W. D. HUFF.

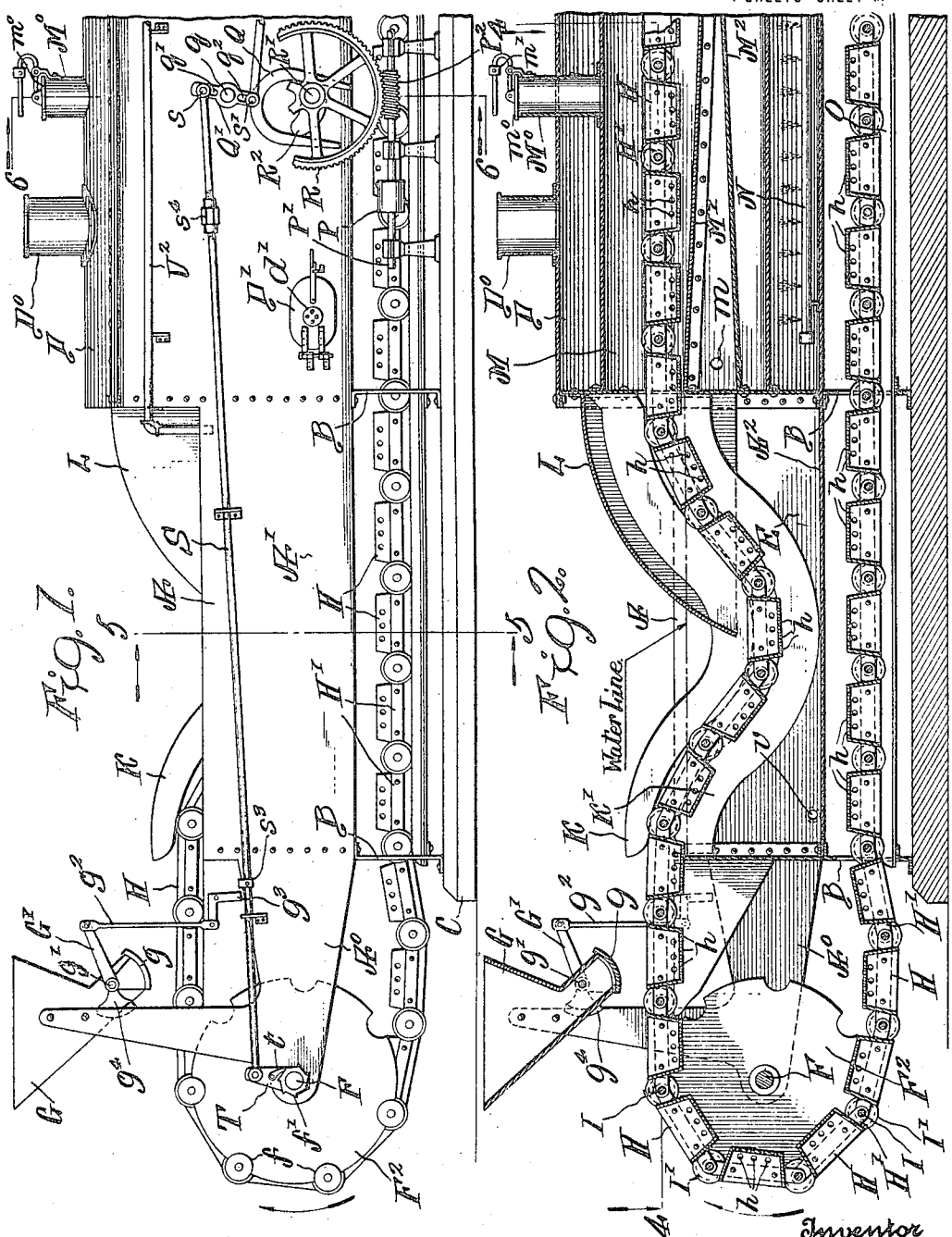
PROCESS AND APPARATUS FOR EXTRACTING SULFUR.

APPLICATION FILED JULY 8, 1918.

1,317,625.

Patented Sept. 30, 1919.

4 SHEETS—SHEET 1.



Witness
Edwin J. Bellas.

Inventor
William D. Huff.
by Williamson & Grosta,
Attorneys

W. D. HUFF.

PROCESS AND APPARATUS FOR EXTRACTING SULFUR.

APPLICATION FILED JULY 8, 1918.

1,317,625.

Patented Sept. 30, 1919.

4 SHEETS—SHEET 2.

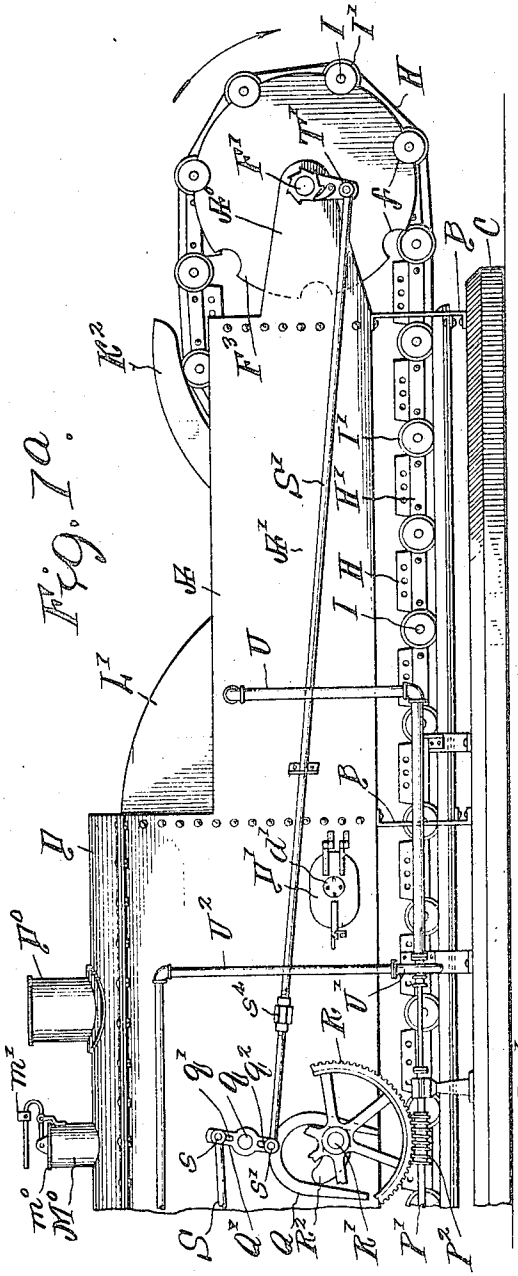


Fig. 1a.

