(No Model.) 3 Sheets—Sheet 1.

H. BRADFORD.

ORE SEPARATING MACHINE.

No. 504,665. Patented Sept. 5, 1893.

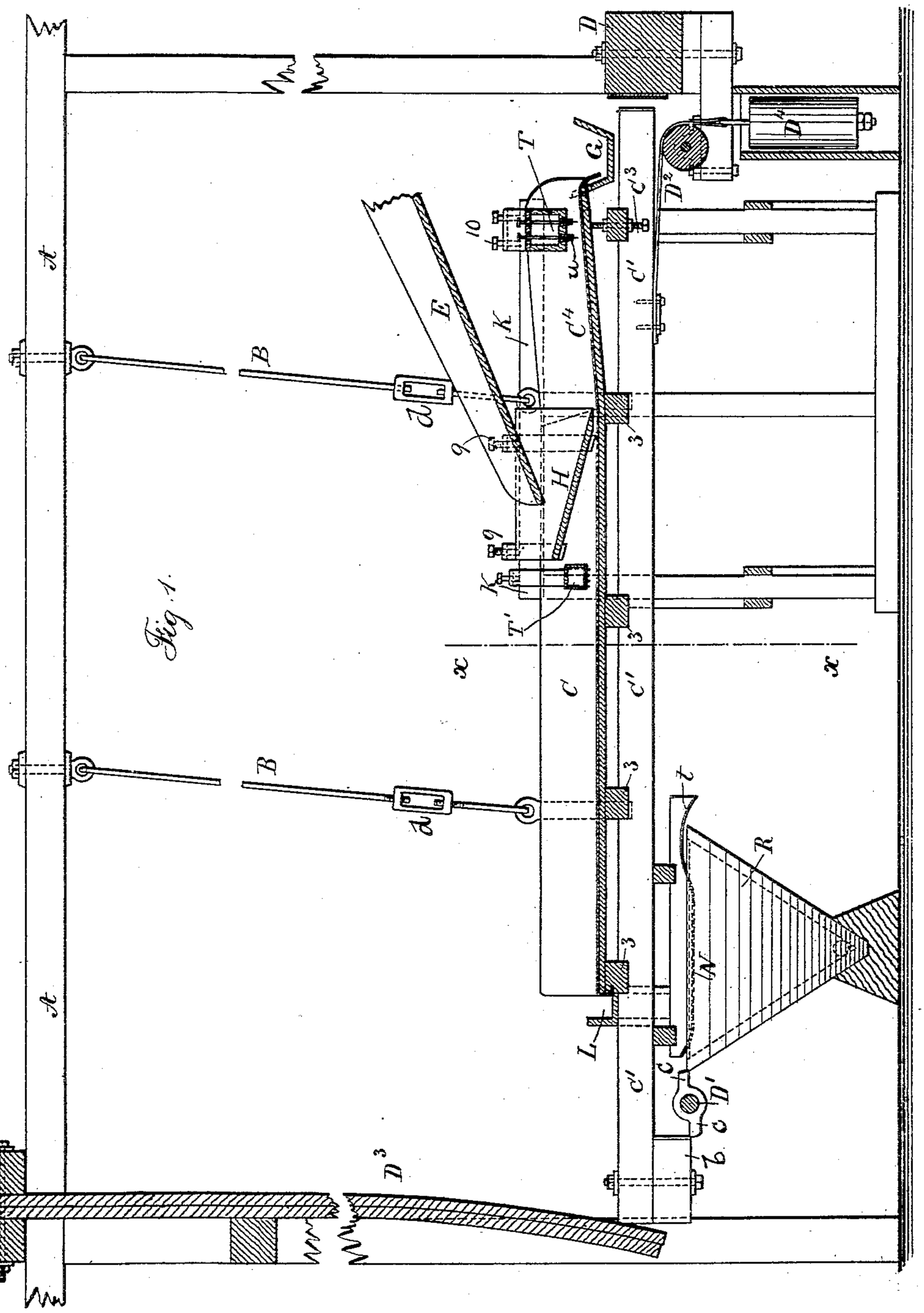

Fig. 1.

Witnesses:
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(No Model.)

3 Sheets—Sheet 2.

H. BRADFORD.

ORE SEPARATING MACHINE.

