J. M. SCHUTZ.

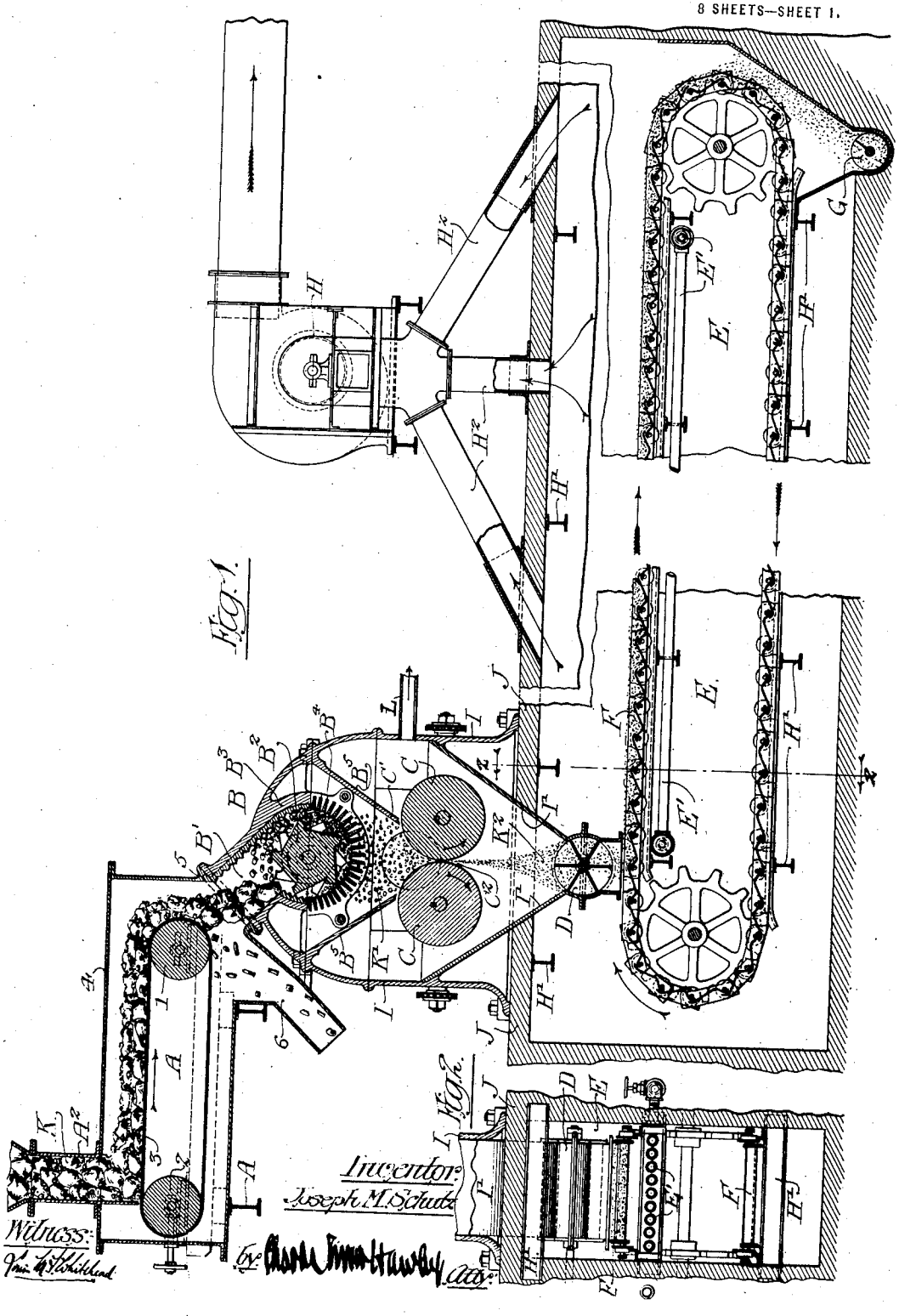
WET COAL MILL.

APPLICATION FILED JAN. 28, 1918.

1,338,845.

Patented May 4, 1920.

8 SHEETS—SHEET 1.



J. M. SCHUTZ.

WET COAL MILL.

APPLICATION FILED JAN. 28, 1918.

1,338,845.

Patented May 4, 1920.

8 SHEETS—SHEET 2.

Fig. 3.

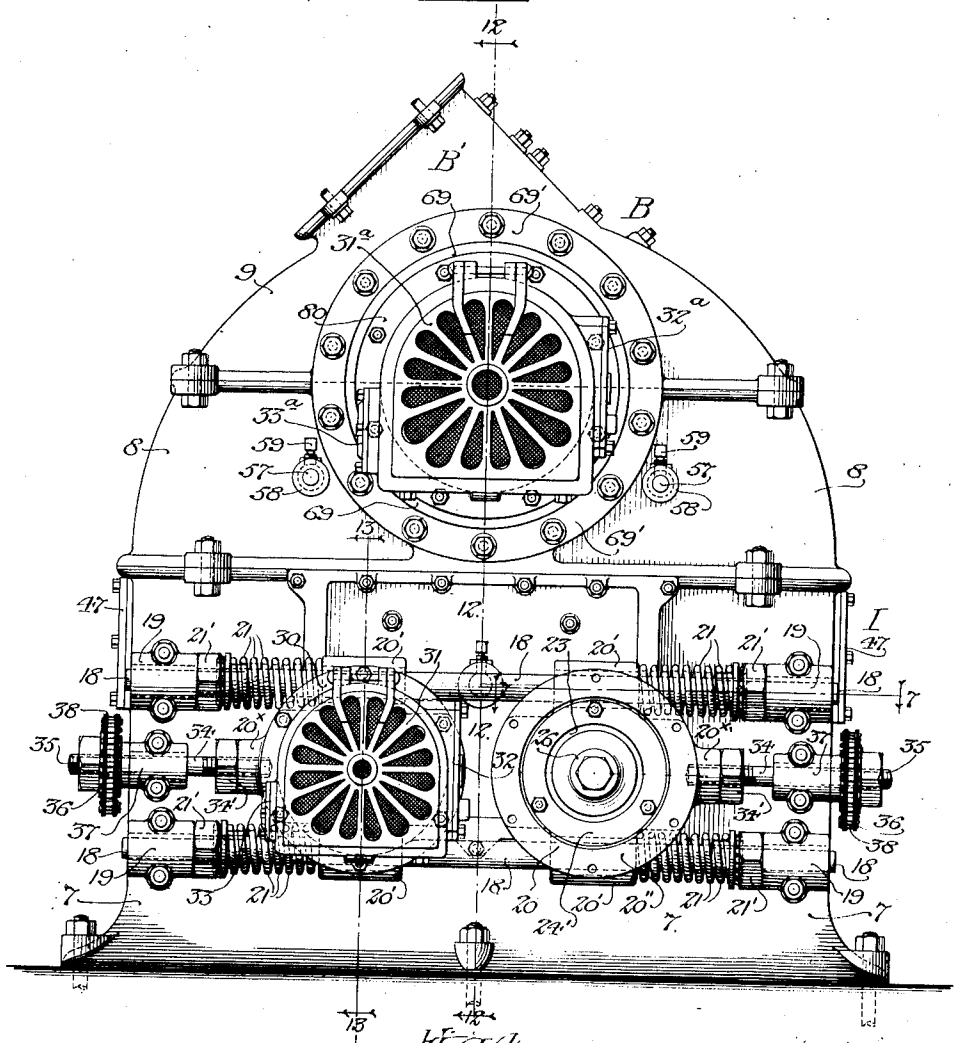
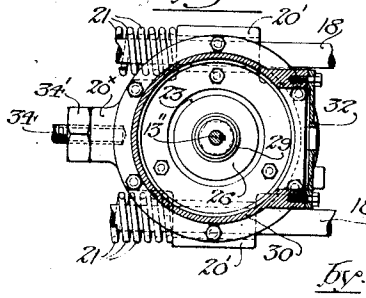


Fig. 4.



Witness:-

Louis W. Whitehead

Inventor:-

Joseph M. Schutz

by:- Munn, Anthony & Hayley

Attys.

J. M. SCHUTZ.

WET COAL MILL.

