Sheet 1-3 Sheets.

W. Hooper.

Ore Separator.

No. 101,132. Patented Mar. 22, 1870.

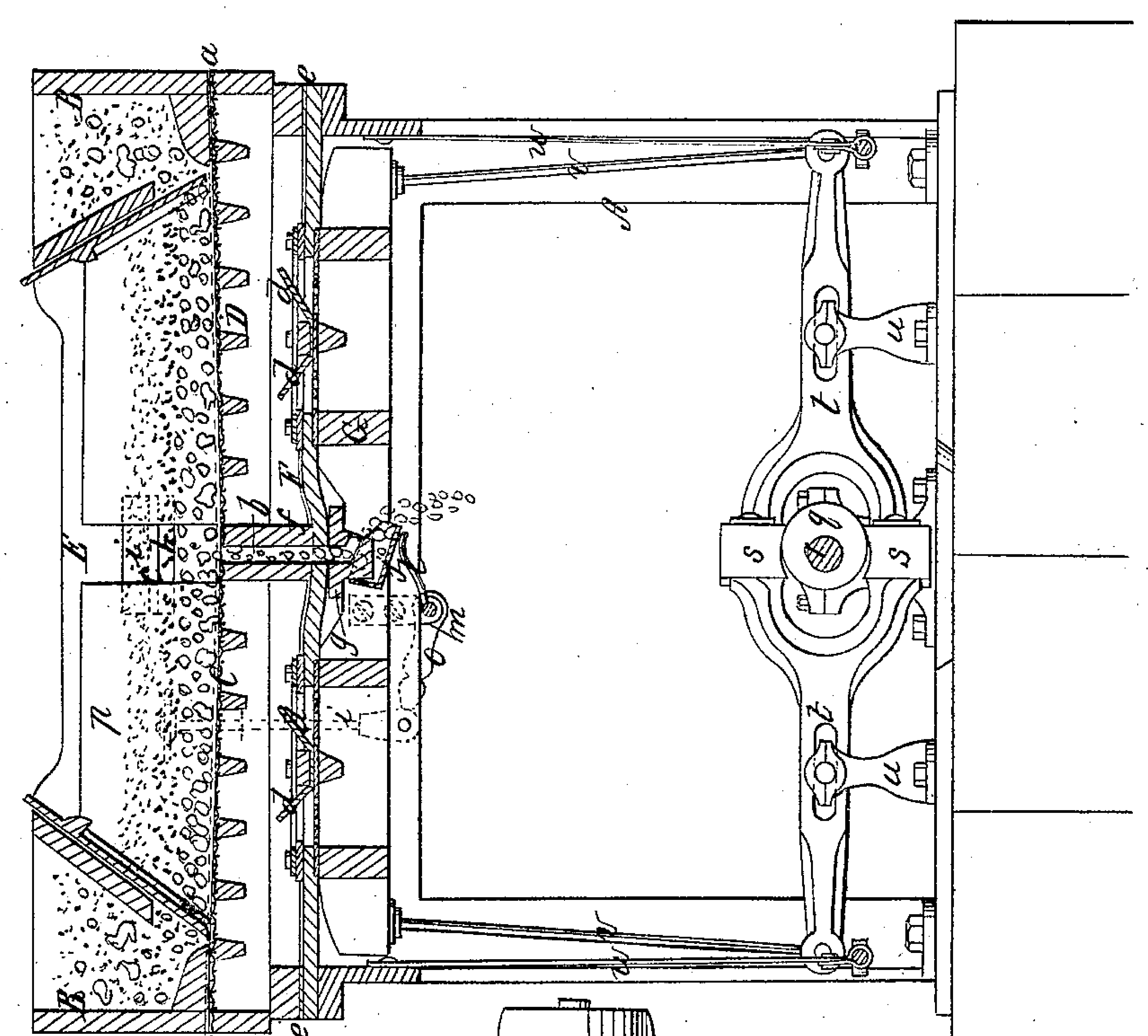

Fig. 1.