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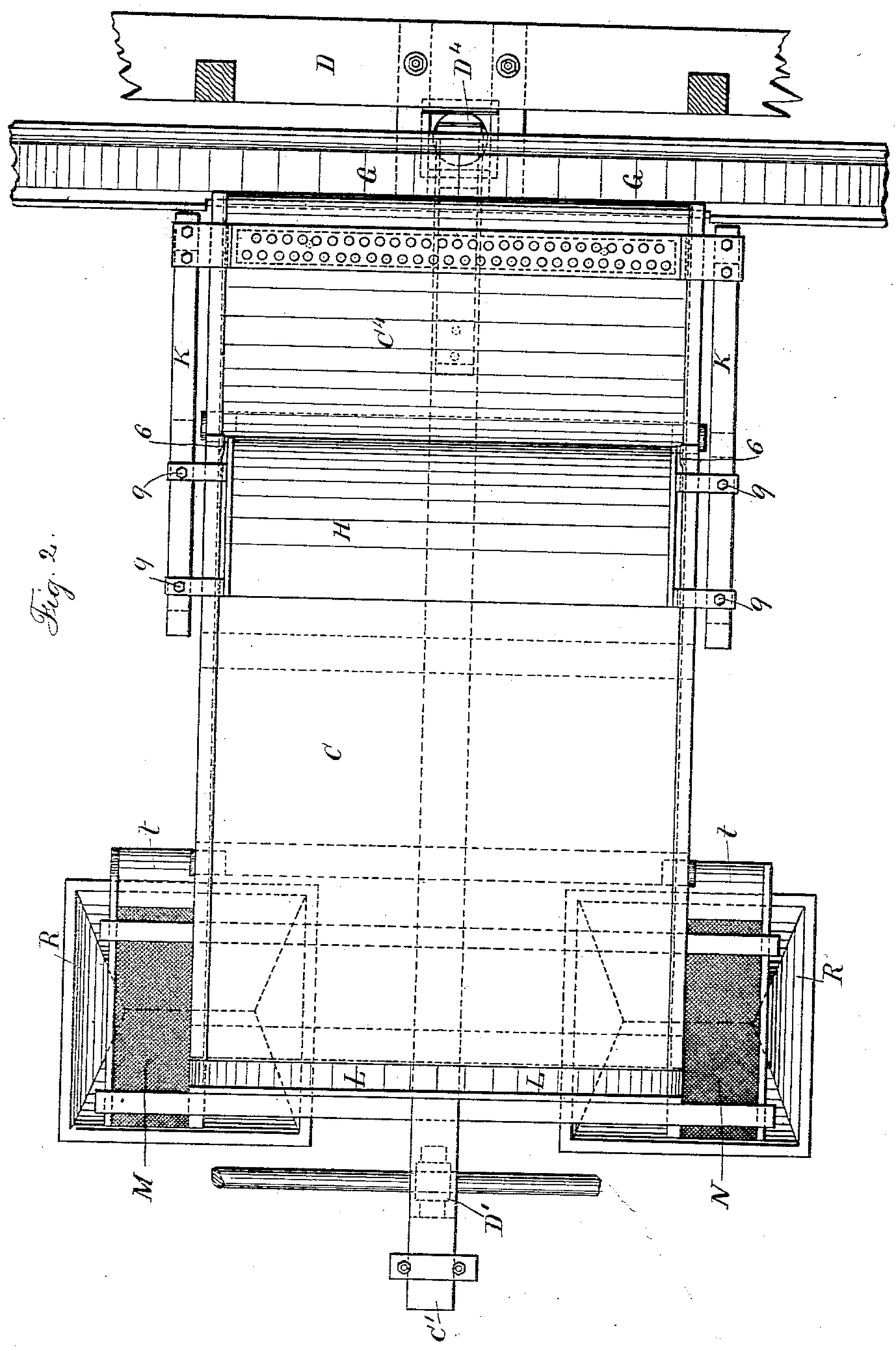

Fig. 2.

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(No Model.) 3 Sheets—Sheet 3.

H. BRADFORD.

ORE SEPARATING MACHINE.

No. 504,665. Patented Sept. 5, 1893.

Fig. 3.

