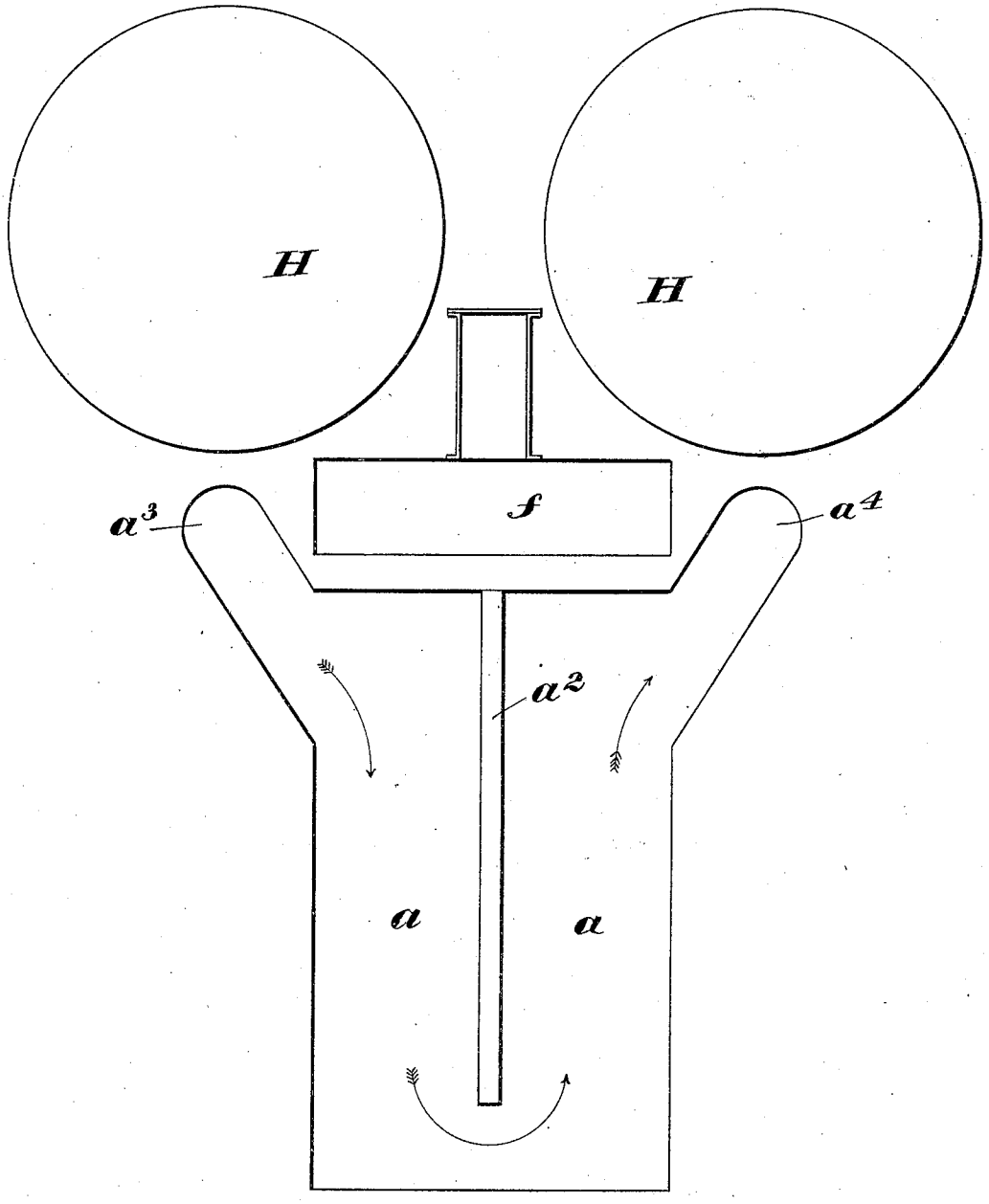
5 SHEETS—SHEET 5.

Fig. 7.



Witnesses:
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Inventor:
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UNITED STATES PATENT OFFICE.