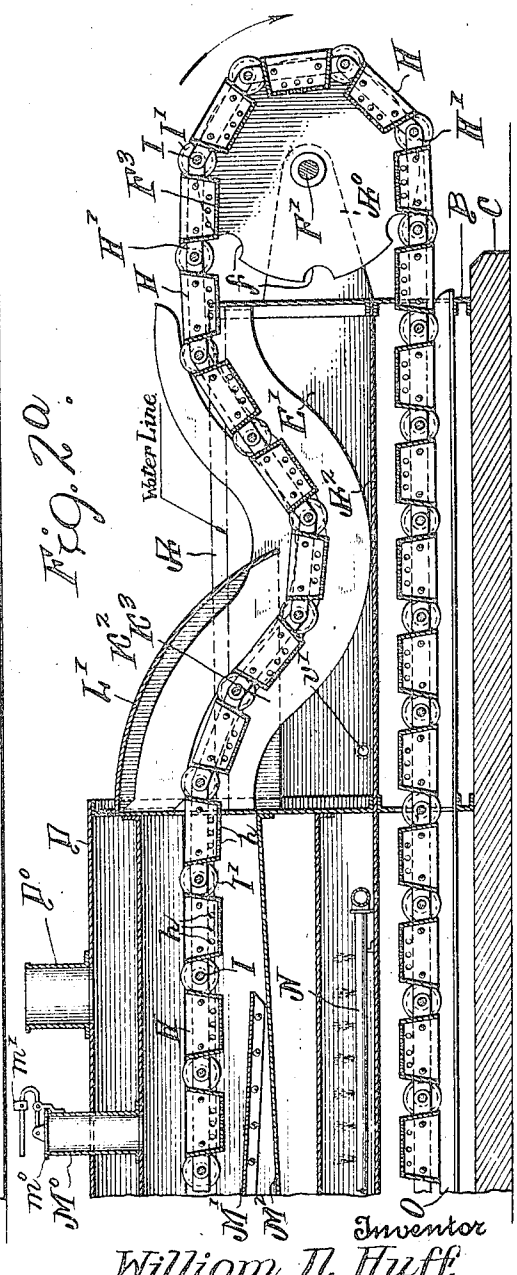


Fig. 2a.

Witness
Edwin J. Beller.

Inventor
William D. Huff.
by Wilkinson & Guste
Attorneys

W. D. HUFF.

PROCESS AND APPARATUS FOR EXTRACTING SULFUR.

APPLICATION FILED JULY 8, 1918.

1,317,625.

Patented Sept. 30, 1919.

4 SHEETS—SHEET 3.

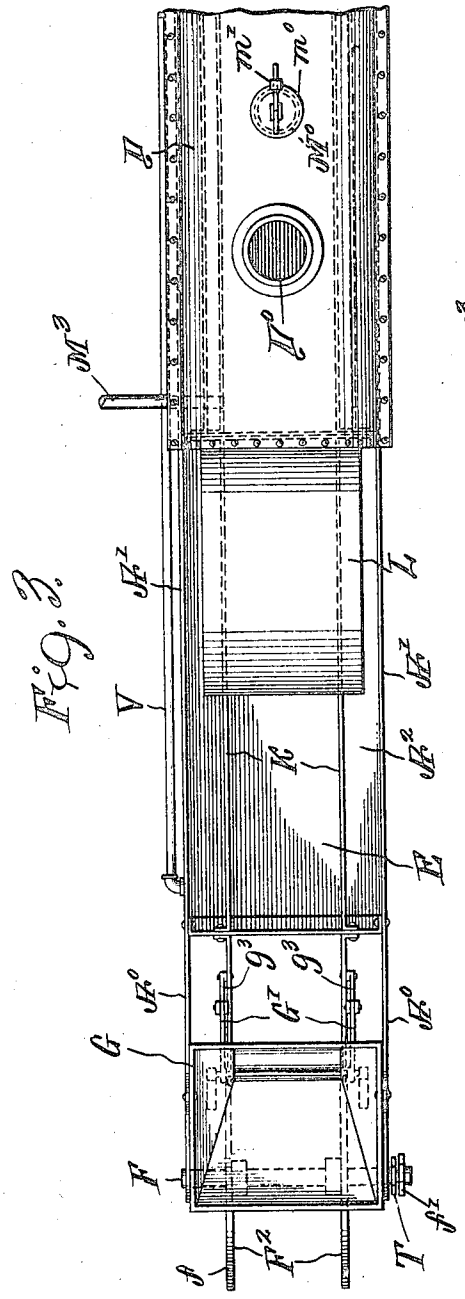


Fig. 3.