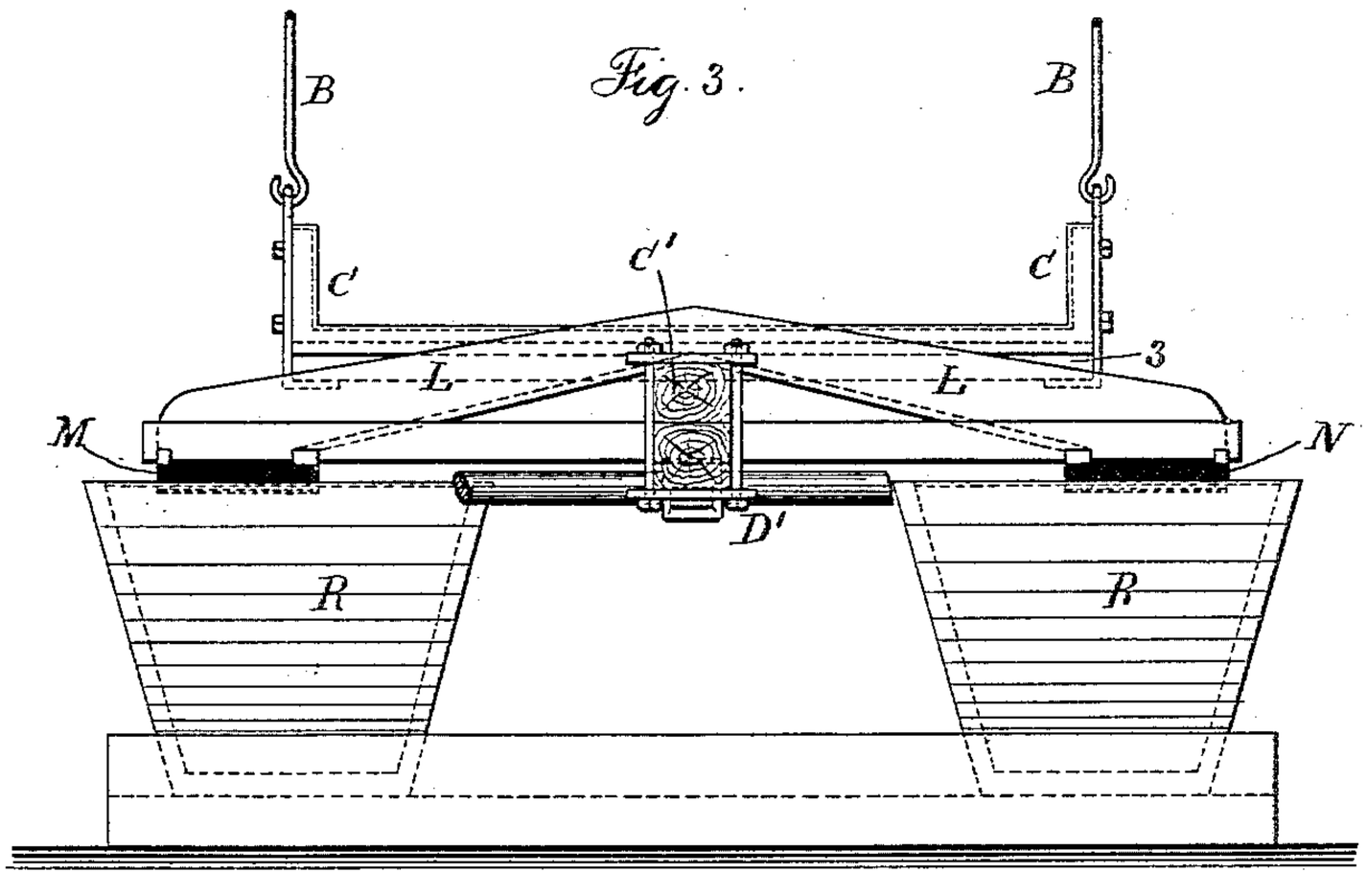


Fig. 4

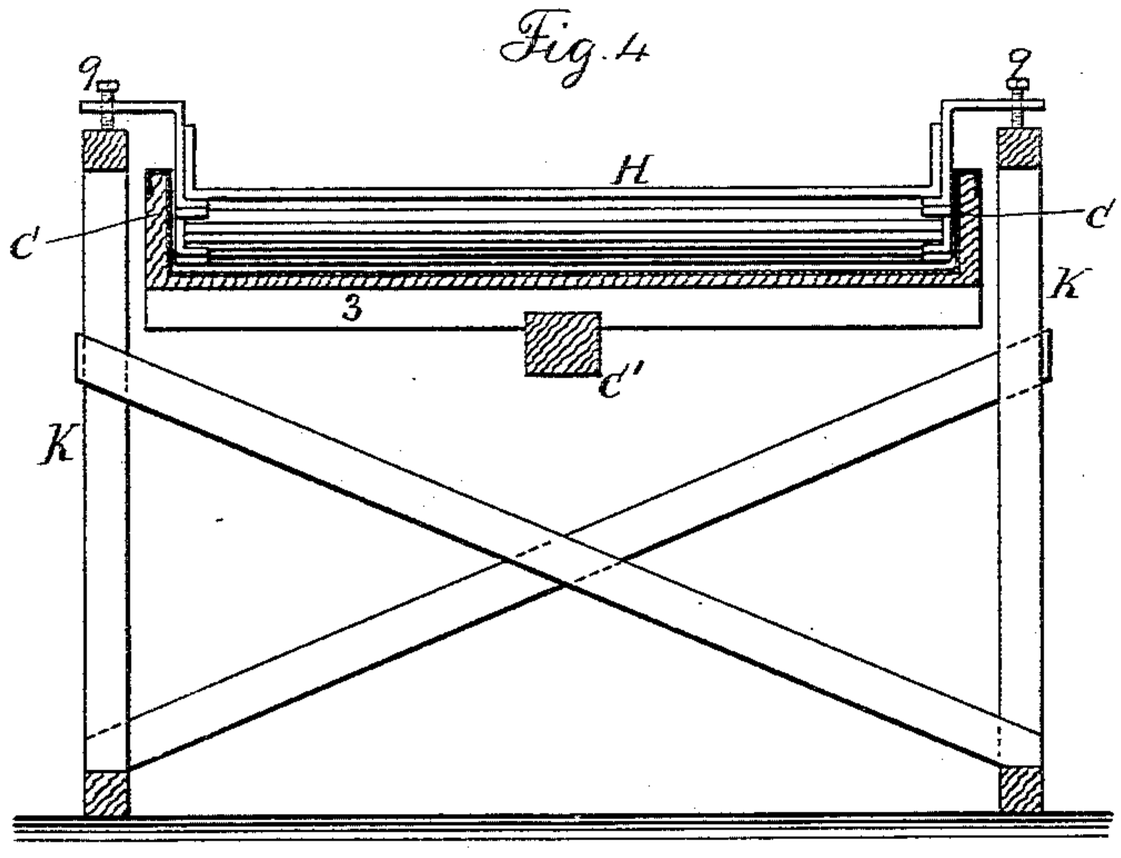
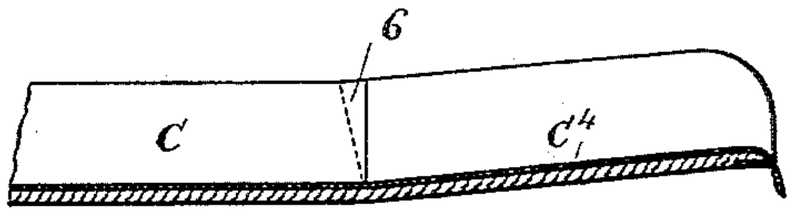