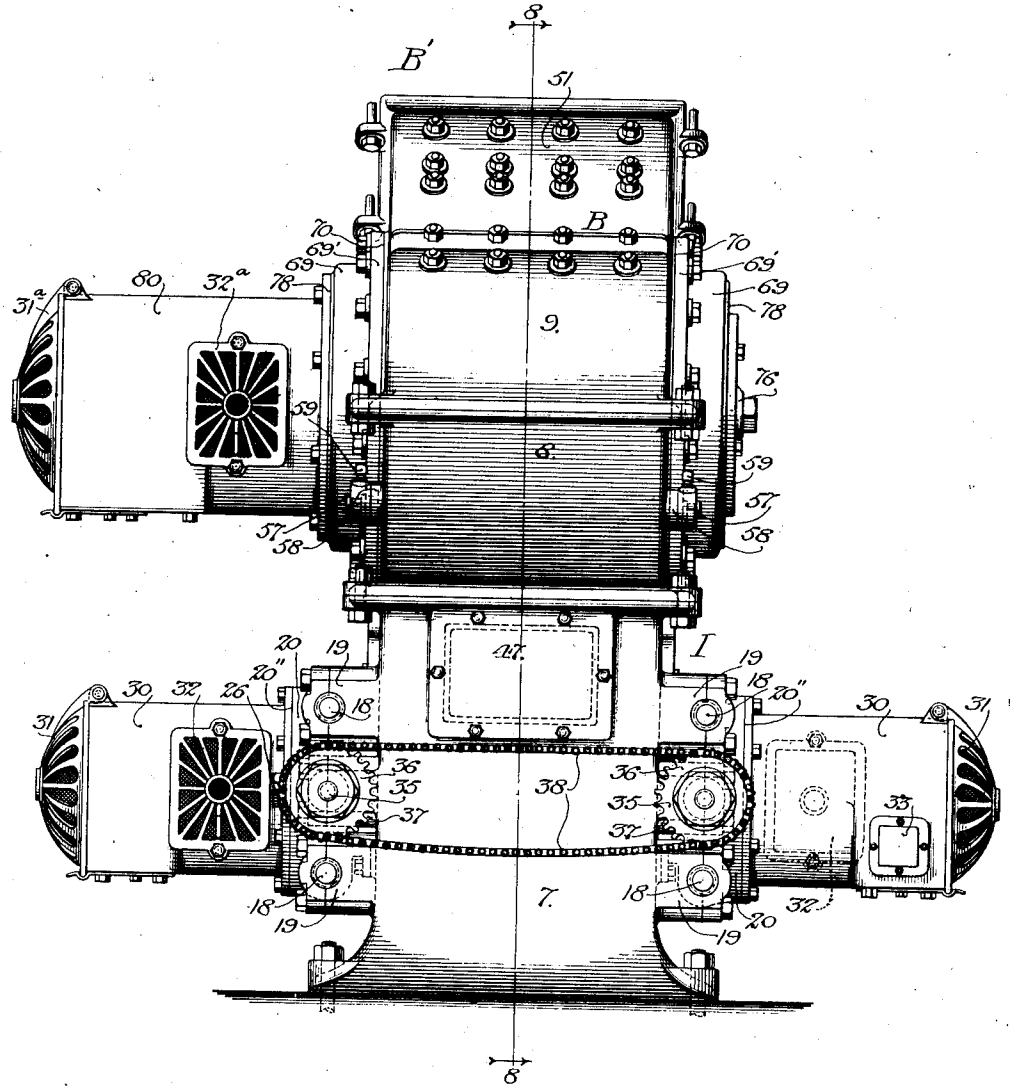
APPLICATION FILED JAN. 28, 1918.

1,338,845.

Patented May 4, 1920.

8 SHEETS—SHEET 3.

Fig. 5.



Witness:-

Louis W. Schlichtkrull

Inventor:-

Joseph M. Schutz

By:- Clarke Brown Hawley & Atty.

J. M. SCHUTZ.

WET COAL MILL.

APPLICATION FILED JAN. 28, 1918.

1,338,845.

Patented May 4, 1920.

8 SHEETS—SHEET 4.

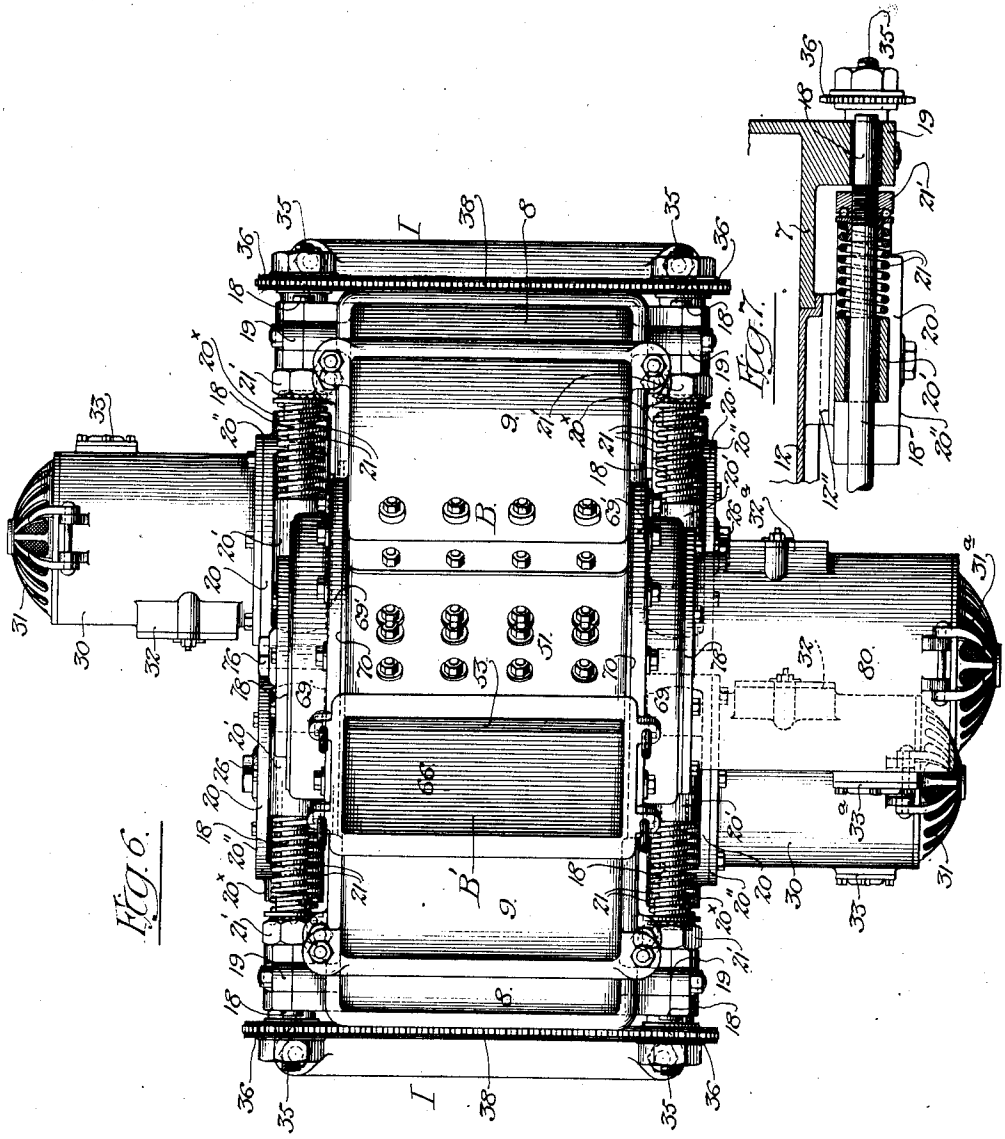


FIG. 6.

FIG. 7.

Witness:-
Louis H. Whitehead

Inventor:-
Joseph M. Schutz

By:- Clarke, Sherman & Kelley Attys.

J. M. SCHUTZ.

WET COAL MILL.

APPLICATION FILED JAN. 28, 1918.

1,338,845.

Patented May 4, 1920.

8 SHEETS—SHEET 5.

Fig. 9.

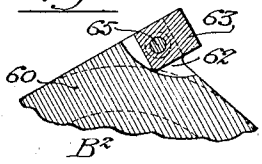
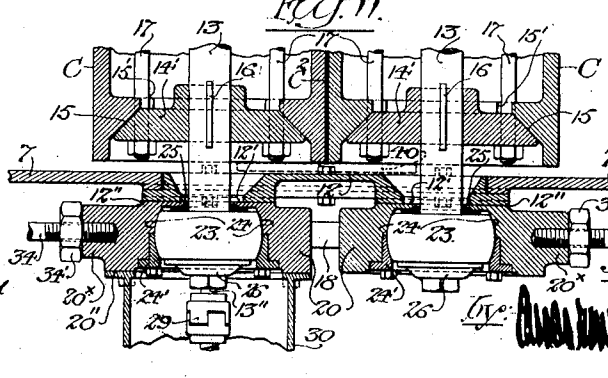


Fig. 8.

Fig. 10.

Fig. 11.



Witness:-
Louis M. Whitehead

Inventor:-
Joseph M. Schutz

By: Clarence A. O'Brien

Atty.

J. M. SCHUTZ.

WET COAL MILL.