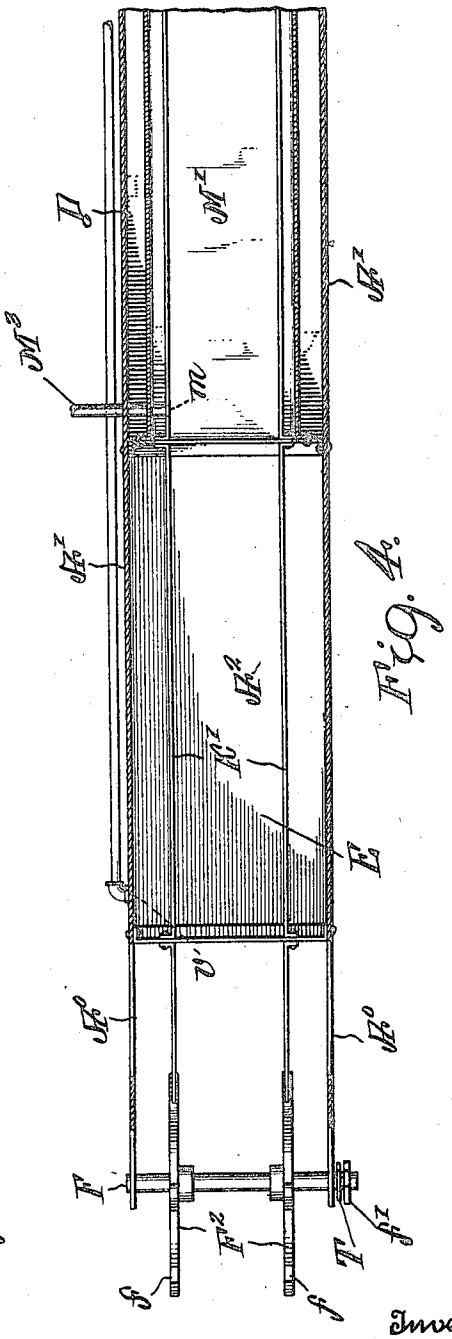


Fig. 4.

Witness

Edwin J. Beller.

Inventor

William D. Huff.

by Williamson & Guista,

Attorneys.

W. D. HUFF.

PROCESS AND APPARATUS FOR EXTRACTING SULFUR.

APPLICATION FILED JULY 8, 1918.

1,317,625.

Patented Sept. 30, 1919.

4 SHEETS—SHEET 4.

Fig. 6.

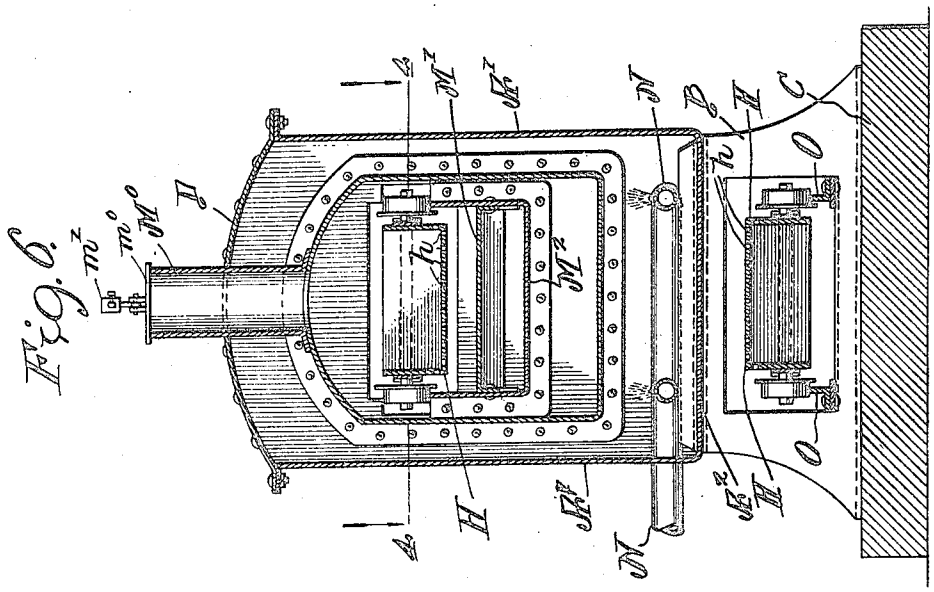
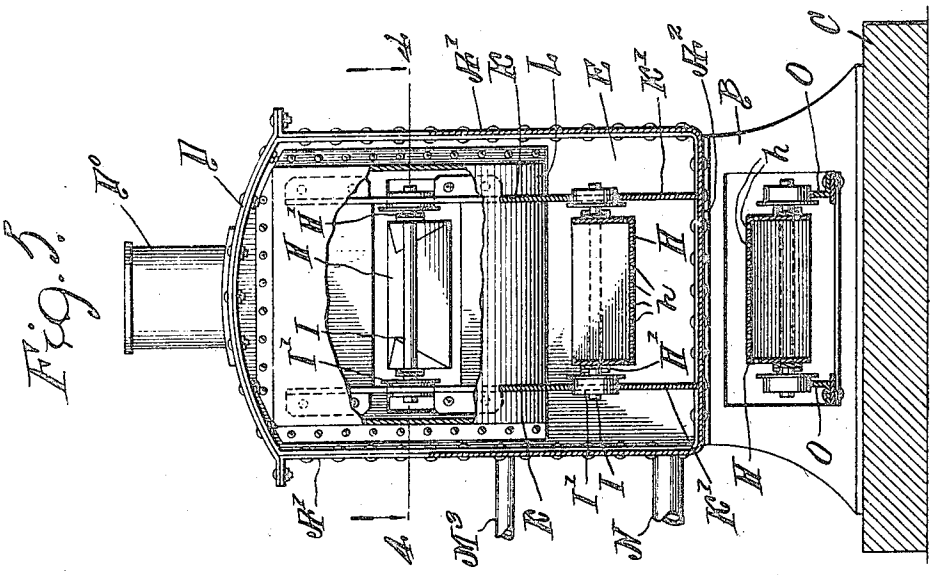


Fig. 5.



Witness

Edwin J. Beller.

Inventor

William D. Huff.

by Williamson & Gusta

Attorneys

UNITED STATES PATENT OFFICE.

WILLIAM D. HUFF, OF LA FAYETTE, LOUISIANA, ASSIGNOR OF ONE-HALF TO JAMES J. CONNOLLY, OF ROANOKE, VIRGINIA.

PROCESS AND APPARATUS FOR EXTRACTING SULFUR.

1,317,625. Specification of Letters Patent. Patented Sept. 30, 1919.

Application filed July 8, 1918. Serial No. 243,821.

To all whom it may concern:

Be it known that I, WILLIAM D. HUFF, a citizen of the United States, residing at La Fayette, in the parish of Lafayette and State of Louisiana, have invented certain new and useful Improvements in Processes and Apparatus for Extracting Sulfur; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same.