Fig. 5.



Witnesses:
J. Staib
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Inventor:
Hezekiah Bradford
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UNITED STATES PATENT OFFICE.

HEZEKIAH BRADFORD, OF PHILADELPHIA, PENNSYLVANIA, ASSIGNOR TO SAMUEL E. GRISCOM, OF SAME PLACE.

ORE-SEPARATING MACHINE.

SPECIFICATION forming part of Letters Patent No. 504,665, dated September 5, 1893.

Application filed January 24, 1887. Serial No. 225,278. (No model.)

To all whom it may concern:

Be it known that I, HEZEKIAH BRADFORD, a citizen of the United States, residing at Philadelphia, in the county of Philadelphia and State of Pennsylvania, have invented certain new and useful Improvements in Ore-Separating Machines; and I do hereby declare that the following is a full, clear, and exact description of the same.

The aim of my invention is to provide a machine in which the separation of the ore and gangue may be carried on unceasingly and automatically, and in which there shall be under all conditions a rapid and perfect separation.

My machine belongs to the class in which the crude pulverized ore and water are delivered upon a reciprocating bumping table, and consists in various improvements hereinafter pointed out, whereby the evils incident to the operation of prior machines are overcome. In all machines of this class the aim is to cause the lighter matters to rise above the metal and remain in suspension in the water, so as to be floated over the tail of the machine, thereby, while the metal lying beneath, on the surface of the table, is carried by its momentum, and as a result of the bumping action, in the opposite direction over the head of the table. Now in order to secure this action in an efficient manner it is necessary, first, that there shall be a considerable depth of water on the table; second, that the water shall flow over the table with moderate speed, to the end that it may not sweep the ore over the tail with the gangue; third, that there shall be a constant vertical vibration of the table in order to separate the light and heavy matters and insure the constant suspension of the former in the water. Now in order to secure and maintain all these conditions I make use of a flat, open ended reciprocating table the body portion of which, [on which the separation is effected,] is horizontal or practically so instead of being strongly inclined downward toward the tail as usual. I adopt the horizontal position of the table in order mainly to lessen the velocity at which the water flows thereover and to enable me to maintain thereon a deeper body of water than is usual in this class of machines. The reduction in the velocity of the water enables me to carry away the light suspended matters toward the tail without danger of carrying therewith any portion of the ore. The increase in the depth of the water, admits of the light matters being suspended entirely above and clear of the ore which remains on the surface of the table. The increase in depth also admits of the water being given a more violent ebullition, as hereinafter described, in order to effect the primary separation of the light and heavy matters.

Hitherto it has been the practice to subject the table to a bumping action in order to cause the ore to advance step by step over its surface toward the head through and beneath the overlying gangue floating toward the tail. It was found, however, that the vertical separation of the ore and gangue was imperfect, and that to a certain extent they remained intermingled so that a portion of the ore would pass over the tail with the gangue. I have discovered that this was due in part to the shallowness and high velocity of the water, but largely to the fact that the bumping action tended to carry the material horizontally only, and to retard or prevent the vertical separation and suspension of the light matters. I therefore construct my machine with special reference to the production and maintenance of a rapid vertical vibration or tremor of the table, in addition to its horizontal reciprocation. This tremulous vertical movement of the table results in disintegrating the crude ore, loosening and throwing up the light matters so that they will be suspended in the water, and, in producing a bubbling, rippling, or effervescing movement of the water which is peculiarly effective in maintaining the light matters in suspension and causing their clean and perfect separation from the heavy ore as the two travel horizontally in opposite directions. This bubbling movement of the water is peculiar to my machine, and in appearance is widely different from that of water flowing over the ordinary strongly inclined tables which have little or no vertical vibration. I secure this peculiar action of the water by bumping my horizontal table at its head, after the manner of a battering ram, endwise against a solid