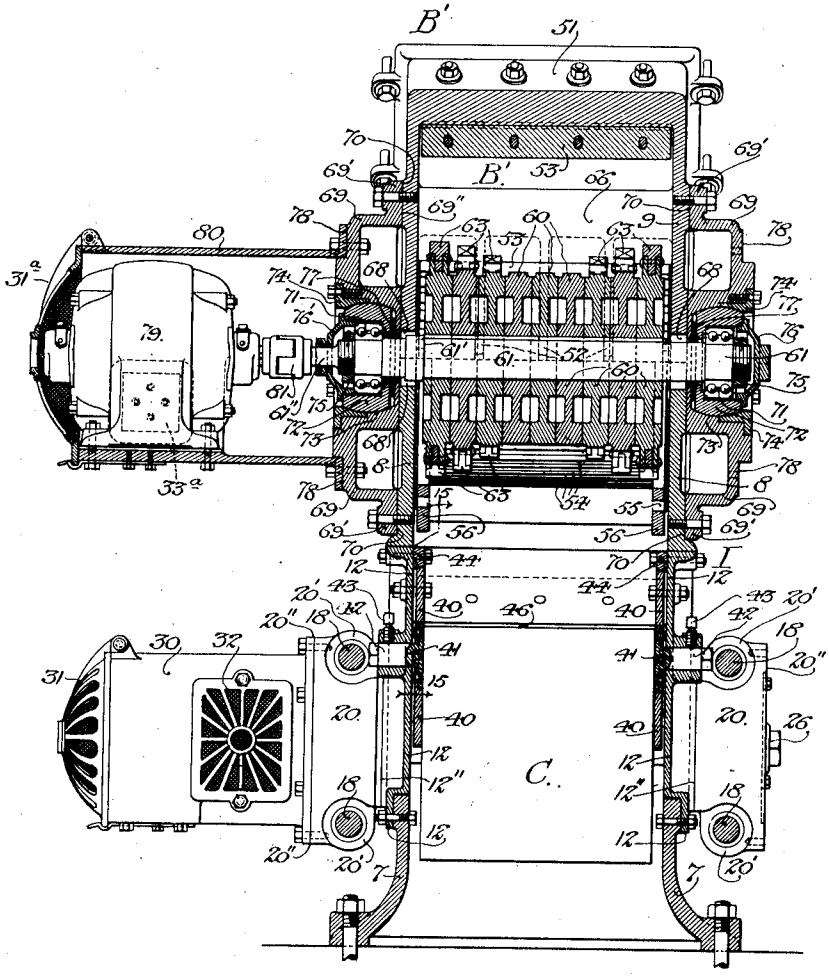
APPLICATION FILED JAN. 28, 1918.

1,338,845.

Patented May 4, 1920.

8 SHEETS—SHEET 6.

Fig. 12.



Witness:-

Louis M. Whitehead

Inventor:-

Joseph M. Schutz

by:- Atty:-

J. M. SCHUTZ.

WET COAL MILL.

APPLICATION FILED JAN. 28, 1918.

1,338,845. **Patented May 4, 1920.**

8 SHEETS—SHEET 7.

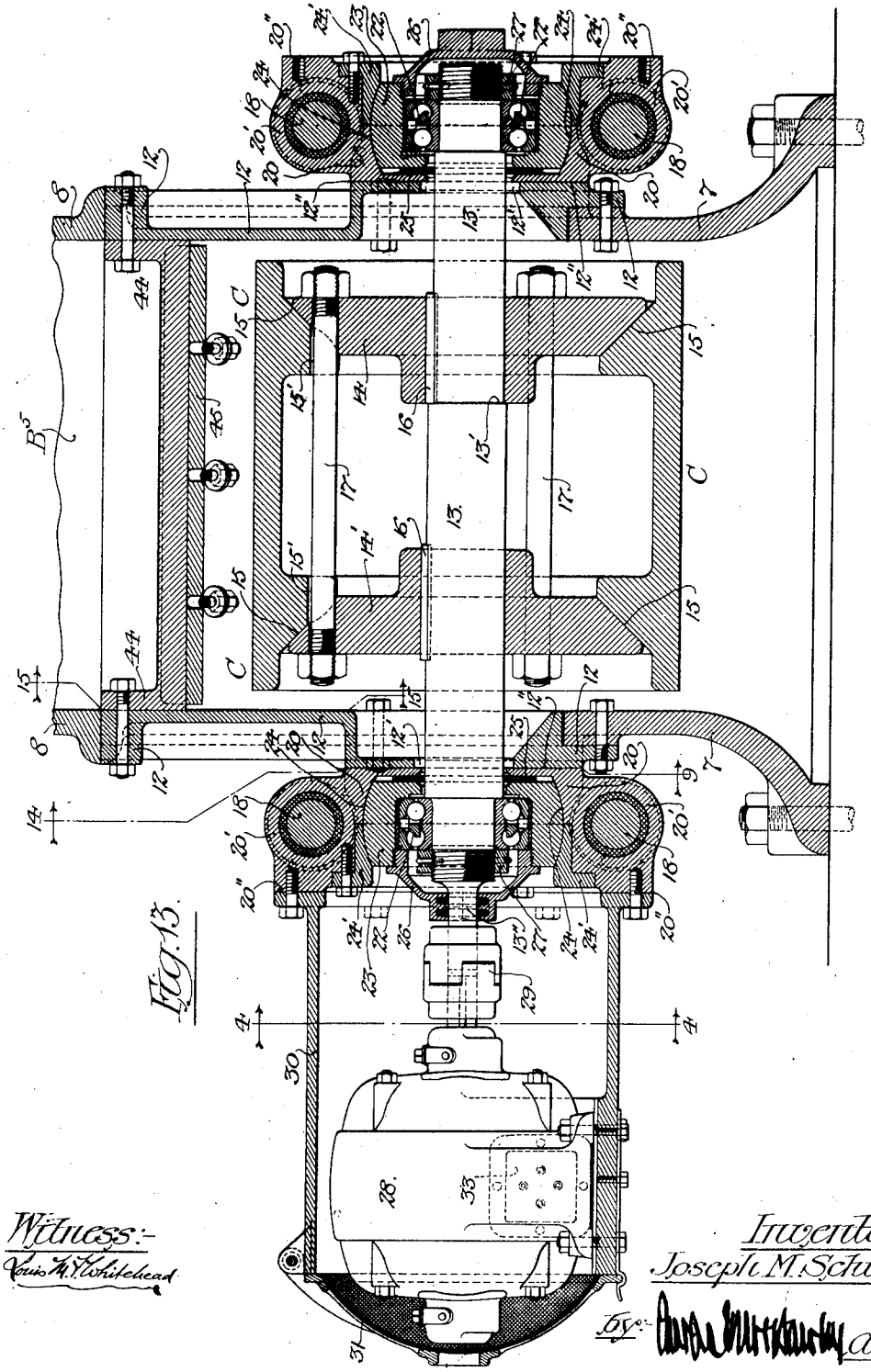


FIG. 13.

Witness:-
Louis M. Whitehead

Inventor:-
Joseph M. Schutz
by: Atty.

J. M. SCHUTZ.

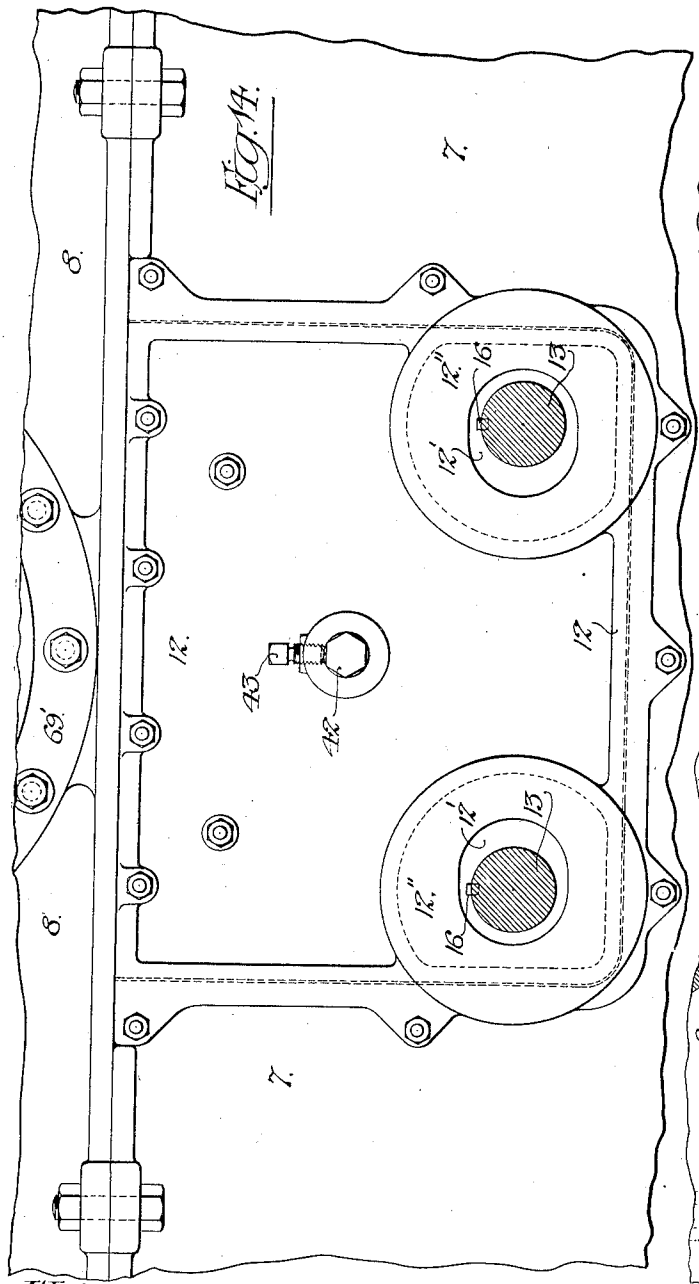
WET COAL MILL.