My present invention relates to an improved method and apparatus for separating sulfur from the clay, sand, or other gangue with which it is associated when found in the native state, and for delivering it in the commercially pure form.

Native sulfur is a mineral that cannot be successfully separated from its gangue, by fusing in an open retort, because its flashing point and its fusing point are so near the same temperature that when fused in the presence of oxygen, such as is found in atmospheric air, the sulfur ignites.

Most of the sulfur now mined in the United States is secured by means of the well known Frasch process, in which the sulfur is melted out of the bed containing it by forcing hot water under pressure into the bed, melting the sulfur and allowing it to form into pools between the stratum of rock beneath and the water above, and the sulfur while still melted is lifted to the surface by air jets.

This process, however, is necessarily limited to wells of a certain depth, for the hot water has to be supplied under pressure to be of a temperature high enough to melt the sulfur, the melting point of sulfur being 239° F.

This process is, therefore, not suitable for the large quantities of native sulfur contained in beds located near the surface of the ground.

For extracting the sulfur from its gangue when the sulfur beds are at or near the surface of the ground, what is known as the "wet process" is ordinarily used. In this process the sulfur is placed in an inclined retort, which is then closed, and steam is injected under sufficient pressure to have a temperature of above the melting point of sulfur; the sulfur is melted from its gangue and descends to the bottom of the inclined retort and is drawn off at the lower end thereof. The stem is then shut off, the retort is opened, and the residual gangue or slag is taken out.

This process has proved in practice to be expensive and unsatisfactory. The principal cause of the excessive expense is due to loss of latent heat while expanding the water into steam, the chilling of the retort and the containers for the material at each operation, and the loss of heat left in the gangue or slag taken out of the retort, and also the expense of handling the material.

To avoid these objections I provide an automatically operating apparatus, in which the material being treated has the air expelled therefrom by immersion in water, and has the sulfur melted out by the heat applied to the wet mass in an atmosphere of steam substantially free from any free oxygen; and in which the heat given off in cooling the material, after it has been treated, is transmitted to the original water bath, and in which finally the slag or gangue from which the sulfur has been removed is automatically dumped out of the apparatus.

In order to get the best results, the apparatus is caused to operate with an intermittent or step by step motion, as will be hereinafter more fully described.

My invention will be more fully understood after reference to the accompanying drawings, in which like parts are indicated by similar reference symbols throughout the several views, and in which:—

Figures 1 and 1ª show a side elevation of the complete apparatus.

Figs. 2 and 2ª show a central vertical longitudinal section through the complete apparatus.

Fig. 3 shows a plan view of one end of the apparatus, the other end being substantially similar in construction.

Fig. 4 shows a horizontal section along the broken line 4—4 of Fig. 2, and shows the upper tracks on which the rollers supporting the buckets containing the material travel.

Fig. 5 shows a section along the line 5—5 of Fig. 1, and looking in the direction of the arrows; and

Fig. 6 shows a section along the line 6—6 of Fig. 1, and looking in the direction of the arrows.

A represents the main frame or housing

which is mounted on the supporting legs or frame B, which rest upon any suitable platform C.

The side plates A′ of this housing are deeper in the center and form the side walls of the furnace chamber D, at one side of which the depth of these plates is somewhat less, and they form the side walls of the immersion chamber E and of the cooling chamber E′, which are adapted to be filled with water to the level shown in Figs. 2 and 2^a.

These chambers D, E and E′ are closed with the bottom plates A^2. The ends of the side plates A′ are tapered, as shown at A^0, to provide journal bearings for the shafts F and F′ of the driving wheels F^2 and F^3, respectively.

The material to be treated is periodically fed from a hopper G near the delivery end of the apparatus, as will be hereinafter described.

The material from this hopper is fed *seriatim* to the buckets H, carried by the links H′ which are hinged to the axles I of the rollers I′.

The rollers I′ engage in sockets *f* in the driving wheels F^2 and F^3, and a step by step motion imparted to these wheels gives an intermittent travel to the endless belt comprising the links, buckets and rollers just described.

The chamber E for the immersion bath is provided with oppositely-disposed pairs of downwardly curved guide plates K and K′, separated by a slot, in which slot the rollers I′ travel, the lower guide plate K′ serving as a track for these rollers and causing the buckets to descend beneath the level of the water in the immersion bath chamber E. As these buckets travel upward from the lower position in the immersion bath, they pass beneath the curved hood L located in front of the melting chamber M, and projecting beneath the level of the immersion bath to a sufficient depth, for instance twenty-four inches, more or less.

The melting chamber M is shown as surrounded by the furnace chamber D, in which the heat is supplied in any convenient way, as by means of the gas pipe N.

Mounted in the melting chamber M are the inclined false bottoms M′ and M^2 to receive the melted sulfur, which falls through the perforations *h* in the buckets H. This sulfur runs down the inclined bottom M′ and, falling on the bottom M^2, accumulates until it is carried off through the opening *m* (see Fig. 2) which connects with a pipe M^3.

After passing through the melting chamber M, the chain of buckets passes below the hood L′, and is guided by the guide plates K^2 and K^3 into the cooling bath contained in the chamber E′. There the treated material or slag is cooled, the chain of buckets is finally carried over the driving wheels F^3, and their contents are dumped onto a dump pile, or into a suitable conveyer or wagon, not shown.

The question of the removal of the slag is one that may be answered in a great variety of ways, but does not constitute a part of my present invention.

After dumping their contents, the chain of buckets, with the buckets inverted, pass beneath the chambers E′, D and E, the rollers traveling on tracks O supported in openings in the frames B, which openings permit the passage of the chain of inverted buckets, as shown most clearly in Figs. 5 and 6.

The furnace chamber D is provided with one or more suitable smoke stacks, or escape openings D^0, for the products of combustion, and the melting chamber M is provided with an escape valve arrangement M^0 controlled by the weighted valve m^0, whose weight m' is so set that the pressure in the melting chamber shall never become high enough to counterbalance the water seal contained in the chambers E and E′; otherwise the steam from the melting chamber would blow out part of the water in the chambers E and E′, and might permit the influx of air into the melting chamber, which should at all times be kept as free from free oxygen as practicable.