resistance or anvil, the effect of which is not only to carry the heavy ore over its surface toward the head as usual, but also to set up throughout the entire surface the vibratory or tremulous motion above referred to. In order to secure this tremulous motion in the most effective manner and to insure the distribution of the motion uniformly throughout the table, I secure centrally, longitudinally and rigidly to the table throughout its length a heavy beam or timber the end of which, at the head of the table, abuts against the rigid stop or anvil, so that the blow which suddenly arrests the end motion of the table, that the ore may continue its advance toward the head, also sets up in the bumping beam an intense tremulous motion which is communicated vertically to the table. In consequence of the table being suspended there is nothing to interfere with the tremulous movement aforesaid, and the whole table is equally influenced; the inertia of the links or suspending devices under the sudden stoppage tending to curve the suspending devices and lift the table, thereby promoting this vibration of the table. The bumping actions occur with such frequency (from eighty to one hundred and fifteen times per minute) that the tremor of the table is unceasing, and the ebullition of the water continuous, so that the settling and accumulation of the ore on the table technically known as "packing" are impossible. The result is that the machine is enabled to act uniformly, without interruption, and without requiring attention.

In practice I find that the tremulous or vibratory motion peculiar to my table is obtainable only by the shock or impact directly against its end at the head, so that the entire mass is in motion directly toward the stop or abutment at the instant of impact. Unless such is the case the requisite tremor is not produced.

I am aware that tables have been provided on the under side near the head with a block or shoulder to bump against a stop, but the block thus applied was not intended to and in practice does not set up any appreciable vertical vibration of the table.

In practice it is found that if the body of the table is steeply inclined a portion of the ore will inevitably find its way over the tail. If on the other hand the table be horizontal from end to end, and the flow of the water slow, there is in some ores a tendency for the gangue and water to work over the head to a limited extent. I therefore give the head of my table, which is left open for the free discharge of the ore, a slight upward inclination in relation to the remaining portion, so that although the ore by reason of its greater specific gravity and inertia will work slowly over this raised end, the water and lighter matters are prevented from so doing. This inclined end of the table is made adjustable, so that its angle may be varied according to the nature of the material under treatment. The crude ore and main supply of water with which it is mingled are delivered on the table midway of its length, and their vertical separation or stratification is effected almost immediately, so that the light and heavy matters commence to travel in opposite directions. As this horizontal separation is effected mainly at the middle of the table, the ends are lightly loaded, and the separation there completed in the deep, bubbling, slowly flowing water in a very efficient manner, almost every particle of the ore being delivered at the head without the presence of any impurity whatever.

In practice I find it advantageous to provide the machine with means for showering a limited quantity of water gently upon the inclined head across its entire width to wash back any light matters which may find their way thereto. I also find it advantageous to provide for a third supply of water to the table near the point of ore supply, between such point and the tail. This supply aids in securing the effervescing effect, and in keeping the gangue loose that the particles of ore may settle therethrough by reason of their greater specific gravity. In order to urge the table endwise to cause the bumping action I may use a weight or spring or both; but the weight, acting through a strap is strongly preferred for the reason that it descends with accelerating speed, so that although made of a size which may be readily lifted it imparts to the table a slow initial movement but a velocity and sharpness of impact not attainable by a spring of practicable size.

Figure 1, is a longitudinal vertical section of a machine containing my improvements; Fig. 2, a top plan view of the same; Fig. 3, an end elevation of the tail of the table and attendant parts; Fig. 4, a vertical cross section on the line 4—4 of Fig. 1; Fig. 5, a longitudinal vertical section through the head of the table.

Within the frame A of the machine, suspended by rods B, B, so as to swing thereon, a flat table C is securely mounted upon cross pieces 3 which latter are firmly fastened to a central longitudinal bumping beam C′ which projects at both ends beyond the table, in line or parallel with the movement of the table C and the travel of the ore, tailings, and water on the table, and in line with the fixed and rigid bumper block D. The rods B, B, are preferably inclined, as shown in Fig. 1, so that the bumping beam C′ and the table C shall gravitate toward the bumper block D, which is secured to the frame A. In case a more vigorous blow is desired against the bumper block D, then to the gravity of the table may be added the pull of a weight D^4, attached to the bumping beam C′, by a strap which passes over a pulley D^2, and in addition to this, the spring D^3, acting against the opposite end of the beam C′, may be used. I prefer, however, only the action of the gravity of the table, and the weight D^4, as they both cause the beam to advance with an accelerating speed

against the bumper block D, while a spring on the contrary acts with diminishing effect; in other words, a spring strong enough to give the necessary sharp, vigorous blow without the help of the weight or the gravity of the table, would move the table so fast at the beginning of the stroke or impulse as to cause the table to move from beneath the ore on the table surface, so that the ore would, before its inertia were overcome, be relatively and temporarily moved toward the tailings end of the table instead of toward the head as demanded. The movement of the table from the bumper block D, is effected by the action of lugs or cams, preferably the former, fixed upon the revolving shaft D′ against the block *b* which block is secured firmly to the beam C′ at its lower end. The table C is made as light as is consistent with durability and is firmly secured to bumping beam C′. It presents a flat uninterrupted surface horizontal throughout the greater portion of its length, but can be inclined by means of the screw yokes of the suspension rods B, B to a limited extent.