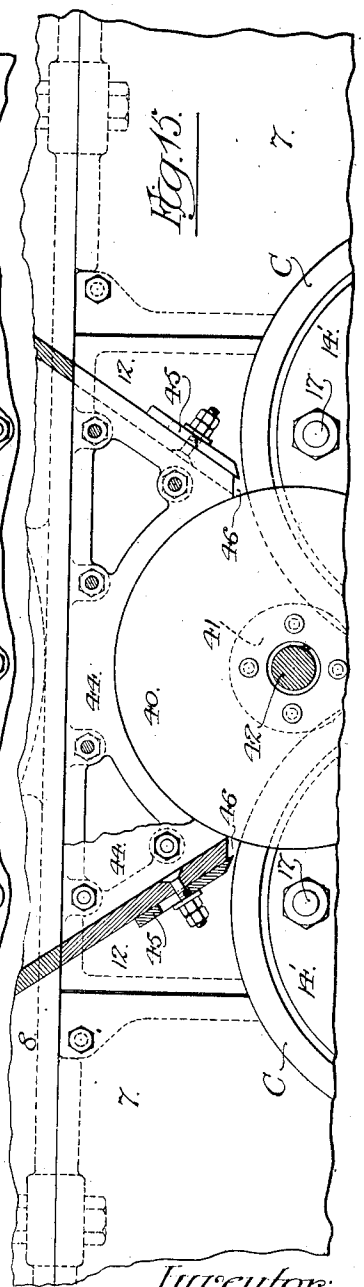
APPLICATION FILED JAN. 28, 1918.

1,338,845.

Patented May 4, 1920.

8 SHEETS—SHEET 8.





Witness:-
Louis M. T. Whitehead

Inventor:
Joseph M. Schutz

By: Clarke Mackaye & Berry Atty's.

UNITED STATES PATENT OFFICE.

JOSEPH M. SCHUTZ, OF CHICAGO, ILLINOIS, ASSIGNOR TO SCHUTZ HAWLEY COMPANY, OF CHICAGO, ILLINOIS, A CORPORATION OF ILLINOIS.

WET-COAL MILL.

1,338,845. Specification of Letters Patent. Patented May 4, 1920.

Application filed January 28, 1918. Serial No. 214,133.

To all whom it may concern:

Be it known that I, JOSEPH MARTIN SCHUTZ, a citizen of the United States, and a resident of Chicago, Cook county, Illinois, have invented a new, useful, and Improved Method and Apparatus for Milling Coal and the like, to which I have given the general name Wet-Coal Mill, and whereof the following is a specification.

My invention relates primarily to a method of milling, that is, for reducing to granular and powdered states, anthracite, semi-bituminous, bituminous, and lignite coals.

The immediate object of my invention is to cheaply and expeditiously reduce natural coal to any desired extent; ranging particularly, from an aggregate of both coarse and fine particles, down to a uniformly powdered or impalpable condition; without resort to or dependence upon any drying of the material as a preliminary or intermediate step or incident in the milling operation.

A further object of my invention is finally to condition the more or less wet finished product (the aggregate or the fine powder) by drying it to any extent required for its convenient and economical use, or storage.

It is to be understood that my invention is intended for use with coal in any state; whether wet, or dry; fine, or mixed, or in all-lump form.

In most cases the invention will be used in milling naturally moist mine-run coals of various kinds and "blends," which contain large and small lumps, plus the portion more or less pulverized in the mining and handling operations.

In carrying out my invention I feed the coal as a stream which is substantially constant, except as affected by the presence of many or few lumps; and, constantly or continuously reduce the coal, thus supplied, to any desired predetermined finished form; all in one operation.

The reducing or milling process is continuous; and this, whether the material be wet or dry; and as will appear, the operation is as rapid in the one case as in the other. Furthermore, the process is not hindered by the presence of any normal amount of slate or of pyrites in the coal, for both yield to the forces employed almost as rapidly as does the coal.

The coal from the primary feeder is received into a mechanism, which is a combined coarse breaker and secondary feeder. This mechanism is of such construction that the already fine material and the semi-reduced material may pass directly through it without imposing an appreciable load upon the breaker, while the latter acts upon and retains the lumps until they also are reduced to at least a semi-finished state.

In this breaker and secondary feeder I take advantage of the fact that even very wet mine-run bituminous coal may be indiscriminately pulverized, crushed, or broken down to pass a coarse mesh screen or grate without becoming so pasty (with liberated moisture and fine dust) as to clog the mechanism or render its operation difficult.

The moist, semi-finished material, including much fine material, is delivered in substantially constant volume by the second feeder and may be considered as comprising a second stream of material flowing at the relatively low rate of speed determined by the rate of feed at the primary feeder. Obviously, this stream of semi-finished material varies somewhat according to the volume and the regularity of the initial feed; and again, many large lumps may be received from the primary feeder, and at other times only comparatively fine coal, which can pass directly through the secondary feeder.

As fast as it falls from the secondary feeder, the semi-finished material is received between two large, high-speed rolls that rotate toward one another at the top and which are separated by a narrow space or crack, the width of which determines the quality or size of the finished product.

Preferably these rolls have fine, smooth surfaces, or at most fine corrugations, and produce therefore a uniform product, either coarse or fine, according to the distance between the rolls.

The two rolls, preferably, are of the same diameter; and, in any case, I impart to them as nearly as possible the same peripheral speed. By so doing I avoid or suppress the cutting, grinding, and scoring effects

which so objectionably diminish the durability of the differentially speeded roll pairs now used in this and kindred arts.

I find that with bituminous coal good results are secured from rolls having a peripheral speed of twelve thousand feet per minute. Thus far I have found no practical limit to the speed, other than the strength of the rolls to resist the destructive effects of centrifugal force and any lack of exact balance. These factors obviously vary with the nature of the materials composing the rolls, the diameter of the rolls, and the nicety of the machine work upon the rolls and their bearings.

Ordinarily I do not find it necessary to vary the predetermined speed of any single machine; nor do I find it necessary to resort to use of belts for driving the rolls; preferring, as will appear, to use the constant or fixed speed, direct connected electric, steam, or gas motors, or turbines, for driving both the breaker and the high speed rolls.

The width of the crack or opening between the smooth rolls determines the size of the largest pieces which will be found in the finished product. If the space is, for example, one thousandth of an inch (and this is a practicable dimension) the product will be an extremely fine powder; wet or dry according to the starting material; and finer than thus far required in any industry with which I am familiar. If the opening is wider, particles of that size will appear in the finished aggregate along with a proportionate amount of smaller pieces, and a proportion of very fine material.

By my method of operating the rolls at the extremely high peripheral speeds indicated, I secure the centrifugal riddance or discharge of all material and water from the faces of the rolls, and thus maintain them in clean, perfect working order at all times, without using scrapers, wipers, or brushes upon the rolls; indeed, and by way of contrast with former practices, the high-speed rotation of the rolls makes it impossible to use such accessories thereon because the frictional heat generated would destroy them.

A marked advantage of the spaced-apart smooth rolls is that particles of material already smaller than the space between the rolls, fall or are projected through the opening without effecting an appreciable load upon the rolls or resisting their rotation. The extent of this advantage will be appreciated when it is understood that in the case of the ordinary coal aggregate, about seventy-five per cent. of the semi-finished bulk from the secondary feeder is composed of these smaller particles, leaving only about twenty-five per cent. of the bulk to be directly acted upon by the rolls.

Ordinarily, even the largest semi-finished pieces or lumps do not greatly exceed the width of the opening between the rolls, and hence as they fall from the breaker and feeder they are instantly grasped by the rolls at a level only slightly above the horizontal plane of the axes of the rolls; that is, at a point where the roll tangents approach at an acute angle. In consequence, the opening action of the rolls is exercised at an extremely favorable leverage, and this, plus the tremendous speed at which the rolls operate, results in the crushing of the small lump or piece by a squeezing action, so sudden as to amount to a sharp blow; whereby the lump is caused to burst into many parts. From this it will be apparent that the proportion of coarse material found in the aggregate is determined not so much by the direct breaking action or impact of the rolls, as by the width of the opening between the rolls; for it will be obvious that pieces which are too large to freely fall through the opening, are instantaneously shattered into pieces much smaller than the opening.

In effect the high-speed rolls constitute a live screen which not alone allows, but also positively enforces the passage of the whole bulk of the material, however moist it may be; and, as stated, this effect is secured without resort to the use of mechanical means for clearing the roll-formed screen.

Having described the self-clearing action of the high speed rolls, I have now to mention the correlative high-speed ejection or discharge of the material by the rolls. The material ejected at speeds ranging upward to three miles per minute, is further broken or shattered by impact with the first surface or material encountered beneath the rolls. When a pronounced increase of pulverization is desired, I utilize this force by fixing a baffle wall or breaker-plate beneath the rolls to receive the first impact of the forcibly ejected material.

The high speed rolls, due to their momentum or kinetic force, admirably absorb all normal irregularities in the feed of the material, and compensate for variations in the nature (hardness) of the material.

In my method there is no handling of the material over and over again, as in ordinary pulverizing processes; the mill is at no time required to act upon a bank or mixed mass of material, and there are no tailings to be returned and re-milled. In consequence, the power consumed is only a fraction of that hitherto supposed and found to be necessary.

The material having been finished in a wet state, which precludes its ignition by sparks or even by flames within the mill or pulverizer, is deposited, preferably upon a conveyer which takes the material to the point of use, or to storage bins or to cars.