JOHN HICKEY, OF BUFFALO, NEW YORK, ASSIGNOR OF FIFTY-FIVE ONE-HUNDREDTHS TO THE AMERICAN AGRICULTURAL CHEMICAL COMPANY, OF NEW LONDON, CONNECTICUT, A CORPORATION OF CONNECTICUT.

AUTOMATIC DRYING APPARATUS FOR ORES, &c.

No. 836,187. Specification of Letters Patent. Patented Nov. 20, 1906.

Application filed December 4, 1903. Serial No. 183,701.

To all whom it may concern:

Be it known that I, JOHN HICKEY, a citizen of the United States, residing at Buffalo, in the county of Erie and State of New York, have invented an Improvement in Automatic Drying Apparatus for Ores and the Like, of which the following description, in connection with the accompanying drawings, is a specification, like letters on the drawings representing like parts.

My invention relates to apparatus for drying ores, stone, sand, pulverent or finely-divided coal, grain, and other similar or equivalent materials.

Since my invention has been first used in the drying of ore, such as used in the manufacture of sulfuric acid for phosphate fertilizers, I will describe my invention as adapted for and used in connection with such manufacture without, however, thereby limiting the invention thereto to the exclusion of any other use to which it may be found applicable.

In the manufacture of phosphate fertilizers sulfuric-acid gas is employed, and this gas is obtained originally from a sulfur-bearing ore which is received at the phosphate plants in a more or less pulverized or finely-divided form, particles of which are of varying sizes, graded from relatively fine particles to particles of the size of walnuts or even larger at times. This ore is first commonly passed through burners, of which the well-known Herreshoff burner is an example, and in which the ore is subjected while under agitation to the action of an intense heat, which drives off the sulfuric-acid gas therefrom. The ore is turned over or stirred sufficiently during this roasting process to enable it to be thoroughly acted upon by the high temperature of the burner. Usually this ore is received in a more or less damp condition, sometimes quite wet, which necessitates a preliminary drying thereof in order that the burner may perform its work with efficiency and economy, and heretofore it has been customary to dry the ore upon suitable drying-tables specially prepared therefor and which require the ore to be spread out thereon and subjected to the drying action and again removed therefrom for conveyance to the burner, all as a separate operation from that of the roasting and requiring one or more employees especially detailed for the purpose, involving considerable additional expense. In some instances it is spread out in large areas and permitted to dry in the sun. In either case the drying is more or less insufficient.

My invention comprehends a drying apparatus which not only more effectually dries the ore or material, but which performs its work automatically, involving scarcely any additional cost either for power or attendance.

Prior to my invention the hot gas or gases given off from the burners have been permitted to go to waste. In the embodiment of my invention which I shall presently describe I utilize this heat for the drying of the ore before it is delivered to the burner, and I also prefer to take the power for operating the apparatus directly from the parts required for the operation of the burner. The ore to be dried is deposited in a suitable hopper, from which it is delivered automatically upon a drying-table, over which it is fed automatically and gradually and also shifted, turned over and over until finally, in a thoroughly-dried condition, it is automatically delivered to the burner or burners to be supplied therefrom.

To enable my invention to be understood clearly, I will describe, in connection with the accompanying drawings, one embodiment thereof upon the lines above indicated, it being understood, however, that my invention is not thereby restricted to the embodiment or use particularly disclosed.

In the accompanying drawings, Figure 1, in side elevation and partial section, shows a drying apparatus illustrating one embodiment of my invention. Fig. 2 is an enlarged detail, in side elevation, showing the ore turning and feeding appliances. Fig. 3 is a cross-sectional detail on the dotted line 3 3, Fig. 2. Fig. 4 is a cross-sectional detail on the dotted line 4 4, Figs. 2 and 3. Fig. 5 is a plan view of the apparatus; Fig. 6, a vertical cross-section on the dotted line 6 6, Fig. 1, showing a convenient arrangement of Herreshoff burners in connection with which I am about to disclose my invention; Fig. 7, a plan showing the outline of the drier-pit.

In the particular embodiment of my invention selected for illustration herein and shown in the drawings, referring first to Figs. 1 and 5, A indicates a suitable concrete or other floor of the building in which the apparatus is located. In this floor is constructed a pit *a*, (see Fig. 7,) covered by a metal plate or table *a'*. (See Fig. 1.) This pit is shown partially divided along its middle by a partition a^2, so that hot products of combustion or other heating medium admitted, for instance, at the point a^3 is caused to circle around or through substantially the entire chamber before it can take its exit at a^4, thus to insure full heating of the table *a'*.