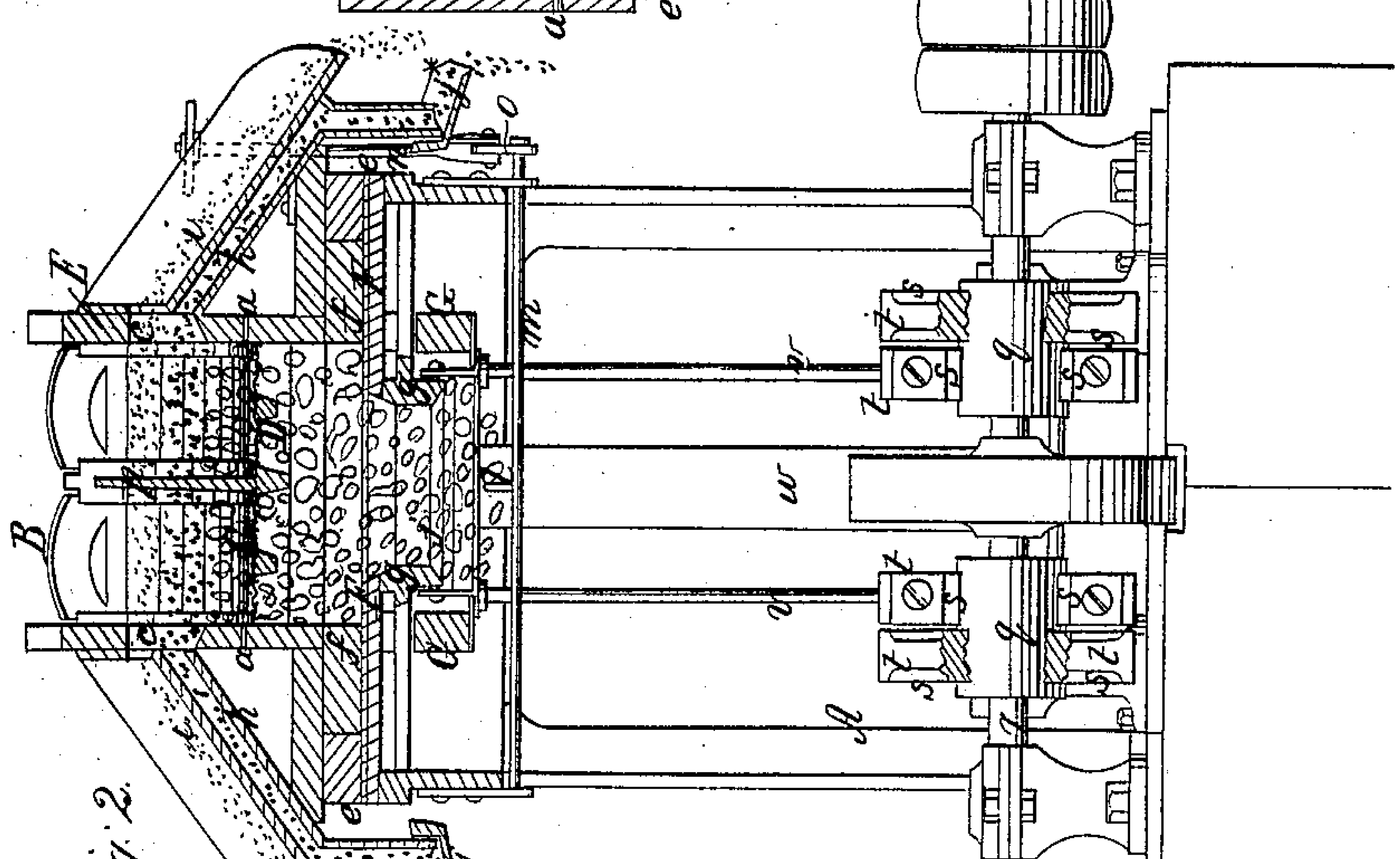

Fig. 2.

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Sheet 2-3 Sheets.