The arrangement of the table to present a horizontal or practically horizontal surface on which to effect the separation is a marked and important feature of my construction. It enables me to reduce the velocity of the water flowing thereover, to maintain a deeper body of flowing water on the table without unduly increasing the amount consumed, and to effect a more perfect separation and suspension of the gangue.

In all prior machines with bumping tables of which I am aware the inclination of the table was considered an important and necessary feature, and in no case within my knowledge was the table given an inclination of less than one in thirty-six. For my purposes the inclination is not desirable. I prefer that the surface shall be truly horizontal, but a merely colorable inclination, an inclination less than one in thirty-six, or so slight as to be imperceptible in its effects, is not to be considered as falling outside of my invention. The end C^4 of the table, commonly known as the head, is preferably inclined upward in the direction of the ore delivery, that is to say, toward the bumping end. I prefer to so construct this part of the table that by means of an adjusting screw or other suitable device, the angle of the head can be changed in relation to the body portion, to suit the different specific gravities or grades of the ore being treated, or to different rates of travel, or length of movement of the table. Desirable proportions for the table, are a length of about five feet for the body and thirty inches for the inclined head, and a width throughout, of about three feet in the clear. These dimensions however may be varied. The table may be covered with a sheet metal lining which is extended up and over the side walls of the table, as seen in Figs. 1 and 4 and also over the open ends of the table, so as to prevent water, sand, and slime from getting between the lining and the wooden floor of the table, as that action would raise the lining, and make an uneven surface. At the junction of the horizontal and inclined parts of the table it is preferable to have the metal lining of the side walls lapping, as shown at G in Fig. 5, the over-lap being smoothly soldered. When it is desired to change the angle of the incline, the over-lap of the metal lining can be readily unsoldered and resoldered. It is of great importance that the soldering should be perfectly smooth, where it comes in contact with the ore and water being separated, as any protuberance will prevent a good concentration for some distance around it. The nearly horizontal part of the table, and the elevated ore delivery incline, should each be perfectly smooth planes both lengthwise and crosswise as any unevenness on the surface of the table, will prevent a perfect concentration. The crude pulverized ore to be concentrated, or separated, is delivered, mixed with water, by the chute E, to a stationary inclined feed board H and thence to table C. The feed board H situated within the walls of, and extending across the table C is detachably secured by straps, and by adjustable screws 9 to the stationary frame K so as to be horizontally adjustable thereon, thus allowing of the delivery of the mixed crude pulverized ore and water, at such different points upon the table C as may be desired. By means of the adjustable screws 9 the delivery end of the feed board H may be adjusted so as to deliver the crude ore mixed with water as near the surface of the water on the table as desired, without touching the water, the purpose of this, being to allow the material to be fed gently so as not to plunge with force enough to disturb the ore already resting on the bottom of the table, and for this reason no more water should be mixed with the crude ore than is necessary to properly distribute the ore evenly from the feed board. The crude ore should be distributed on passing over the feed board by any of the ordinary contrivances, so that it can be equally supplied to the table, across its whole width.

Secured to the stationary frame K so as to be horizontally adjustable thereon, and so as to extend across and be a short distance above the surface of the inclined part of the table C^4, is a water trough T, having a perforated bottom through which only a sufficient and second supply of clear water is to be evenly distributed across the entire width of the elevated ore delivery to wash back any particles of gangue that might otherwise pass over the incline with the ore, into trough C. If more water were used at this point than is necessary to wash back the particles of gangue it would also wash back some of the concentrated ore. When the table is properly worked the entire concentration should take place on the nearly horizontal portion of the table, but if any particles of gangue should

be mixed with the ore as it begins to ascend the incline the water from trough T, would wash it back. The water trough T, may be adjusted vertically from and toward the surface of the elevated ore delivery incline by means of set screws 10.