Along the edges of the sheet-metal table *a'* are arranged two parallel channel-irons *b b*, which serve as tracks for the wheels *b'* of the drier-carriage B. This drier-carriage comprises the parallel side bars b^2, to which are secured the adjustable bearing-brackets b^3, and through these brackets are passed the axles b^4, upon the ends of which said wheels *b'* are journaled. The axles b^4 may conveniently be of gas-pipe, and they may be connected by gas-pipe-connecting rods or members b^6. (See Fig. 5.) This frame may be reciprocated in suitable manner, I having found it convenient to connect the same by a pair of gas-pipe-connecting rods b^7 with an eccentric b^8 on a shaft b^9, which drives the stirrers or agitating devices within the Herreshoff or equivalent burners or furnaces H H, so that the same power which operates the burners may also operate the drying apparatus.

The side frame members b^2 of the drier-frame are connected by a series of parallel cross-rods *c c*. These rods are preferably of non-circular cross-section—as, for instance, square—and upon them are slid in desired number the ore-shifter heads *c'*, each of which is provided with one or more, preferably two, diagonally-placed depending fingers c^2, which resemble in appearance the blades of propellers. (Best shown in Fig. 4.) As the drier-frame is reciprocated over the drier-table *a'* these propeller-like shifting-fingers in passing through the ore upon the said table cause the ore to be shifted or turned first to the right and then to the left, according to the direction of reciprocation, thereby turning the ore over and over, so as to present at each reciprocation new particles thereof to the action of the heated table and to the atmosphere for the more effectual drying of the ore.

To feed the ore gradually from one end of the drier-table to the other end thereof, I have provided a series of feeding-plates *d*, which extend transversely of the table and drier-frame and which depend, respectively, by pivots *d'* from the horizontal arms of elbow-levers d^2. These elbow-levers are fulcrumed at d^3 in ears d^4, formed on the shifter-heads *c'* or upon spacing-blocks interposed between the same and also mounted upon the cross-rods *c*. The vertical arms of these elbow-levers are connected, respectively, with rods d^5, which extend throughout the entire length of the drier-frame, at each edge thereof, and the endmost levers are provided with weighted arms d^6, which act, through the said rods d^5, to hold the entire series of elbow-levers in position with their respective depending feeding-plates in lowermost position close to the drier-table and to cause the same to move at all times toward their feeding positions. As the drier-carriage reciprocates in one direction, as to the right, Fig. 1, the depending feeding-plates *d* being prevented from turning on their pivots push before them the ore upon the table, moving the latter bodily for a distance represented by the length of travel of the carriage. On the return movement of the carriage said depending plates yield to the ore or material upon the table and swing clear thereof, leaving it in the position in which it was moved by the previous feeding movement, excepting as the ore is turned or moved laterally by the angular or propeller-like nature of the turning-fingers c^2. Thus at each reciprocation of the carriage in one direction the ore is fed bodily forward upon the table a distance corresponding to the travel of the carriage, and at each return movement of the carriage the ore is merely turned over laterally by the depending fingers to expose new parts to the action of the heat without disturbing the longitudinal position of the ore as left by the last feeding movement of the carriage.

For example, if the length of the table is eight feet and the travel of the carriage at each reciprocation thereof is eight inches it would take twelve reciprocations to feed the material from one end of the table to the other, and between each of the twelve feeding movements there would be twelve periods of rest, during which the material would be merely turned over laterally for better drying thereof, and when the reciprocations are slow, as is usually the case, there is an appreciable period of rest at the end of each reciprocatory movement for further drying of the ore. Thus there is given ample time for thorough and effectual drying, coupled with a most complete shifting or turning over of the material, so that every part thereof shall be subjected to the drying action.