This I deem to be the proper procedure with any aggregate or powder than can be economically used or burned in its wet or moist condition; but for some uses the product should be partially dried; and for other uses should be completely deprived of its moisture. In such cases I dry the finished product as fast as it comes from the mill, preferably by converting the conveyer into a drier. As will appear, this is easily accomplished by heating the conveyer, or by inclosing it in a heated chamber and providing means for gently exhausting the steam which rises from the coal on the moving conveyer, or equivalent mechanism. In special cases, the finished and dried product from the conveyer should be used promptly or stored in a manner to prevent subsequent excessive absorption of moisture.

Obviously, the method and machine here described may be used in milling dry coal and like non-gritty materials; but, in the case of any material as explosive as coal, it is of decided importance that the coal need not be dried at all until its pulverization has been completed, and that the product may thereafter be dried at non-igniting temperatures, under positive and easy control, and therefore without danger.

The chief advantages of mills which embody my invention and whereby I carry out these processes, are their comparatively low cost, their great capacity, their relatively small use of power, their advantageous application of power, their compactness, dustlessness, and durability, the certain delivery and uniformity of their products, and the ease with which repairs can be made.

Embraced within the methods and the mill or apparatus, described in the foregoing, are several incidental steps and many features of construction, and combinations of parts; all as hereinafter described and particularly pointed out in the appended claims.

My invention will be more readily understood by reference to the accompanying drawings that form part of this specification and in which:

Figure 1 is a diagrammatic illustration of my method and machine for milling wet coal;— Fig. 2 is a sectional detail on the line 2—2 of Fig. 1;—Fig. 3 is an end elevation of the mill proper;—Fig. 4 is a sectional detail on the line 4—4 of Fig. 13, the dimensions being those of Figs. 3 and 7;—Fig. 5 is a side elevation of the mill;—Fig. 6 is a plan view;—Fig. 7 is a sectional detail on the line 7—7 of Fig. 3;—Fig. 8 is a vertical section on the line 8—8 of Fig. 5;—Figs. 9 and 10 are enlarged sectional details illustrating the manner of forming and attaching the hammer-heads of the breaker roll or drum;—Fig. 11 is a horizontal section on the line 11—11 of Fig. 8;—Fig. 12 is a vertical section on the line 12—12 of Figs. 3 and 8;—Fig. 13 is an enlarged vertical section on the line 13—13 of Figs. 3 and 8;—Fig. 14 is an enlarged partial end view and section on the line 14—14 of Fig. 13;—and, Fig. 15 is an enlarged partial section on the line 15—15 of Figs. 12 and 13.

No attempt will be made to set forth herein all of the possible uses of the several steps of my novel method or process; nor all of the ways in which my mill may be constructed for use with different grades of coal, nor in different situations. Such other uses and constructions will readily suggest themselves to those who are skilled in the several branches of the art.

In describing my method I shall refer first to Fig. 1 of the drawings, in order that the several elements of a complete apparatus or plant may be quickly distinguished and understood; after which, I will explain the construction of the mill proper, in detail; and co-incidentally my complete method, as exemplified in the milling of wet coal by means of the plant illustrated.

As depicted in Fig. 1 of the drawings, A is the beforementioned primary feeder;—B is the breaker feeder or as it will be called herein, the secondary feeder;—C is the pair of high speed rolls;—D is a rotary valve which I prefer to use for the discharge of the mill;—E is the drier containing the conveyer, F, and a heater, E′, and having a discharge conveyer, G, for the finished, dried product;—and, H is a suction fan which removes the moisture evaporated from the material on the conveyer. The elements, B and C, are arranged within a housing or frame, I, and therewith constitute the mill proper. This machine (hereinafter called simply the mill) is secured upon a suitable foundation, J, and preferably straddles the drier, E. Frames, A′, and, H′, support the primary feeder and the exhaust fan.

The material to be milled being, in the assumed case, mine run coal, K, in the natural moist condition, enters through the trunk A^2, of the primary feeder. Preferably the feeder is also a magnetic separator of approved form. Its chief elements are a magnetized pulley, 1, an inert pulley, 2, and a conveyer belt, 3, which runs on the pulleys, 1 and 2. The pulleys are slowly driven by means of a suitable variable speed motor (not shown) and the device is adapted to forward or feed the coal as a substantially constant stream, which varies in volume only as the speed of the motor is varied by the operator. The parts, 1, 2 and 3, are inclosed by a dust housing, 4. This has one discharge opening, 5, for the coal, and another, 6, for the pieces of metal magnetically extracted from the stream of coal.

The coal may fall directly from the pri-

mary feeder into the tangential throat, B′, of the secondary feeder. The chief elements of this secondary feeder are the heavy breaker roll, B^2, and a cylindrical casing, B^3, preferably eccentric to the roll and having its bottom formed by a grating, B^4. The breaker roll, B^2, is rotated at high speed, and this, co-acting with the surrounding walls of the casing, shatters the coal as rapidly as it enters through the throat, B^1. The coal thus shattered, together with material already fine in the mine-run product, passes through the grating, B^4, in, what I have termed, a semi-finished state, in which it is adapted for final reduction by the finishing rolls. In other words, the element, B, is a feeding mechanism which performs the double function of insuring the reduction of all the coal to a semi-finished condition and continuously feeding it to the finishing rolls, C. Obviously the size of the largest pieces of the semi-finished stock is determined by the spacing of the bars which form the grating, B^4.

A hopper formed by walls, B^5, and the roll saddle, C′, serves properly to confine the semi-finished material and direct it upon the rolls, C. Dust cannot escape from the breaker-feeder, for, as shown, that element is inclosed by the housing, I.

The rolls, C, C, preferably are heavy, and of large diameter. I prefer that their surfaces shall be smooth, but, as before stated, I may make use of fine longitudinal corrugations therein for some materials, and particularly where circumstances make it desirable to employ high speed rolls of comparatively small diameter. But the action of the rolls will be better understood if they are considered in their best form; that is, as having smooth surfaces. These rolls are independent; and are held out of contact. Therefore, neither one accelerates or retards the rotation of the other. For the usual milling of coal the width of the space or opening, C^2, may vary from a quarter of an inch to a just-out-of-contact condition, according to the degree of fineness required in the finished product. These rolls are rotated at as nearly as possible the same speed, and at very high speed. The means by which the rolls, C, are rotated preferably comprise two independent high speed connected motors;—one for each roll, as hereinafter explained.

The capacity of the finishing rolls, as gaged by their high peripheral speed and the size of the opening between them, exceeds the capacity of the secondary feeder; hence there is no banking of material on the rolls, C. Therefore the semi-finished material may be referred to as falling or flowing from the secondary feeder at one speed and as being caught and projected, or expelled, by the rolls, C, at a much higher speed.

The fine material received from the secondary feeder readily passes through the opening, C^2, between the rolls without further material reduction thereby. There are two reasons for this: First, the opening between the rolls is large enough to let the small particles pass freely; and, second, the rotating rolls create a strong downward suction which imparts to the fine particles a speed approximating the peripheral speed of the rolls, whereby the fine material, in the main, is forcibly drawn into and then ejected from the opening between the rolls without being materially impeded by the accompanying larger particles.

The coarser particles fall as far as they may between the rolls, and, being there caught between the rolls, are instantaneously shattered and expelled downward through the opening, C^2. However, wet the semi-finished product, K′, may be, it is in this manner caught by and ejected from the rolls in the finished state, indicated at K^2. Coincidentally, all particles of material and all liquid which, except for the high speed, would adhere to the rolls and thereby quickly render them inoperative, are forcibly detached therefrom by centrifugal force. In this manner, that is, by rotating the rolls very rapidly, the surfaces of the rolls are kept clean and dry without the aid of accessory cleaners or wipers of any kind.

The finished coal, K^2, is received by the hopper, I′, which forms the bottom of the mill. The opening of the discharge hopper, I′, is preferably equipped with the rotary valve or closure, D, for the avoidance of air drafts in either direction through the mill. This suitably rotated valve, D, discharges the finished product directly upon the top of the drier-conveyer, F.

As indicated the high speed rolls create a strong movement of air between the secondary feeder and the space below the rolls. In other words, the rolls, C, create a suction downward through the breaker and its grating; and also create a pressure in the space beneath and surrounding the rolls (beneath the hopper walls, b^5). To prevent the blowing of dust-laden air outwardly through the bearings of the rolls, I prefer to provide the mill with an air relief trunk, L; and in most cases this relief will be augmented by a suction fan connected therewith.

A conveyer, F, of some kind is usually required to carry the material from the mill to the point of use or storage, and, as in many cases it is desirable that the material shall be either partially or wholly dried before its use, I prefer to make this conveyer, F, part of a drying system. As

shown, the drier, or retort, may comprise a closed chamber, E, wherein the shallow conveyer F is arranged in conjunction with a steam coil or other heater, E'.