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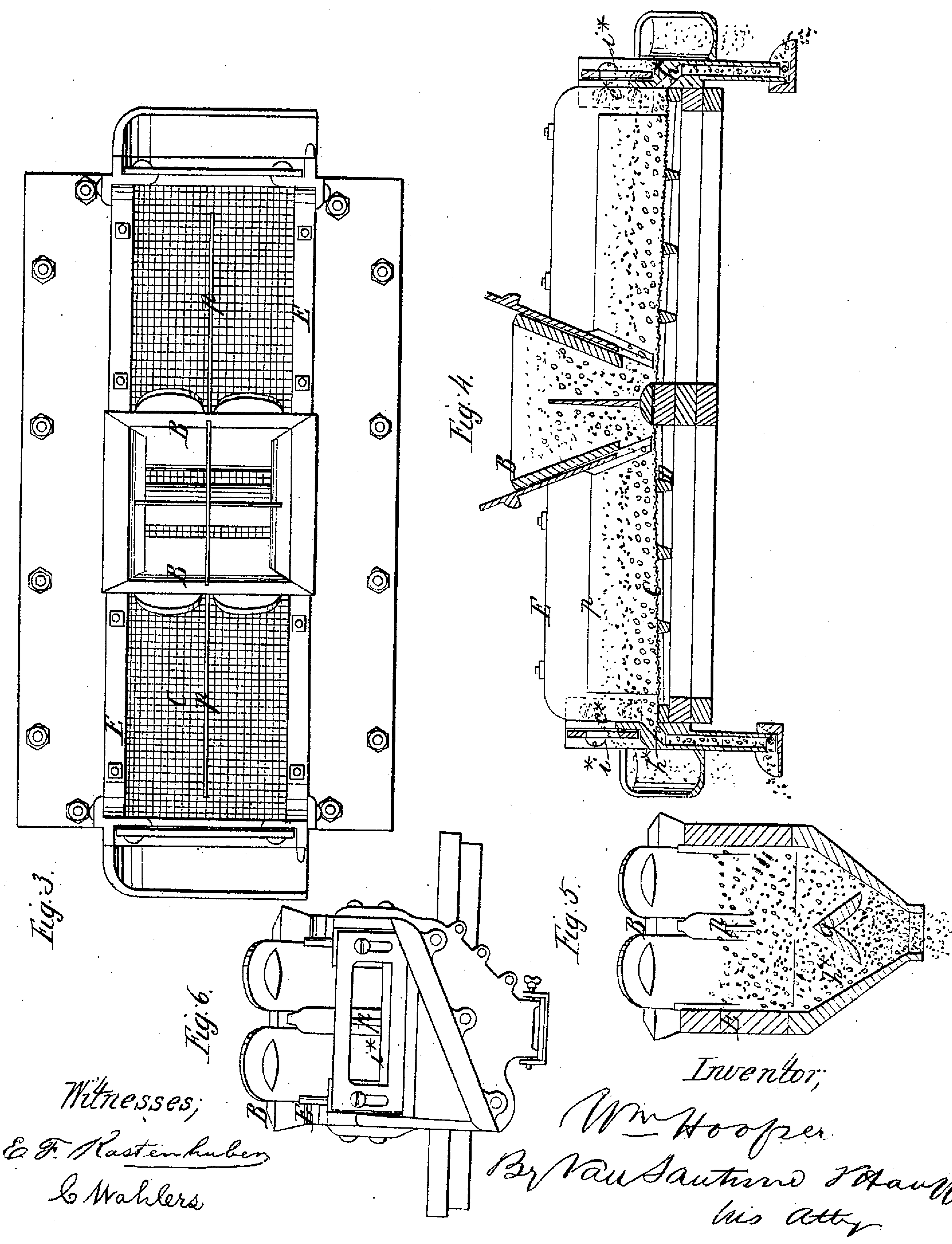
Ore Separator.

No. 101,132 — Patented Mar. 22, 1870.



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W. Hooper.