At the outer end of the drier-plate is a hopper *e*, which extends transversely for the entire width of the drier-carriage and is also preferably mounted to be adjustable along the said plate in the direction of the reciprocation of the said carriage. The bottom of

this hopper is closed by a plate e^2, which is mounted and to reciprocate with the carriage. The rear and end walls of the hopper reach close to this movable plate e^2, while the front wall of the hopper terminates a short distance above said plate, the distance being preferably variable or adjustable in any suitable manner. The material to be dried is deposited in this hopper and rests upon this reciprocable or movable plate e^2, and at each forward movement thereof as the carriage moves to the right, Fig. 1, said plate e^2, moving with said carriage, carries out from the bottom of the hopper a quantity of materials therefrom, which is immediately replaced by further material dropping down behind it upon said plate. The area of materials so taken from the hopper is that of the area of the hopper-outlet reaching across the carriage, and the depth of material so taken out depends upon the distance between the said table and the lower edge of the front hopper-wall. Upon return movement of the carriage no material can be removed from the hopper, because the rear wall thereof drops close to the table e^2 and the material in the hopper, which has dropped down upon the plate behind that material which was taken out by the plate under the front wall, now acts as a block against the return of the material so removed, causing the latter during this return movement of the table and carrage to be pushed off the front edge of the said table upon the drier-table, where it is subjected to the feeding and lateral shifting action above described. Thus it will be seen that the ore when once deposited in the hopper is at each reciprocation of the carriage fed or drawn therefrom in definite determinable quantity, is then deposited automatically upon the drier-table, and there gradually fed along and turned from side to side while in transit until it has been thoroughly dried, when it is finally fed off the end of the drier-table into a suitable receptacle therefor, which may and preferably is a hopper f.

The various ores require to be dried through longer or shorter periods of time, and my invention readily admits of proper adjustment to this end by moving the hopper e along the table into position where it will deposit the ore upon the drier-table at the proper point to give it the necessary time of travel to the delivery end of the drier-table, and this adjustment is easily and quickly made.

The transverse square rods c may be filled in for their entire lengths with shifter-heads provided with depending propeller-like shifter-fingers, or finger-bearing heads may be spaced at greater or less distances one from the other, using intervening spacers c^3. In any event, however, the best results are attainable by staggering the depending fingers c^2 upon one bar with relation to those upon adjacent bars.

Referring to Fig. 1, at the rear end of the drier-table is an inclined deflector-plate h, mounted upon the carriage and which acts to catch any material or ore which may have worked through to the rear of the plate e^2 and direct the same upon the drier-plate a. In a suitable position upon the carriage is mounted a hand-lever m, Fig. 1, which is suitably connected with both rods d^5, so that by throwing over said lever and locking it by a suitable locking device m' for the purpose all the series of elbow-levers d^2 may be moved to lift all feeding-plates d away from the drier-table, and thereby stop effective operation of the feeder-plates, permitting the fingers of the mechanism thereof to operate without interruption in the stirring of the material.

The operation of this apparatus is so slow and so gradual and its motions and actions upon the material are of such a nature that little power is required for its operation, so that it may conveniently be connected with the operating-shaft for the Herreshoff burner or burners and operated therefrom without appreciable addition of load. The material is deposited in the hopper e precisely as it would be deposited in a hopper to be fed to the burners, so that so far as attendance is concerned and, practically speaking, so far as power is concerned no additional cost is involved, and the ore is in every instance delivered to the burner or burners in a thoroughly-dried condition, in which it will best give off its acid in passing through said burners.

Prior to my invention the heated gas or gases from these burners H have gone to waste; but my invention comprehends the bringing of such heated gas down to and passing the same through the drier-chamber a. I refer to this merely to enable the apparatus in the form shown to be readily understood and make no claim thereto in this present application, having included the same in another application pending concurrently herewith, Serial No. 183,700.

The dried materials which have been deposited in the hopper f at the right, Fig. 1, may be permitted to pass therefrom at once or under proper control and at proper times into a conveyer-pit o, from which they are taken by a suitably-driven conveyer apparatus o' to the tops of the burners and delivered thereto through the hoppers o^2 automatically. A gate may be provided at o^3 for the control or flow of materials from the hopper f into the conveyer-pit o; but this arrangement likewise is shown and claimed in said copending application.

It will be readily apparent how perfectly this application is adapted for the drying of fine coal, rock, sand, grain, and other materials in a finely-divided or lump condition,

and it is not necessary that the lumps be uniform in size.