The conveyer runs rapidly in order to carry the material away in the form of a thin layer, in which condition it may be gradually and sufficiently heated at a low temperature, which in turn expels the water. I make the drier long enough to insure the complete drying of the coal before it is discharged from the end of the conveyer. By the means illustrated I am able to dry the coal as rapidly as it is furnished by the mill and without evolving a cloud of dust, or a separation of fine and coarse particles; and, furthermore, by maintaining only a low temperature in the elongated or long-period drier I am able to dry the coal virtually without loss of any of its valuable volatile constituents, should I so desire. To prevent the condensation of the evaporated moisture upon the coal, I employ the exhaust fan, H, and its connections, H^2, as a means to quietly exhaust all the vapor which rises from the material on the hot conveyer, F. By subdividing the suction in the chamber, E, in this manner I avoid raising even the finest dust from the conveyer; and incidentally I am able to recover the water as a clear distilled product, at the exhaust end of the suction fan, H. Conversely, by increasing the temperature in the drier, or continuous retort, I can very effectively distil off any desired proportion of the volatile gases of the coal, for which a valuable use can be found separate from the combustion of the solids.

In most cases, and particularly in the instance of coal for my furnaces, the coal will be discharged either in its natural state as to moisture, or in an only partially dry condition, and in such cases the coal may be stored in open bins without danger and without annoyance from dust, the product being sufficiently moist to retain the dust. The use of the coal in this partially dried condition will also be found desirable from the standpoint of the saving of heat in the drier.

Obviously, the construction of the parts shown in Fig. 1 may be extensively modified and still retain the spirit and essentials of my invention. I prefer, however, that in practically every case where the mill is to be used for milling coal it shall be constructed in substantial accordance with the detailed forms and relations depicted in Figs. 3 to 15 of the drawings. This is true even for large mills which are adapted to handle many carloads of coal per hour.

I have attained great success with a mill of the identical construction herein depicted and wherein the breaker roll, B^2, is twenty-four inches in diameter and twenty-four inches long; wherein each finishing roll, C, is twenty-four inches in diameter and twenty-four inches long; wherein each of the rolls mentioned weighs approximately one ton; and using constant speed, direct connected electric motors for operating the several rolls, the motor of the breaker roll being of twenty-five horse power and the motors of the finishing rolls being each of five horse power, and all of the motors operating at approximately eighteen hundred revolutions per minute. The most efficient capacity of the mill mentioned is thirty tons of coal aggregate per hour, the larger pieces in the aggregate being of approximately eight-inch size, and there being in the bulk approximately twenty-five per cent. of these large pieces and seventy-five per cent. of smaller particles. I have given these facts with reference to an exemplary mill in order that both the structure and the method herein described may be the more readily visualized, with a resulting better comprehension of the invention.

The mill is a unitary structure, as disclosed in Figs. 3 to 15. That is, it has a single base which contains and supports all of its other parts, and which base is supported by a single foundation. The base referred to is constituted by the before-mentioned frame or housing, I. This housing for ease of manufacture and the assemblage of the parts therein, is made in sections, as, for example, a bottom section, 7, a middle section, 8, and a top section, 9; parted upon horizontal planes, and all firmly bolted together. These sections are preferably rectangular in horizontal cross section. The distance between the sides of the housing is determined by the length of the contained rolls, B^2, and C, which dimension may be proportionately less, or more, than herein shown; according to the desired capacity of the mill. To enable the easy placing of the rolls, C, C, I provide rectangular openings, 11, in the sides of the base portion, 7. These openings are closed by light plates, 12, bolted in place, for further purposes herein explained.

The construction of the rolls, C.—These rolls preferably are identically the same. Each roll is nicely balanced, either by exact initial manufacture or by means of weights added thereto when needed; a nice balance being necessary because of their speed of rotation. The crushing strength of coal in the semi-finished condition, above described is not great, and no great kinetic force is required in the rolls, C, to compensate for irregularities of feed. Therefore, I do not find it necessary to make the rolls solid throughout. Instead the roll proper, in

each case, is formed by a heavy walled shell or cylinder preferably made of manganese steel, and which is held centrally upon the complementary shaft, 13, by the disks or ends, 14 and 14′. The cylinder and the ends meet upon truncated cones, 15, formed thereon. Both heads are tightly fitted to the shaft and are also secured by keys, 16. The head, 14, is located by a shoulder 13′, on the shaft; the other head, 14′, though tight on the shaft, is otherwise free to adjust itself longitudinally. The parts are bound together by heavy bolt rods, 17, which pass through the heads, 14, 14′, and through notches or holes, 15′, in the internal cone ribs of the cylinder, C. After being thus assembled the roll is nicely balanced, as before indicated. The ends of the shaft extend outwardly through relatively large elongated holes 12′, in the side plates, 12; the shaft has no bearing in either of these plates, 12 (see Fig. 14).

The means which support the rolls, C.— The axes of the rolls are and should be parallel and in a horizontal plane. To adjustably support the rolls in this situation, I employ guides and cross-heads, arranging within the cross-heads fine anti-friction bearings for the shafts, 13, of the rolls. Referring now to Figs. 3, 5, 6, 7, 11 and 13, it will be seen that I provide this cross-head equipment upon both sides of the mill housing or frame. Thus on each side are two parallel cross-head guides comprising sufficiently strong bars, 18, rigidly clamped and held in blocks or brackets, 19, projecting horizontally from the sides of the base portion, 7, of the mill housing. These rods do not move. They are arranged in vertical planes, as nearly as possible perpendicular to the horizontal plane of the roll axes. Slidably, but otherwise rigidly held on the guides, 18, are the cross-heads, 20, two on each pair of guides; that is, two on each side of the mill. The portions, 20′, form the slide bearings on the guides, 18, and present square shoulders to the hereinafter mentioned pressure springs, 21. Except for the parts, 20′, each cross-head is preferably circular and in particular is provided with a circular face, 20″, to serve as the base for a motor containing bracket, as hereinafter described. The ends of each roll shaft, 13, are borne in the opposite cross-heads, on the two sides of the machine. In each case the direct bearing between the shaft and the cross-head comprises an anti-friction ball bearing, 22, of approved construction, together with an indirect bearing which comprises a ball, 23, and socket joint. This forms a universal joint between the shaft and its cross-head. The ball portion is a part of a sphere. It is bored out to receive the ball bearing, 22. In accordance with best practice, the inner ring of the ball bearing is fixed on the shaft between a shoulder thereon and an end nut, 27, threaded on the end of the shaft. The ball portion, 23, is snugly but not immovably held in a complementary spherical cavity, 24, provided at the center of the cross-head, 20. A removable ring or section, 24′, permits the insertion and removal of the ball proper, 23, and provides means for tightening the ball in the socket. In each case, the ball and socket connection between the shaft, 13, and the cross-head permits a considerable degree of malalinement between those parts and thereby prevents the cramping of the relatively delicate ball bearing, 22. A felt washer, 25, in each bearing serves to exclude dust from the inner end of the bearing and the outer end of the bearing is closed and protected by a cap, 26, threaded into the ball portion, 23. When packed with grease, these bearings will run indefinitely. As best shown in Figs. 11, 13 and 14, the escape of dust from the mill through the openings, 12′, is prevented by the formation of a tight sliding joint between each cross-head and the adjacent side plate, 12. To this end the inner side of the cross head is faced off; and the projecting part, 12″, of the plate is faced to fit it. The joints secured in this manner are usually effective without the employment of interposed packings, but, if desired, the latter can be used between each cross-head and its sliding seat, 12″. The only thing essential is that the cross-heads shall not be restrained by their engagement with the sides of the mill, but shall be free to slide upon the guide bars, 18. Obviously, the proper arrangement of the roll shafts is that in which they are perpendicular to the vertical plane of the cross-heads. Supported in the manner described, these heavy rolls may be turned by an effort as slight as the pressure of a single finger of the hand; which, obviously implies that they may be started into rotation by the torque of a relatively weak motor, and, once started, may be kept in rotation by the expenditure of comparatively little power. At this point, I call attention to the fact that when rotated at the high speeds defined, these rolls, C, become gyrostats and tend to maintain their relative initial positions; a matter of considerable moment when it is considered that at any given instant (due to lack of feed from the secondary feeder or due to irregular distribution of the feed) only one end of the crack or opening, C^2, between the rolls may be occupied by material, tending to spread the rolls at that point. This slight spreading force, however, is insufficient to overcome the gyrostatic force of the rolls, and therefore the latter remain in parallelism.

The means for driving the rolls, C.— Where necessary a suitable motor may be

attached to each end of each roll shaft, 13. But in most cases an adequate drive is secured at only one end of each shaft. As illustrated, and chiefly to made the mill as nearly as possible symmetrical, I prefer to drive one roll from one side of the mill and the other roll from the other side thereof. Each shaft, 13, has a reduced end, 13″, which projects through a dust proof hole in the bearing cap, 26. The motor, 28, is directly connected with the end, 13″, of the shaft, through the medium of a flexible coupling, 29. In the case illustrated, I employ constant speed electric motors of approved design. Any other form of high-speed motor may, of course, be substituted. Each motor is supported by its respective cross head, and therefore may be adjusted, and move with, its respective roll. To this end I employ, for each motor, a bracket, 30, which takes the form of a cylindrical housing therefor and which is bolted to the outer face, 20″, of the cross-head, 20. The motor is fixed within the bracket, the latter serving as the sub-base therefor. Access doors, 31 and 32, are provided at the outer end, and in the side of the motor housing or bracket; and to permit a proper circulation of air through the motor and at the same time exclude dust, these doors are perforated and provided with screens. The electrical connections for the motor enter the housing through an insulating block, 33, provided in the side of the bracket.