Ore Separator.

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Fig. 9.

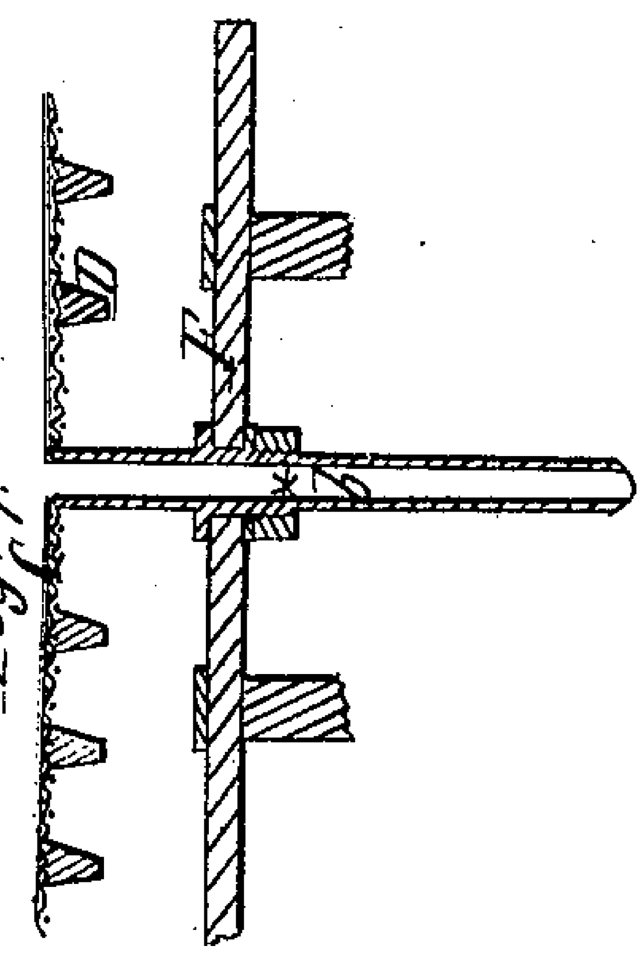


Fig. 10.

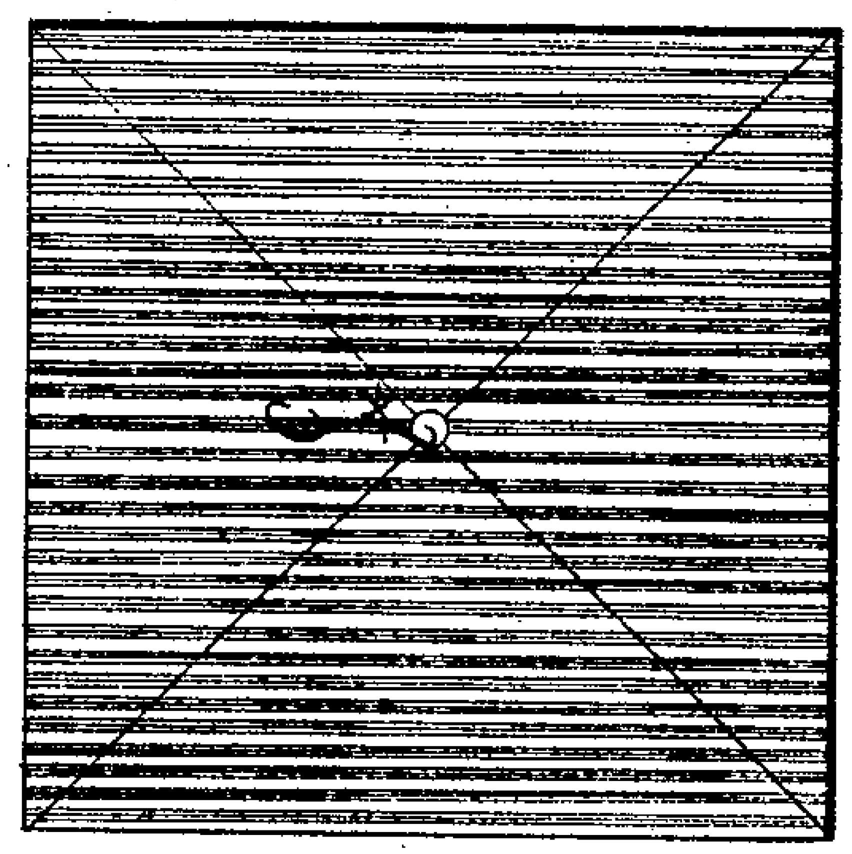


Fig. 7.