Secured to the frame K so as to be horizontally adjustable is another water trough T′ furnishing the third supply of water reaching across the whole width of the table. The bottom of the trough is perfectly level and is composed of thin sheet metal, pierced with numerous small holes like a grater with the rough side down. These holes deliver clear water, perpendicularly, there being just sufficient water in the trough to cover the bottom, and distribute it as a fine gentle rain upon the water and material on the table. To increase this effect, the trough is placed as near the surface of the water on the table as possible without touching it. There should be no more water in the trough than is necessary to supply equally all the holes with the least possible pressure. The object of this trough is to supply, in addition to the two previously mentioned supplies, extra clear water enough to insure the ebullition and the suspension of the lighter matters and to keep the gangue sufficiently loose to allow the particles of mineral, by reason of their greater specific gravity, to settle quickly down through it, to the bottom of the table, and to carry the gangue out of the way and off the tailings end of the table as soon as the mineral particles have settled to the surface of the table. Meanwhile the mineral particles by reason of their greater specific gravity, are kept directly on the surface of the table and are carried forward by the concussions and their momentum to and over the ore delivery end of the table, into the trough G without being disturbed by the fine streams of water delivered by the trough T′ that penetrate the gangue only, nor disturbed by the loose gangue passing toward and off the tailings end of the table. At the lower end of the table, are suitable gutters as L, L, to deliver the tailings to the screens M, N. These screens are firmly attached to the beam C′ and beneath the table C so as to move with the table. The screens have side walls their entire length and rear end walls, and the delivery ends of the screens are curved over the edge of the vats R, forming delivery chutes, over which the particles too large to pass through the screens are bumped. The bodies of the screens are within the vats R, a little below the top edges, so that the bottom of the screens are slightly below the surface of the water in the vats, the side and rear walls of the screens being sufficient to receive and hold the tailings discharged thereon from the lower end of the table and the screens are moved back and forth with the beam and table, and receive through the medium of beam C′, sharp and vigorous bumps the same as the table receives through the same medium. In the operation, the lugs of the revolving shaft strike sharp vigorous blows against the block on the lower end of the longitudinal bumping beam C′, which is followed by the pushing motion of the lugs which move the bumping beam and table back from the bumper block D. When the striking lug passes the block on the beam C′, the gravitation of the table, the weight D^4, and spring D^3, if the latter is used, move the longitudinal beam C′, and table toward the bumper block D, to strike a sharp, vigorous blow at the end of the beam, the shock of which blow is transmitted through the said beam, and is distributed by the beam and cross pieces 3, equally to every square inch of the surface of said table, causing an equal, longitudinal, oscillating, and a vertical vibrating, tremulous, quivering, jarring motion to the material and water on every portion of said table, which motion causes the water and material to assume an ebullition, and an appearance resembling effervescence, or the gentle boiling of shallow water on a level surface, equally over every portion of the surface of said table, preventing the gangue from subsiding or packing on any part of the table, and keeping it in such loose condition as to allow the particles of ore to settle quickly down through the gangue to the surface of the table, by reason of their greater specific gravity, and the ore is bumped by its momentum forward to and over the elevated ore delivery into the trough G, without being disturbed by the flow of the loose gangue in the other direction to and over the tailings end of the table, into the screens M, N. The shock of the sharp blow of the lugs against the bumping beam C′, as before described, is also conveyed and distributed through the medium of the bumping beam and cross pieces 3, to every part of the table C, and assists in bumping the ore forward over the delivery end of the table and also assists in causing and keeping up the vibrating and jarring motion above described, and in preventing the packing of the ore and tailings on the table. The table may be suspended in many other ways than by rods, but I prefer the suspension by rods as the shaking of the rods helps to keep up the tremulous motion between the blows of the beam and the lugs.

It will be seen that the table has several pieces 3 secured transversely across its bottom and that the bumping beam is fastened firmly to these cross pieces at right angles thereto. These cross pieces 3 reaching entirely across the table, serve a double purpose. First they strengthen the table and, secondly, they connect the bumping beam at various independent points with the table, the bottom of which is made of board placed parallel with the beam, and hence, serve to transmit and distribute equally and vertically throughout the entire length and breadth of the table the force of the shocks imparted to the bumping beam C′, assuring thereby practically equal agitation of the ore and water

over every square inch of the table's working surface.

The apparatus may be operated at the rate of eighty to one hundred and fifteen strokes per minute, the movement of the table being two or three inches; the length of movement. The number of strokes per minute, however, may be greatly varied. In all cases the movement should be as regular as possible.

By different adjustments of the ore delivery incline end, the ragging may be caused to pass over the ore delivery incline with the solid particles of ore, or it may be caused to pass to the tailings end of the table. If the former operation is desired, the incline is lowered to suit the specific gravity of the ragging. Otherwise the incline is raised to allow nothing but particles of solid ore to pass over.

The tailings will always contain some very small particles of ore, too small to settle down through the coarser particles of gangue to the tables, but if the gangue is kept quite loose and the table nearly level, no particles of ore larger than those which will pass through about one hundred and fifty mesh will pass off with the tailings. These particles, with the slime will pass through the meshes of the screens M, N, while the gangue larger than the meshes of the screens, will be bumped over the curved end of the screens. The water in contact with the screens will wash from the coarser parts of the tailings. The adhering slime and fine particles of ore which will pass through the meshes of the screens into the vats R, R, the contents of which, together with the mineral contained in the ragging, may be afterward treated or concentrated. A single screen obviously may extend under the entire width of the table, in place of the two screens at the sides of the table.

I am aware that most of the specific mechanical devices made use of by me have before been employed separately by others. I do not therefore claim either of such parts or devices separately. By my new combinations and arrangements, however, of the devices to which the invention relates, the apparatus is rendered more effective and perfect in its operation. It is designed that there shall not be a constant depth of more than from one third to one-half of an inch of ore and water together on the table, as a greater depth thereof prevents proper concentration of the ore. Properly operated, a table of the dimensions given above will successfully work from ten to fifteen tons of ore a day.