The furnace chamber D may be provided with one or more doors or other openings D′ carrying suitable dampers *d*′.

The chain of buckets, if desired, may run continuously through the apparatus at any desired or preferred rate of speed; but in order to provide for the filling of the buckets *seriatim* from the hopper, to provide for the submersion of the material for a sufficient length of time in the immersion bath, and to provide for the heating of the material for a sufficient length of time in the melting chamber, I have arranged mechanism for imparting a step by step motion to certain of these parts, as will be hereinafter referred to.

Referring to Figs. 1 and 1^a, P represents a pulley driven by any suitable source of power (instead of a pulley any suitable driving mechanism may be used). This pulley is fast on the shaft P′ carrying the worm P^2, engaging in the gear wheel R mounted on the shaft R′. This shaft carries a cam R^2, engaging one or the other of the arms of the yoke Q, which is pivoted, as at *q*, at one side of the main housing A.

The arm Q′ of this yoke is slotted, as at *q*′ and q^2, to engage the pins *s* and *s*′ connected, respectively, to the rods S and S′, whose outer ends are pivoted, respectively,

to the arms T and T′, each mounted loosely on the corresponding shaft F or F′ and carrying a pawl *t* engaging with a corresponding ratchet wheel *f′* fast on the shaft F or F′, respectively.

It will be seen that the movement of these two rods S and S′ in one direction will cause the pawls *t* to slide over the ratchet wheels *f′*, and a movement in the reverse direction will cause these pawls to push the ratchet wheels around, at the same time turning the drive wheels F^2 and F^3 through a predetermined angle.

By having the cam R^2 operated through one-quarter of a revolution of the wheel R, or during any other predetermined part of said revolution, the whole chain of buckets may be caused to move only for a brief interval, and then may be allowed to rest for a longer interval; and thus a step by step motion may be imparted to the chain of buckets, and this step by step motion may be so arranged that whenever the chain of buckets come to a rest one of the buckets will be under the gate *g* of the hopper G into which the material to be treated is fed.

The opening of this hopper gate may be controlled by hand, if desired, but I have provided an automatic arrangement by which the gate of the hopper may be opened as each bucket is moved *seriatim* beneath the same, and may be closed after the chain of buckets has assumed its onward motion. This automatic control of the hopper gate may be accomplished in any convenient way, as by means of the weighted lever G′ pivoted, as at *g′*, to the side of the hopper and connected by the link g^2 to the bell crank lever g^3, which is engaged by a set collar or stop s^3 on the rod S when the said rod is moved to the left as shown in Fig. 1.

Thus it will be seen that the rotation of the cam R^2 is caused to rock the yoke Q and incidentally to impart a step by step motion to the drive wheels F^2 and F^3, and at the same time will intermittently open the hopper gate *g*, which hopper gate will be automatically closed by the weight g^4 on the arm G′.

The length of the rods S and S′ may be adjusted by means of the turn buckle arrangement s^4.

It will be noted that the material to be treated, being first under ordinary atmospheric temperature, will be carried beneath the water in the immersion bath chamber E, and that the hot slag will be carried beneath the surface of the water in the cooling chamber E′, in which latter chamber the stored up heat in the slag, buckets, and other moving parts will in a large measure be given up to the water contained in the cooling chamber E′.

In order to make use of this heat, which would otherwise be lost, I provide a water circuit comprising the pipe U leading from the upper and hotter part of the water in the cooling chamber E′ to the centrifugal pump U′ driven by a continuation of the worm shaft P′. From this centrifugal pump U′, the hot water is pumped through a pipe U^2 to the top of the immersion bath chamber E, where it heats the incoming chain of buckets with their contents. The cooler water flows by gravity from the chamber E through the opening *v*, and the pipe V, and the opening *v′* into the cooling chamber E′.

Thus the heat stored up in the chain of buckets and their contents, after passing through the melting chamber M, is imparted to the water in the cooling chamber E′ and is returned to the water in the immersion bath chamber E, and therefore the buckets with their contents will be comparatively hot when they enter the melting chamber M, after passing from the immersion bath; and it will require only a very small increase of temperature to raise the contents of these buckets to a sufficiently high temperature to melt the sulfur out of the material being treated.

Thus there is a great efficiency in the apparatus, both as regards the saving of heat units and also as regards the time required to melt the sulfur out of the material and dump the slag at the delivery end of the apparatus.

Having thus described the details of the apparatus, the mode of operation may be more fully understood, which is as follows:—

The mineral material comprising the sulfur with its gangue, sometimes known as "sulfur ore", is placed in a more or less broken up or finely divided form in the hopper G, the fire is started in the furnace and the shaft P′ is set in rotation. As the worm P^2 rotates it will cause the worm wheel R to rotate the cam R^2, which will intermittently rock the yoke Q and will intermittently vibrate the rods S and S′. These rods will impart, through the arms T and pawls *t* and ratchet wheels *f′*, a step by step motion to the drive wheels F^2 and F^3, which will cause the buckets to pass *seriatim* beneath the hopper gate *g*.

The hopper gate may be controlled by hand if desired, or it may be automatically operated by means of the bell crank lever g^3 and the stop s^3 hereinbefore described.

After each bucket is filled, the hopper gate will automatically close, and when the cam R^2 is rotated through the predetermined angle the chain of buckets will stop, and the various buckets with their contents will remain either immersed in the immersion bath chamber E, or in the melting chamber M, or in the cooling chamber E′.

After the cam R^2 is rotated through the

further predetermined angle it will again rock the yoke Q and the chain of buckets will be moved forward another step. The slag will be automatically dumped out at the end of the apparatus, while the fresh material to be treated will be supplied at the receiving end of the apparatus.

The melted sulfur will be drawn off in a commercially pure condition through the opening *m*.

The heat stored up in the chain of buckets and their contents, while passing through the melting chamber, will be delivered to the water in the cooling chamber and will be returned by the pump U′ to the immersion bath, thus heating up the incoming material as it is fed to the melting chamber, so that a comparatively small amount of additional heat will be required to vaporize the water adhering to the wet material and convert it into steam, and raise the temperature of this steam to a temperature high enough to melt the sulfur contained in the material being treated.