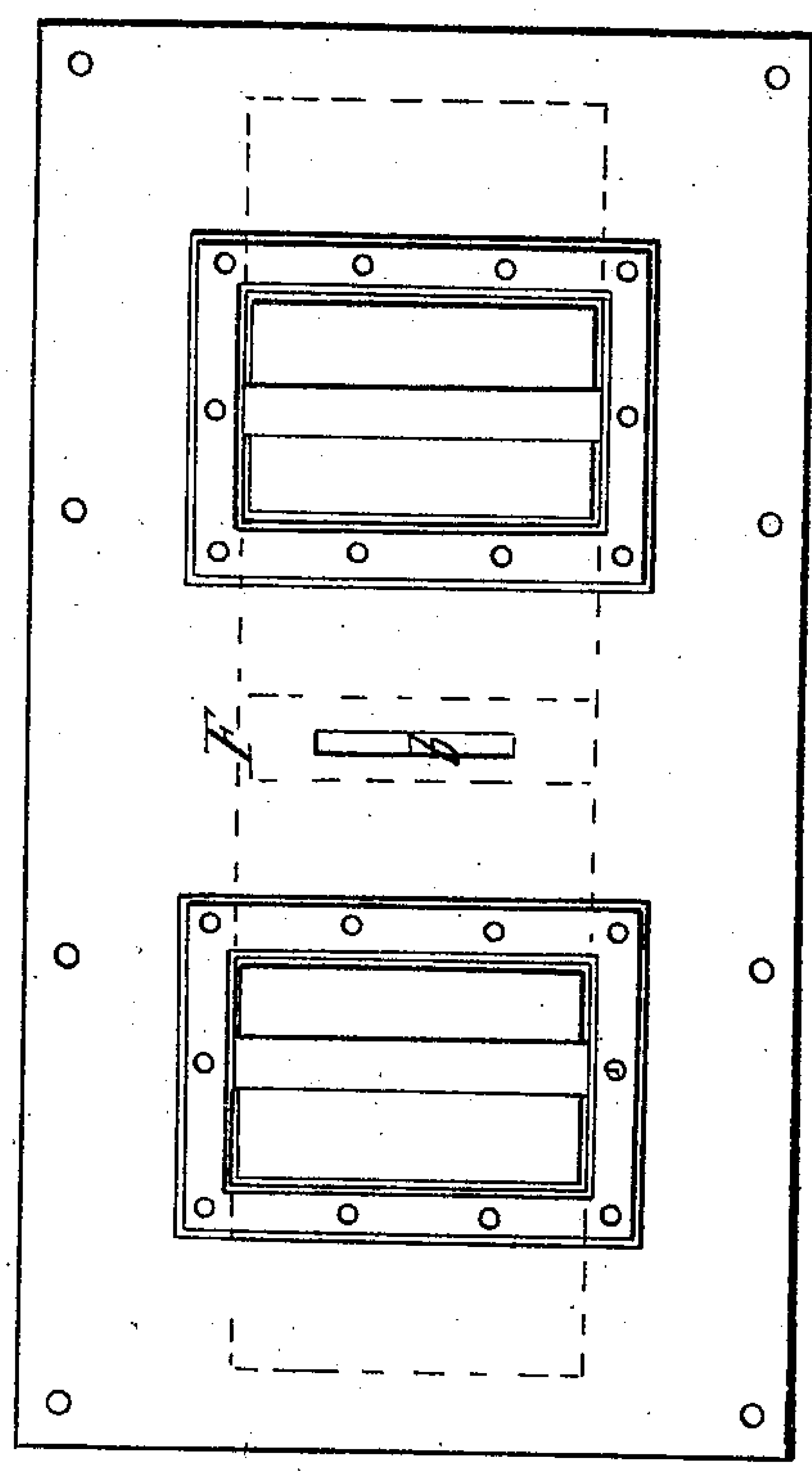


Fig. 8'.