The means for adjusting the rolls, C.—As previously explained, the rolls, C, are held out of contact. This is accomplished by means of retracting jacks that are coupled to the cross-heads of the rolls and whereby the rolls may be drawn apart to make the opening, C^2, of any desired width, ranging between actual contact and the maximum separation permitted by the length of the elongated slots, 12′, in the plate, 12. It may here be explained that these slots, 12′, also permit the adjustment of the rolls toward one another to compensate for the wearing away of the faces of the rolls. The jacks prevent the closing together of the rolls beyond the fixed distance; but are so formed as to permit free separation of the rolls in event a large piece of metal, or the like, falls between them. This is a wise precaution in view of the fact that the grate bars, B^4, are not indestructible, and a broken bar might otherwise wreck the finishing rolls. While the jacks hold the rolls apart, they are at the same time held firmly in their given positions by the action of the strong springs, 21, on the guides, 18, which press against the cross-heads. As best illustrated in Fig. 7, the pressure of these springs, 21, may be varied by means of respective spring follower nuts, 21′, threaded upon the fixed guide bars, 18. As best shown in Figs. 3, 4, and 11, the retracting jack of each cross-head comprises a rod, 34, having its inner end fixed securely in a boss, 20^x, on the cross-head, and having its outer end, 35, threaded to receive the internally threaded hub of a sprocket wheel, 36. The intermediate portion of the rod, 34, is slidably held in a horizontal pillow-block, or bracket, 37, on the side of the mill base and against which the hub of the sprocket wheel bears. Obviously, each jack may be separately adjusted by rotating its threaded sprocket wheel, 36. Except for the initial positioning of the rolls, such separate adjustment is objectionable. Therefore, I provide, first, for an initial adjustment by means of the lock nuts, 34′, against the cross heads, and, secondly, for the simultaneous and equal adjustment of each pair of jacks. The simultaneous adjustment is secured by means of sprocket belts, 38, that join the sprocket wheels, 36, of respective pairs of jacks. Actual motion is imparted through a large lever or wrench (not shown) applied to the hub of one of the sprocket wheels. Obviously, by thus rotating the sprockets simultaneously the jacks may be retracted equal distances or may be slackened under the influence of the compression springs, 21. By these simple mechanisms I am able to adjust the two heavy rolls, C, at equal distances from the middle plane of the mill, to maintain their parallelism, and to nicely adjust and maintain the width of the working opening, C^2, between the rolls.

The roll saddle, C^1.—The saddle of my machine differs from those in common use, in that it co-acts with the extreme ends of the rolls, instead of overlapping them. I cannot use the old constructions because such saddles, by protecting the rolls at the ends, maintain those ends at their initial dimensions and thus prevent the taking up of roll surface wear. The saddle which I employ allows the wear to be uniform from end to end of the rolls, leaving them always in condition for accurate adjustment. At each end of the pair of rolls, C, I provide a disk, 40, having its axis parallel with the rolls and in the middle vertical plane of the pair. The disk, as best shown in Fig. 12, is adjusted close to the end of the rolls and thus prevents material from passing over those ends instead of through the opening, C^2. A single plate might be used at each end, but there is considerable wear by the material which eventually cuts a groove in a plate so situated, the cut-groove coinciding with the V-opening between the rolls, and allowing the escape of some unfinished material. I therefore prefer the disk formation. By rotating the disk slightly from time to time the essential closure at the ends of the V of the rolls may be restored, the

worn or cut-out portion being moved to one side. To the end that each disk may be used in this way, I prefer to mount it upon the head, 41, of a spindle, 42, which is held in the side plate, 12. A set screw, 43, is provided for fastening the disk after adjustment. Obviously, the two plates or disks close the ends of the V-gap between the rolls and more effectively prevent the spilling over of material than would saddles of the old type, at the same time exposing the full surface of the rolls to normal wear. The saddle is completed by a rectangular frame having perpendicular ends, 44, joined by the inclined hopper sides or extensions. The vertical parts are bolted to the inner sides of the plates, 12, 12. Segmental recesses formed in the parts, 44, admit the tops of the disks, 40. Further additions to the saddle comprise the adjustable plates, 45, which may be set close to, but not in contact with, the rolls, C, and which may be adjusted as said rolls wear down. The purpose of these plates 45 is to prevent the escape of material, which falling upon the rolls, either bounds therefrom or is thrown in the direction of the opposite hopper wall and might otherwise pass through one of the openings, 46. Manholes, 47, are provided in the ends of the mill housing; through which the clamping bolts of the plates, 45, may be reached, and allowing access to the surfaces of the rolls, C, when necessary.

The construction of the breaker casing, B^3.—The upper half, 50, of the breaker casing, together with the throat forming portions, 51, is integral with and is partly formed by the casting or section, 9, of the mill housing, I. The internal walls, 50 and 50′, are strengthened by heavy webs, 52, as required to take the heavy blows to which they are subjected. To prevent direct wear upon the internal walls of the casing I line the same with manganese steel castings or the like, 53, preferably sharply corrugated, as shown. The lower half of the breaker casing comprises the before mentioned grating B^4. This grating is composed of a plurality of identical bars, 54, having squared ends, 55, held and preferably riveted in the curved cradle hangers, 56. These hangers are provided with ears, 56′, and the grating as assembled is removably supported by means of two cross-bars or bolts, 57, which pass through these ears and which have their ends held in bosses, 58, formed on the sides of the sections, 8. Set screws, 59, prevent the loosening of the grate or screen supporting rods, 57. By employing bars, 54, of different sizes and spacing, the grating is adapted to the production of different grades of semi-finished stock. Where a fine finished product is to be made, a narrow spacing is used between the grate bars; and where a coarse aggregate is to be produced the grate bars will be separated by wider spaces. Obviously a single set of grate bars may be used in making up the different gratings, provided differently perforated hangers, 56, are furnished as extra parts with the mill. The grate bars, 54, are preferably made of manganese steel, or like tough metal, and together form a somewhat corrugated open bottom for the breaker casing. The grating may be got out by removing the top section, 9, of the mill. It should be noted that the casing is slightly eccentric to the axis of the breaker roll, B^2, whereby the space, 67, between the inner periphery of the casing and the periphery of the breaker roll is given the form of a geometric volute, thus providing for a progressive reduction of material which is received between the two parts.

The construction of the breaker roll, B^2, is well disclosed in Figs. 8, 9, 10 and 12 of the drawings. As there shown, the breaker roll preferably comprises a plurality of polygonal sections, 60, set side to side upon the heavy shaft, 61, and keyed thereto in different positions whereby the polygonal parts are staggered. That these polygonal sections or disks need not be solid is indicated in Fig. 12. The first section, 60, is pressed against the shoulder, 61′, on the shaft. The other sections are similarly placed on the shaft and then the last section containing a slightly smaller shaft hole is forcibly pressed onto the shaft, thereby locking all of the sections in place. At each corner of each section I provide two forwardly projecting ears, 62, and to these I attach a hammer block, or face, 63, preferably made of manganese steel. The T-lug, 64, of the hammer block enters between the lugs, 62, and the head-proper rests upon the ends of said lugs, 62. The block is there rigidly secured, as by means of a stout rivet, 65. This construction repeated at each angle of each section, 60, provides a breaker roll which has a large number of tangential hammers. The sections proper are not greatly worn by use, the rigid hammer blocks performing the essential work. When the hammers become worn, the rivets, 65, are sheared and knocked out, and new hammer blocks riveted in place on the lugs or anchorages, 62. The roll as a whole being rotated in the direction of these hammers (as indicated by the arrow in Fig. 8) it is obvious that the hammers successively strike the pieces and chunks of coal which enter through the throat, B^1. Being rotated at high speed, the whole weight and momentum of the heavy roll backs the blow of every hammer thereof and in consequence even the largest chunks of material are instantaneously shattered when struck by one or more of the hammers. It should be noted that the throat is so formed as to deliver the

material directly upon the top of the breaker roll, that is, it has an inclined bottom, 66, which is above the roll, and the top of the throat overhangs said roll. Every piece of the material struck by the hammers is in the main shattered before it reaches the upper or opposed wall, 53, of the casing, and, striking the latter at high speed, is further shattered by impact therewith. Thus the operation proceeds step by step, as the material progresses in the volute, 67, before mentioned. Material which enters the throat in an already fine condition is not much reduced by the action of the breaker roll, but, being carried downward thereby, sifts directly through the feeder screen, B^4, along with the material shattered by the breaker. Little, if any, coarse material is carried over, for the closely adjusted breaker or liner plates below the throat floor, 66, are effective to finally reduce lumps carried around to that point.