Before the pressure of the steam becomes high enough to blow out the water seals of the chambers E and E′, the safety valve m^0 is lifted and the pressure of the steam is released.

By having the melting chamber surrounded by the furnace chamber, the steam in the melting chamber M may be superheated, and the requisite temperature of about 240° F. may be secured in that chamber without there being any excessive pressure of the steam generated.

It will be noted that incident to the operation of the apparatus the air contained in the material to be treated will practically be all expelled, as this material dips beneath the level of the surface of the water in the immersion bath chamber E, and when the wet material reaches the melting chamber M it will be practically free from air and incidentally practically free from free oxygen.

As the water in this material is converted into steam in the melting chamber, it will so dilute any traces of air, and incidentally all free oxygen remaining in the wet material when it enters said melting chamber, that the material will be inclosed in a mass of steam and aqueous vapor practically free from free oxygen, and therefore there will be absolutely no danger of the sulfur igniting, however high, within limits, the temperature of the surrounding gas may be raised.

It will be noted that although there is a step by step motion imparted to the chain of buckets, the operation of the entire apparatus is practically continuous, and is or may be made automatic; the only attendants required being those to fill the hopper, to carry away the dump, and to start and stop the engine when desired.

Thus it will be seen that I effect great economy in handling the materials to be treated, as also in applying to a useful purpose the heat units stored up in the slag and in the chain of buckets after passing through the melting chamber, which heat units would ordinarily be wasted.

While the process is a continuous one at the beginning of operations, or whenever starting up for a new run, it will be evident that the melting chamber M will contain an objectionable quantity of either air from the exterior atmosphere, or of water from the tanks E and E′ sucked in by the vacuum created in said chamber M, when the steam therein condenses, as when the heat is turned off for any material length of time.

To get rid of the imprisoned air, it will be sufficient to temporarily weight the safety valve m^0 at the beginning of the run until the steam accumulating in the top of the chamber M will press the heavier air down until it depresses the water seal far enough to allow the imprisoned air to escape upward beyond the outer edges of the hoods L and L′, leaving the upper portion of the chamber M filled with steam. Then the weight may be re-adjusted on the safety valve m^0, to give such pressure only to the steam as may not impair the water seal for the chamber M, whereby any air is excluded except the minute quantity entrained in the water and the immersed material, which is so small as to be negligible.

If the melting chamber M be filled or partly filled with water, sucked up therein when the apparatus is allowed to cool, the major portion of this water may be drawn off through the pipe M^3, or through any suitable drain pipe provided for that purpose, or it may be evaporated and converted into steam by heat from the furnace chamber. Thus, in case of excess of water in the melting chamber at the beginning of operations, no special attention to the safety valve m^0 is required.

It will be obvious that the air originally imprisoned in the heating chamber may be driven off with the steam generated therein, which may be accomplished by leaving the safety valve open at the beginning of operations; or if desired the heating chamber may be filled in the beginning of operations with some inert gas, such as nitrogen, and the safety valve may thereafter be kept closed except when the pressure exceeds the predetermined limit.

It will be obvious that various modifications might be made in the herein described apparatus, and in the construction, combination and arrangement of parts which could be used without departing from the spirit of my invention, and I do not mean to limit my invention to such details except as particularly pointed out in the claims.

BEST AVAILABLE COPY

Having thus described my invention what I claim and desire to secure by Letters Patent of the United States is:—

1. The continuous method of separating native sulfur from its gangue, which consists in submerging the material to be treated in water, then carrying the wet material through a heated and water sealed melting chamber filled with steam, and draining off the melted sulfur from said chamber.

2. The continuous method of separating native sulfur from its gangue, which consists in submerging the material to be treated in hot water, then carrying the wet material through a heated and water sealed melting chamber filled with steam carrying away the slag, and draining off the melted sulfur from said chamber.

3. The continuous method of separating sulfur from its gangue, which consists in submerging the material to be treated in water, then carrying the wet material through a heated and water sealed melting chamber normally filled with steam evaporated from the preceding similar wet material carried into said chamber, and draining off the melted sulfur from said chamber.

4. The continuous method of separating sulfur from its gangue, which consists in submerging the material to be treated in an immersion bath of water to drive off the air and wet the same, then carrying the wet material through a heated and water sealed melting chamber normally filled with steam evaporated from the preceding similar wet material carried into said chamber, then draining off the melted sulfur from said chamber, carrying the heated slag through a cooling bath of water, and conveying the heated water from the cooling bath to the immersion bath, whereby the water is used to heat up the incoming material with heat carried off by the waste products.

5. The continuous method of separating sulfur from its gangue, which consists in submerging the material to be treated in an immersion bath of water to drive off the air and wet the same, then carrying the wet material through a closed heated melting chamber, then draining off the melted sulfur from said chamber, carrying the heated slag through a cooling bath of water, and conveying the heated water from the cooling bath to the immersion bath, whereby the water is used to heat up the incoming material with heat carried off by the waste products.

6. The continuous method of separating native sulfur from its gangue, which consists in submerging the material to be treated in water, then carrying the wet material through a heated melting chamber having its ends protected against the admission of air, thereby converting the water contained therein into steam with the exclusion of air, and draining off the melted sulfur from said chamber.

7. The continuous method of separating native sulfur from its gangue, which consists in submerging the material to be treated in hot water, then carrying off the wet material through a heated and water sealed melting chamber having its ends protected against the admission of air, thereby converting the water contained therein into steam with the exclusion of air, carrying away the slag, and draining off the melted sulfur from said chamber.

8. The continuous method of separating sulfur from its gangue, which consists in submerging the material to be treated in water, then carrying the wet material through a heated and water sealed melting chamber normally filled with steam evaporated from the preceding similar wet material previously carried into said chamber, carrying away the slag, and draining off the melted sulfur from said chamber.