Not only is my invention not limited to any particular use or material, but it is not limited to the particular embodiment thereof, which has been herein shown and described for illustrative purposes. Obviously the particular embodiment of the invention may be widely varied without departing from the spirit and scope of the invention itself.

I claim—

1. A drying apparatus comprising a drier table or surface to receive the material to be dried, combined with a reciprocable carriage, a plurality of swinging feeding devices carried thereby, and a plurality of depending propeller-like shifting devices interspersed with said feeding devices.

2. A drying apparatus comprising a drier table or surface to receive the material to be dried, combined with one or more reciprocable feeding devices, and means to raise the same clear of said table or surface to render the reciprocation ineffective.

3. A drying apparatus comprising a drier table or surface to receive the material to be dried, combined with one or more reciprocable feeding devices, means to cause reciprocation thereof and means connected with a plurality of said devices to cause the same to move into feeding position.

4. A drying apparatus comprising a drier table or surface to receive the material to be dried, combined with a reciprocable carriage, a plurality of swinging feed devices, and elbow-levers carrying the same and mounted in said carriage.

5. A drying apparatus comprising a table or surface to receive the material to be dried, combined with a reciprocable carriage, a plurality of swinging feed devices, connected elbow-levers carrying the same mounted in said carriage and means acting through said elbow-levers to maintain said feeding devices normally in feeding relation to said table or surface.

6. A drying apparatus comprising a drier table or surface to receive the material to be dried, combined with reciprocable feeding devices and means adjustable along said table to supply material thereto.

7. A drying apparatus comprising a drier table or surface to receive the material to be dried, combined with reciprocable feeding devices, a relatively stationary hopper, and means connected and movable with said feeding devices to control the delivery from said hopper.

8. A drying apparatus comprising a drier table or surface to receive the material to be dried, combined with reciprocable feeding devices, a relatively stationary hopper, and a plate closing the bottom thereof and connected and reciprocable with said feeding devices.

9. A drying apparatus comprising a drier table or surface to receive the material to be dried, combined with reciprocable feeding means to act upon the material on said table or surface and feed the same when moved in one direction and swing clear thereof when moved in an opposite direction, a supply-hopper at one end of said table or surface, a receiving-hopper at the opposite end thereof, and supply-controlling means operated by said feeding means.

10. A drying apparatus comprising a drier table or surface and reciprocating means acting on one movement to feed the material to be dried along said table or surface and on the reverse movement to turn or shift said material and means to interrupt the feeding operation during continued turning and shifting of the material.

11. A drying apparatus comprising a drier table or surface, a plurality of traveling feeding devices for feeding the material along said table or surface, and a plurality of devices for shifting or turning said material intermediate said feeding devices.

12. A drying apparatus comprising a drier table or surface, a plurality of traveling feeding-plates extending transversely the direction of travel of the material to be dried along said table or surface, and a plurality of separated shifting or turning devices intermediate said plates.

13. A drying apparatus comprising a drier table or surface, feeding means, turning means and means for causing the suspension of effective operation of said feeding means while permitting the operation of said turning means.

14. A drying apparatus comprising a drier table or surface to receive the material to be dried, feeding means for feeding the same along said table or surface, a delivery-hopper, means automatically to cause delivery therefrom to said table or surface through the action of said feeding devices, and means to control the amount of material automatically delivered.

15. A drying apparatus comprising a drier table or surface to receive the material to be dried combined with reciprocable feeding devices, a relatively stationary hopper, and supply-controlling connections between said feeding devices and hopper.

16. A drying apparatus comprising a drying-surface, means to feed material to be dried over said surface, an adjustable supply-hopper and means reciprocable transversely of said hopper to feed material from said hopper so constructed and arranged that material within the latter will eject the material carried by said means upon the return stroke thereof.

17. A drying apparatus comprising a drying-surface, means to feed material to be dried over said surface, an adjustable sup-

ply-hopper adjacent said surface and a member reciprocable with respect to said hopper to feed successive portions of material from said hopper so constructed and arranged that the supply of material within the hopper will eject the material carried by said member upon the return stroke of the latter.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

JOHN HICKEY.

Witnesses:

SHEPARD KIMBERLY,

GEO. C. BINGHAM.