The means which support the breaker roll.—On referring to Fig. 12 it will be noted that the shaft, 61, of the breaker roll, like the shafts of the finishing rolls, has ends which extend through and beyond openings, 68, in the sides of the mill housing. These openings are formed, half in part 8 and half in the part 9. The shaft is supported by anti-friction, universal joint or self-adjusting bearings, contained by the large circular castings or disks, 69. Upon the sides of the parts 8 and 9 I form circular ribs, 70, and face these off to provide seats for the flanges, 69′, of the circular plates, 69. The plates are bolted firmly in place on respective seats, 69″. Incidentally the bolted plates, 69, serve to firmly tie together and strengthen the housing parts, 8 and 9, in the immediate region of the breaker cylinder, where the mechanism is subjected to the severest blows and shocks. As in the case of the finishing-roll shafts, direct bearings for the shaft, 61, are formed by anti-friction ball or roller bearings, 71; and the indirect or universal joint bearing is in each case formed by a ball, 72, and its socket, 73, in the plate, 69. As before there is a removable socket ring, 74, which secures the ball, 72, in place. Lock nuts, 75, secure the ball bearings in proper position on the ends of the shaft; and the ball bearings are inclosed and protected by end caps, 76, 76′, respectively, in conjunction with felt washers, 77, that close the inner ends of the bearings. The outer faces, 78, of the plates, 69, on opposite sides of the mill are faced and shouldered to receive the motor containing bracket, which therefore may be attached to either side of the mill, or a motor may be used at each end of the breaker roll.

The means for driving the breaker roll.—Except that in most cases the motor, 79, of the breaker roll will be somewhat larger than the motors of the finishing rolls, the driving arrangement for the breaker is identical with the drivers described in conjunction with the finishing rolls. That is, the motor, 79, is contained and supported by a cylindrical bracket, 80, bolted to the face, 78, of one of the main blocks, or plates 69. There is a flexible coupling, 81, between the motor armature shaft and the extension, 61″, of the breaker shaft, 61. The screened doors and electric connections belonging to the bracket, 80, are of the same design as like parts of the lower brackets; and are indicated by corresponding numerals, 31^a, 32^a and 33^a. Thus supported and connected with the rotor (whatever its kind) of the motor, the breaker roll is adapted for rotation at high speed by minimum power. When once set in rotation the roll tends to maintain its axis; and particularly, the gyrostatic force incident to its rotation is a marked factor in the protection of the ball or roller bearings from the effects of the heavy impacts between the roll and the material which it encounters in the breaker casing.

The mill as a whole has a substantial and pleasing appearance. Its operation is substantially non-vibratory, noiseless, and dustless. No moving parts are exposed to endanger persons working around the mill. These are marked advantages which should be tabulated in connection with others already recited.

When electric motors are used as the drivers for the breaking and finishing rolls, it is an easy matter to protect the machine by the mere use of proper fuse plugs in the electric supply lines of the motors. If the primary feeder is improperly operated and there is a tendency to clog the mill, or if a large piece of metal by chance enters the breaker, or if through error a quantity of material is allowed to bank on the finishing rolls, the excess load upon the motors causes the blowing of the fuse plugs and stops the motors before any damage results to the mill.

The best way in which to start the plant into operation is as follows:—The finishing rolls are first set into rotation, by starting their motors, and they are permitted to attain their normal or high speed. The breaker roll is then similarly started into action. At the same time the valve, D, the conveyer, G, and the fan, H, are started. The plant is then ready to receive the material to be milled, whereupon the primary feeder, A, is set into operation, and, there being a supply of material, K, in the trunk, A^2, the milling operation is instituted and thereafter is automatically maintained as long as the primary conveyer continues to operate. The necessity for the personal attendance of the operator is very slight, comprising only occasional attention to the primary feeder and the watching of the several

bearings of the moving parts to see that they are properly lubricated.

The most important use of my invention will be at the coal mine, where the whole product of the mine may be thus cheaply and quickly reduced to a condition which not only fits the coal for most economical use, particularly in my introgenerative furnaces, but also conditions it to be handled and transported by means and in ways which insure great savings over the present system of handling coal at the mines.

It is understood that the specific method and mechanism hereinafter described have been disclosed merely for purposes of illustration; and the scope of the invention is by no means limited thereto. On the contrary, the specific illustration is susceptible of wide variation by omission, addition, and substitution as will appear to those skilled in the art, all within the proper scope of the subjoined claims. It is not indispensable that all of the features of the invention be used conjointly, since they may be used separately to advantage.

Having thus described my invention, I claim as new and desire to secure by Letters Patent:—

1. The method of milling material as described, which consists in feeding the crude material as a continuous stream, forcibly screening out the finer particles and simultaneously reducing the larger pieces to a degree short of a pasty condition, whereby the whole bulk is forwarded as a semi-finished stock, screening the semi-finished stock between rolls that are separated by a space as wide as the thickest pieces in the finished product are to be, and smaller than the larger pieces in the semi-finished stock, rotating said rolls at speeds which cause them to centrifugally clear themselves of solids and liquids and also causing the rolls to act as impact members and burst the larger pieces of semi-finished stock and discharge the bulk of material as finished stock, irrespective of its contained moisture.

2. The method of milling material as described, which consists in feeding the crude material as a continuous stream, forcibly screening out the finer particles and simultaneously reducing the larger pieces to a degree short of a pasty condition whereby the whole bulk is forwarded as a semi-finished stock, screening the semi-finished stock between rolls that are separated by a space as wide as the thickest pieces in the finished product are to be, and smaller than the larger pieces in the semi-finished stock, rotating said rolls at speeds which cause them to centrifugally clear themselves of solids and liquids and also causing the rolls to act as impact members and burst the larger pieces of semi-finished stock and discharge the bulk of material irrespective of its contained moisture, and at a speed approximating the peripheral speed of said rolls, and allowing the stream of stock from the rolls to impact a surface, which further pulverizes the material.

3. The method of milling material as described, which consists in feeding the crude material as a continuous stream, forcibly screening out the finer particles and simultaneously reducing the larger pieces to a degree short of a pasty condition, whereby the whole bulk is forwarded as a semi-finished stock, screening the semi-finished stock between rolls that are separated by a space as wide as the thickest pieces in the finished product are to be, and smaller than the larger pieces in the semi-finished stock, rotating said rolls at speeds which cause them to centrifugally clear themselves of solids and liquids and also causing the rolls to act as impact members and burst the larger pieces of semi-finished stock and discharge the bulk of material as finished stock, irrespective of its contained moisture, and finally drying the finished stock to a desired extent.

4. The method of milling material as described, which consists in feeding the crude material as a continuous stream, forcibly screening out the finer particles and simultaneously reducing the larger pieces to a degree short of a pasty condition, whereby the whole bulk is forwarded as a semi-finished stock, screening the semi-finished stock between rolls that are separated by a space as wide as the thickest pieces in the finished product are to be, and smaller than the larger pieces in the semi-finished stock, rotating said rolls at speeds which cause them to centrifugally clear themselves of solids and liquids and causing the rolls to act as impact members and burst the larger pieces of semi-finished stock and discharge the bulk of material, irrespective of its moisture and then drying the finished stock to a desired extent, and finally recovering as by-products the constituents distilled from the stock by the drying heat.

5. The method of milling moist coal, which consists in screening the moist coal between substantially smooth rolls that are separated by a space as wide as the thickest pieces in the finished product are to be, and smaller than the large pieces of starting material, rotating said rolls at speeds which cause them to centrifugally clear themselves of solids and liquids and also causing the rolls to act as impact members and burst the larger pieces and discharge the whole bulk of material, irrespective of the restraint of contained moisture and at a speed approximating the peripheral speed of said rolls.

6. The method of milling moist coal, which consists in feeding the moist coal as a

continuous stream, between substantially smooth rolls that are separated by an opening as wide as the thickest particles in the finished product are to be, rotating said rolls at speeds which cause them to centrifugally clear themselves and to act as impact members upon the stock and discharge the whole bulk in a finished state.

7. The method of milling moist coil, which consists in feeding the moist coal as a continuous stream, between substantially smooth rolls that are separated by an opening as wide as the thickest particles in the finished product are to be, rotating said rolls at speeds which cause them to centrifugally clear themselves and to act as impact members upon the stock and discharge the whole bulk at a speed approximating the peripheral speed of said rolls and causing the stream of stock from the rolls to impact a surface, which further pulverizes it.

8. The method of milling wet coal, which consists in feeding the wet coal as a continuous stream, forcibly reducing the coal to a semi-finished state short of a pasty condition, whereby the whole bulk is forwarded as a semi-finished stock, screening the semi-finished stock between rolls that are separated by a space as wide as the thickest pieces in the finished product are to be, and smaller than the larger pieces in the semi-finished stock, rotating said rolls at speeds which cause them to centrifugally clear themselves of solids and liquids and to act as impact members and burst the larger pieces of stock and discharge the whole bulk thereof in a finished state.

9. The method of milling wet coal, which consists in feeding the wet coal as a continuous stream, forcibly reducing the coal to a semi-finished state short of a pasty condition, whereby the whole bulk is forwarded as a semi-finished stock, screening the semi-finished stock between rolls that are separated by a space as wide as the thickest pieces in the finished product are to be, and smaller than the larger pieces in the semi-finished stock, rotating said rolls at speeds which causes them to centrifugally clear themselves of solids and liquids and to act as impact members and burst the larger pieces of stock and discharge the whole bulk thereof in a finished state of reduction, continuously drying the product from the rolls and recovering the constituents distilled by the drying heat.

In testimony whereof, I have hereunto set my hand this 22d day of January, 1918.

JOSEPH M. SCHUTZ