9. Apparatus for separating sulfur from its gangue, comprising an open ended melting chamber provided with a water seal at each end thereof, and a steam space above said water seals, means for heating said chamber, means for carrying off the melted sulfur from said chamber, and means for moving the sulfur bearing material down through said water seals and carrying it through said steam space substantially as described.

10. Apparatus for separating sulfur from its gangue, comprising an open ended melting chamber provided with a water seal at each end thereof, and a steam space above said water seals, means for heating said chamber, means for carrying the melted sulfur from said chamber, an endless chain, and perforated buckets carried by said chain for moving the sulfur bearing material down through said water seals and carrying it through said steam space, substantially as described.

11. Apparatus for separating sulfur from its gangue, comprising an open ended melting chamber provided with a water seal at each end thereof, and a steam space above said water seals, means for heating said chamber, means for carrying the melted sulfur from said chamber, an endless chain, and perforated buckets carried by said chain for moving the sulfur bearing material down through said water seals and carrying it through said steam space, with guide plates for directing said endless chain down through said water seals, substantially as described.

12. Apparatus for separating sulfur from its gangue, comprising an open ended melting chamber provided with a water seal at each end thereof, and a steam space above said water seals, means for heating said

chamber, means for carrying the melted sulfur from said chamber, an endless chain, and perforated buckets carried by said chain for moving the sulfur bearing material down through said water seals and carrying it through said steam space, with means for imparting a step by step motion to said endless chain, substantially as and for the purpose described.

13. Apparatus for separating sulfur from its gangue, comprising an open ended melting chamber provided with a water seal at each end thereof, and a steam space above said water seals, means for heating said chamber, means for carrying the melted sulfur from said chamber, an endless chain, and perforated buckets carried by said chain for moving the sulfur bearing material down through said water seals and carrying it through said steam space, with guide plates for directing said endless chain down through said water seals, and with means for imparting a step by step motion to said endless chain, substantially as and for the purpose described.

14. Apparatus for separating sulfur from its gangue, comprising an open ended melting chamber provided with a water seal at each end thereof, and a steam space above said water seals, means for heating said chamber, means for carrying the melted sulfur from said chamber, an endless chain, and perforated buckets carried by said chain for moving the sulfur bearing material down through said water seals and carrying it through said steam space, a hopper adapted to receive the material to be treated, and automatic means for feeding the material from said hopper to said buckets *seriatim*, substantially as described.

15. Apparatus for separating sulfur from its gangue, comprising an open ended melting chamber provided with a water seal at each end thereof, and a steam space above said water seals, means for heating said chamber, means for carrying the melted sulfur from said chamber, an endless chain, perforated buckets carried by said chain for moving the sulfur bearing material down through said water seals and carrying it through said steam space, with guide plates for directing said endless chain down through said water seals, a hopper adapted to receive the material to be treated, and automatic means for feeding the material from said hopper to said buckets *seriatim*, substantially as described.

16. Apparatus for separating sulfur from its gangue, comprising an open ended melting chamber provided with a water seal at each end thereof, and a steam space above said water seals, means for heating said chamber, means for carrying the melted sulfur from said chamber, an endless chain, perforated buckets carried by said chain for moving the sulfur bearing material down through said water seals and carrying it through said steam space, with means for imparting a step by step motion to said endless chain, a hopper adapted to receive the material to be treated, and automatic means for feeding the material from said hopper to said buckets *seriatim*, substantially as described.

17. Apparatus for separating sulfur from its gangue, comprising an open ended melting chamber provided with a water seal at each end thereof, and a steam space above said water seals, means for heating said chamber, an endless chain, perforated buckets carried by said chain for moving the sulfur bearing material down through said water seals and carrying it through said steam space, with guide plates for directing said endless chain down through said water seals, means for imparting a step by step motion to said endless chain, a hopper adapted to receive the material to be treated, and automatic means for feeding the material from said hopper to said buckets *seriatim*, substantially as described.

18. Apparatus for separating sulfur from its gangue, comprising a furnace chamber, an open ended melting chamber inclosed in said furnace chamber and provided with a water seal at each end thereof, and a steam space above said water seal, means for carrying off the melted sulfur from said melting chamber, and means for moving the sulfur bearing material down through said water seals and carrying it through said steam space, substantially as described.

19. Apparatus for separating sulfur from its gangue, comprising a furnace chamber, an open ended melting chamber inclosed in said furnace chamber and provided with a water seal at each end thereof, and a steam space above said water seal, means for carrying off the melted sulfur from said melting chamber, an endless chain, and perforated buckets carried by said chain for moving the sulfur bearing material down through said water seals and carrying it through said steam space, substantially as described.

20. Apparatus for separating sulfur from its gangue, comprising a furnace chamber, an open ended melting chamber inclosed in said furnace chamber and provided with a water seal at each end thereof, and a steam space above said water seal, means for carrying off the melted sulfur from said melting chamber, an endless chain, and perforated buckets carried by said chain for moving the sulfur bearing material down through said water seals and carrying it through said steam space, with guide plates for directing said endless chain down through said water seals, substantially as described.

21. Apparatus for separating sulfur from its gangue, comprising a furnace chamber, an open ended melting chamber inclosed in said furnace chamber and provided with a water seal at each end thereof, and a steam space above said water seal, means for carrying off the melted sulfur from said melting chamber, an endless chain, and perforated buckets carried by said chain for moving the sulfur bearing material down through said water seals and carrying it through said steam space, with means for imparting a step by step motion to said endless chain, substantially as and for the purpose described.

22. Apparatus for separating sulfur from its gangue, comprising a furnace chamber, an open ended melting chamber inclosed in said furnace chamber and provided with a water seal at each end thereof, and a steam space above said water seal, means for carrying off the melted sulfur from said melting chamber, an endless chain, and perforated buckets carried by said chain for moving the sulfur bearing material down through said water seals and carrying it through said steam space, with guide plates for directing said endless chain down through said water seals, and with means for imparting a step by step motion to said endless chain, substantially as and for the purpose described.