I do not confine myself to the use of one bumping beam in this ore separator, for it is obvious that I can apply two or more extra bumping beams, parallel with the present one, and two or more extra bumping blocks or one wider bumper block, without departing from my invention. In the present improvement the abutment being at one end of the table allows the whole table freely to vibrate from the impact, whereas in cases where the bumping devices have been below the table and between one end and the other, the contact of the bumping devices has tended to lessen the vibration in the middle portion of the table, and in addition to this, the blow tends to lift the tail end of the table and to depress the head end, because the stoppage is below the table instead of in line with the table.

What I claim is—

1. In combination with the central, longitudinal bumping beam, and bumper block directly in line with the front end of the beam, suspending devices and the bumping table having an upwardly inclined ore delivery at the upper end, over which the concentrated ore is automatically, continuously and uninterruptedly delivered, and a reciprocating device substantially as set forth.

2. The combination with the bumping table, whereon the ore is introduced with water, and the feed board, and a second water supply near the concentrated ore delivery to carry back from the ore any refuse material, of a third water supply for promoting the agitation and rapid delivery of such tailings, substantially as set forth.

3. The combination of the bumping beam extending the entire length of the table, and a table fastened to the bumping beam, and having an upward incline in the table toward the ore delivery end, a metallic lining to the table extending up the sides of such table, and an adjusting device for varying the inclination, substantially as specified.

4. The combination of the bumping table having an ore delivery at one end and a tailings delivery at the other end, of a screen connected to the bumping table and receiving the tailings, and a water vat in which such screen is reciprocated, substantially as set forth.

5. An ore separator, comprising a bumping table, having a tailings discharge at one end, and an ore discharge at the other, a block or bumper arranged at the ore delivery end of the frame, and a bumping beam connected to the under part of the table centrally thereof, and extending the whole length of the table, and in line with the block or bumper, in combination with a lateral chute for the tailings, a screen attached to the beam for receiving the discharge from the chute, and provided with an elevated delivery end and a water vat below the screen, substantially as described.

6. The combination with a bumping table ore concentrator to which the ore is delivered with water, of two water troughs substantially as herein shown and described, one of which is set transversely across the table above the inclined part thereof and is adapted to supply water to prevent the gangue passing over the upper end of the table, while the other is set transversely across the table between the feed supply and the ore delivery end and is adapted to the delivery of water

as a fine rain, to assist in keeping the gangue loose enough to allow the mineral particles to quickly settle down through it, as set forth.

7. In an ore separator, the combination with a reciprocating bumping table, having an unobstructed working bottom (a section of which is adapted to be inclined from a nearly horizontal plane), closed at the sides and open at both ends for the free and continuous discharge of ore at one end, and of tailings at the other end, of a bumping beam secured to the table centrally thereto and extending the whole length thereof in the direction of the line of the operative movement of the table and travel of the ore, the tailings and water thereon; a fixed bumper block for the beam to strike against; a shaft carrying lugs adapted, in revolving, to jar the beam and table and move them from the bumper block, and springs or weights applied and arranged to force the beam against the bumper block, all substantially as set forth.

8. In combination with the suspending devices, a bumping table ore separator, open for free discharge of ore at one end and tailings at the other end, constructed substantially as herein shown and described, with cross pieces secured to the table bottom and a bumping beam secured to the cross pieces at right angles to them and in line with the travel of the table, the ore, tailings and water when in operation and reciprocating mechanism, as and for the purposes set forth.

9. In an ore separator a flat horizontally reciprocating table open at both ends, a solid abutment against which the table bumps at one end, and means for supplying crude ore and water to the table midway of its length means for suspending the table and giving end movement to the same; whereby a shallow slowly moving body of water may be maintained, and the light matters floated in one direction above the level of the ore moving in the opposite direction thereunder.

10. In an ore separator a flat reciprocating table open at both ends, having its body portion arranged in a horizontal position and its head inclined slightly upward, a solid abutment against which the table bumps endwise at the head, means for suspending the table and giving end movement to the same, and means for delivering the crude ore and water upon the level portion of the table.

11. In an ore separator and in combination with means for delivering the crude ore and water thereto, a table open at both ends, means for sustaining and reciprocating said table, and a solid abutment against which the table bumps, its body portion being arranged in a horizontal position but its head inclined slightly upward to retain the water and compel its flow in the opposite direction while permitting the purified ore to flow continuously upward to the point of discharge.

12. In an ore separator a reciprocating table having a smooth uninterrupted surface open at both ends, for the passage of ore over the head and the tailings over the tail, and sustaining devices for the table in combination with an abutment arranged in position to receive the impact of the head end of the table, as distinguished from an abutment beneath or at the tail end of the table, and means for supplying crude ore and water to the table.

13. In an ore separator the combination of a flat table open at both ends and having its head inclined upward in relation to the remaining portion, a bumping beam secured to said table lengthwise thereof, an abutment against which the end of the beam strikes at the head of the table, and means for supplying crude ore and water to the table, and means for sustaining the table.

Signed by me this 22d day of January, 1887.

HEZEKIAH BRADFORD.

Witnesses:

GEO. T. PINCKNEY,

WILLIAM G. MOTT.