23. Apparatus for separating sulfur from its gangue, comprising a melting chamber open at both ends, with means for heating said chamber, a water chamber at each end of said melting chamber, said water chambers being adapted to hold water at a level below the upper portion of the melting chamber, hoods projecting down from the open ends of said melting chamber below the surface of the water in said water chambers, means for conveying the material to be treated into the water in the first water chamber and beneath the first hood, then up into the melting chamber, and down again beneath the second hood, then through the water in the second water chamber, and finally discharging same, substantially as described.

24. Apparatus for separating sulfur from its gangue, comprising a melting chamber open at both ends, with means for heating said chamber, a water chamber at each end of said melting chamber, said water chambers being adapted to hold water at a level below the upper portion of the melting chamber, hoods projecting down from the open ends of said melting chamber below the surface of the water in said water chambers, means for conveying the material to be treated into the water in the first water chamber and beneath the first hood, then up into the melting chamber, and down again beneath the second hood, then through the water in the second water chamber, and finally discharging same, said means comprising an endless chain, perforated buckets carried by said chain, and curved guides for said chain mounted in said melting chamber and said water chambers, substantially as described.

25. Apparatus for separating sulfur from its gangue, comprising a melting chamber open at both ends, with means for heating said chamber, a water chamber at each end of said melting chamber, said water chambers being adapted to hold water at a level below the upper portion of the melting chamber, hoods projecting down from the open ends of said melting chamber below the surface of the water in said water chambers, means for causing the water to circulate between said water chambers, and means for conveying the material to be treated into the water in the first water chamber and beneath the first hood, then up into the melting chamber, and down again beneath the second hood, then through the water in the second water chamber, and finally discharging same, substantially as described.

26. Apparatus for separating sulfur from its gangue, comprising a melting chamber open at both ends, with means for heating said chamber, a water chamber at each end of said melting chamber, said water chambers being adapted to hold water at a level below the upper portion of the melting chamber, hoods projecting down from the open ends of said melting chamber below the surface of the water in said water chambers, means for causing the water to circulate between said water chambers, and means for conveying the material to be treated into the water in the first water chamber and beneath the first hood, then up into the melting chamber, and down again beneath the second hood, then through the water in the second water chamber, and finally discharging same, said means comprising an endless chain, buckets carried by said chain, and curved guides for said chain mounted in said melting chamber and said water chambers, substantially as described.

27. Apparatus for separating sulfur from its gangue, comprising a melting chamber open at both ends, with means for heating said chamber, a water chamber at each end of said melting chamber, said water chambers being adapted to hold water at a level below the upper portion of the melting chamber, hoods projecting down from the open ends of said melting chamber below the surface of the water in said water chambers, means for conveying the hot water from the top of the second water chamber to the top of the first water chamber, and for conveying the cooler water from the bottom of said first water chamber to the bot-

tom of the second, and means for conveying the material to be treated into the water in the first water chamber and beneath the first hood, then up into the melting chamber, and down again beneath the second hood, then through the water in the second water chamber, and finally discharging same, substantially as described.

28. Apparatus for separating sulfur from its gangue, comprising a melting chamber open at both ends, with means for heating said chamber, a water chamber at each end of said melting chamber, said water chambers being adapted to hold water at a level below the upper portion of the melting chamber, hoods projecting down from the open ends of said melting chamber below the surface of the water in said water chambers, means for conveying the hot water from the top of the second water chamber to the top of the first water chamber, and for conveying the cooler water from the bottom of said first water chamber to the bottom of the second, and means for conveying the material to be treated into the water in the first water chamber and beneath the first hood, then up into the melting chamber, and down again beneath the second hood, then through the water in the second water chamber, and finally discharging same, said means comprising an endless chain, perforated buckets carried by said chain, and curved guides for said chain mounted in said melting chamber and said water chambers, substantially as described.

29. Apparatus for separating sulfur from its gangue, comprising a melting chamber open at both ends, with means for heating said chamber, a water chamber at each end of said melting chamber, said water chambers being adapted to hold water at a level below the upper portion of the melting chamber, hoods projecting down from the open ends of said melting chamber below the surface of the water in said water chambers, means for conveying the material to be treated into the water in the first water chamber and beneath the first hood, then up into the melting chamber, and down again beneath the second hood, then through the water in the second water chamber, and finally discharging same, said means comprising an endless chain, perforated buckets carried by said chain, and curved guides for said chain mounted in said melting chamber and said water chambers, with means for imparting a step by step motion to said endless chain, and automatic means for filling the buckets at the receiving end of the apparatus, substantially as described.

30. Apparatus for separating sulfur from its gangue, comprising a melting chamber open at both ends, with means for heating said chamber, a water chamber at each end of said melting chamber, said water chambers being adapted to hold water at a level below the upper portion of the melting chamber, hoods projecting down from the open ends of said melting chamber below the surface of the water in said water chambers, means for causing the water to circulate between said water chambers, and means for conveying the material to be treated into the water in the first water chamber and beneath the first hood, then up into the melting chamber, and down again beneath the second hood, then through the water in the second water chamber, and finally discharging same, said means comprising an endless chain, buckets carried by said chain, and curved guides for said chain mounted in said melting chamber and said water chambers, with means for imparting a step by step motion to said endless chain, and automatic means for filling the buckets at the receiving end of the apparatus, substantially as described.

31. Apparatus for separating sulfur from its gangue, comprising a melting chamber open at both ends, with means for heating said chamber, a water chamber at each end of said melting chamber, said water chambers being adapted to hold water at a level below the upper portion of the melting chamber, hoods projecting down from the open ends of said melting chamber below the surface of the water in said water chambers, means for conveying the hot water from the top of the second water chamber to the top of the first water chamber, and for conveying the cooler water from the bottom of said first water chamber to the bottom of the second, and means for conveying the material to be treated into the water in the first water chamber and beneath the first hood, then up into the melting chamber, and down again beneath the second hood, then through the water in the second water chamber, and finally discharging same, said means comprising an endless chain, perforated buckets carried by said chain, and curved guides for said chain mounted in said melting chamber and said water chambers, with means for imparting a step by step motion to said endless chain, and automatic means for filling the buckets at the receiving end of the apparatus, substantially as described.

In testimony whereof I affix my signature.

WILLIAM D. HUFF.