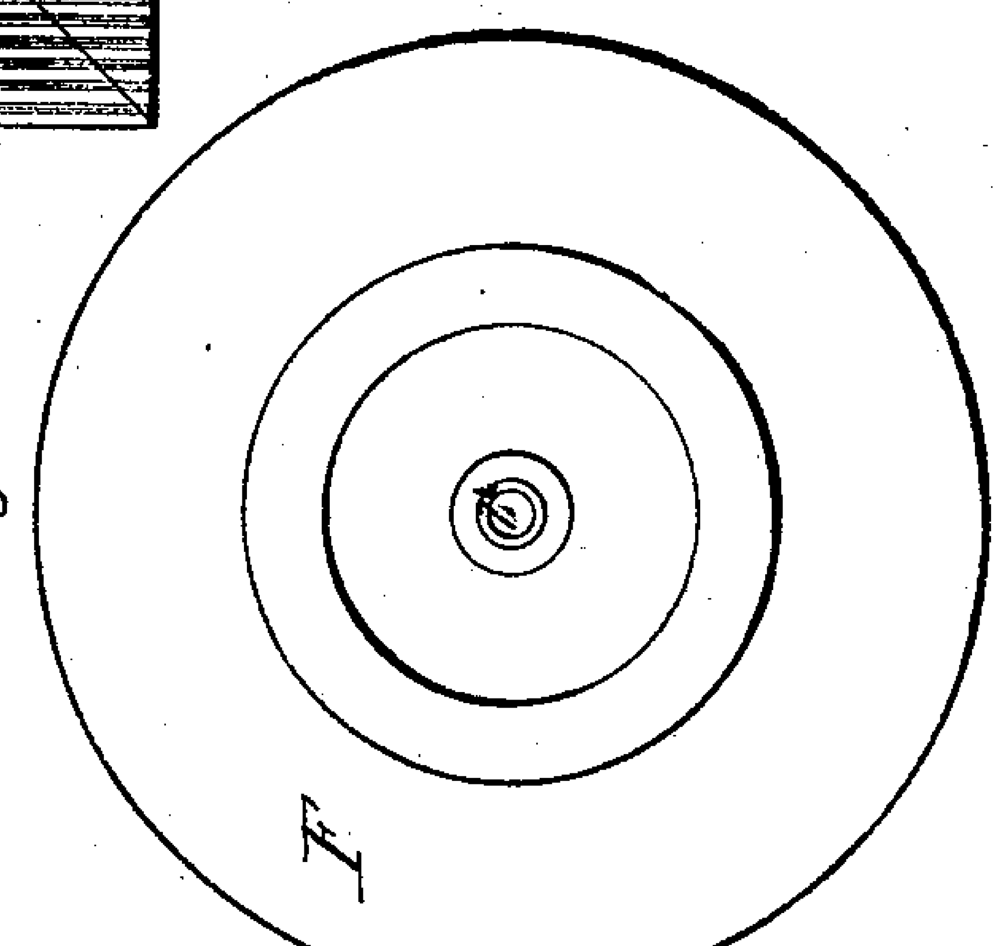
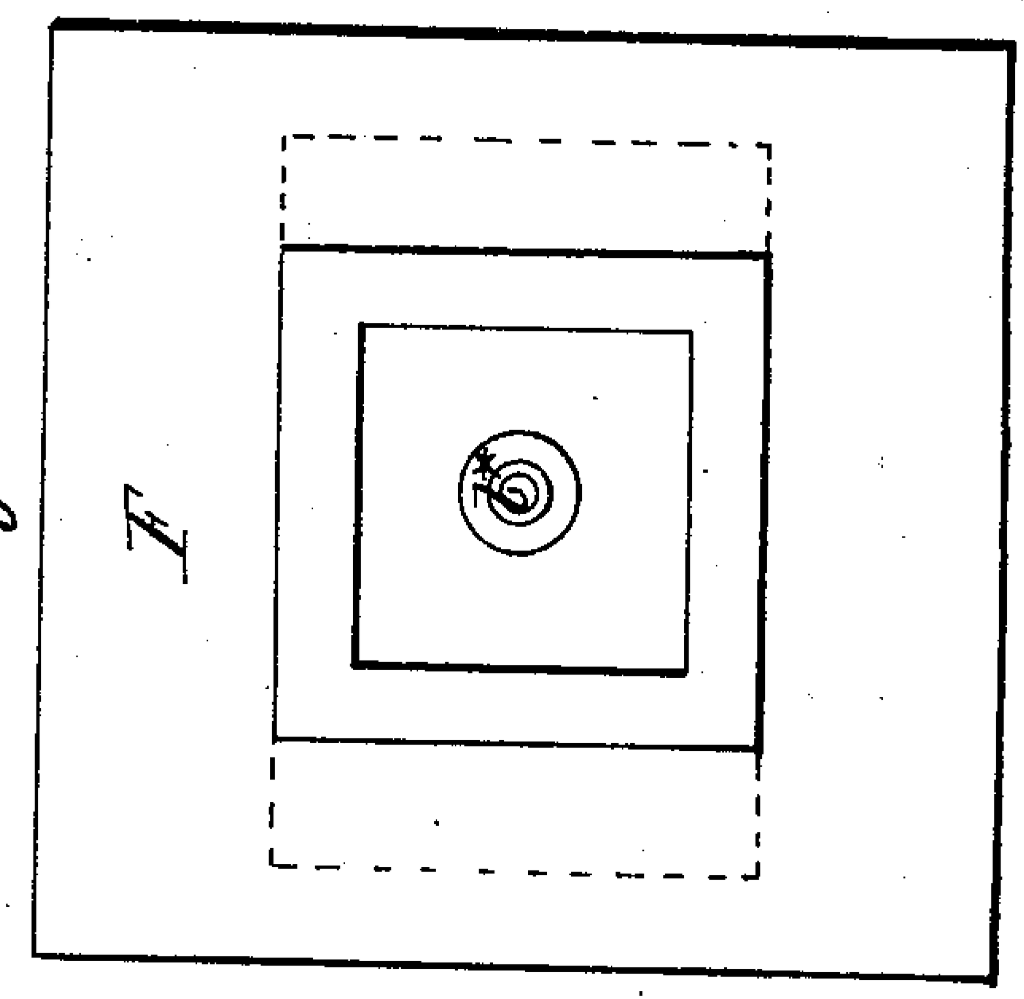


Fig. 8.



Witnesses;
E. F. Kastenhuber
C. Wahlers

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Wm Hooper
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UNITED STATES PATENT OFFICE.

WILLIAM HOOPER, OF TICONDEROGA, NEW YORK.

IMPROVED ORE-SEPARATOR.

Specification forming part of Letters Patent No. **101,132**, dated March 22, 1870.

To all whom it may concern:

Be it known that I, WILLIAM HOOPER, of the town of Ticonderoga, in the county of Essex and State of New York, have invented certain new and useful improvements in machines, means, or apparatus for concentrating or separating ores, metals, sands, earths, grains, and other substances when in a pulverized or granular condition, and when containing grains, granules, or particles of different specific gravities, to which machines I will, for convenience, give the general designation of "ore-separators;" and I do hereby declare that the following is full, clear, and exact description of such improvements, which will enable those skilled in the art to make and use the same, reference being had to the accompanying drawings, which form part of this specification.

My description will be confined to the treatment of ores, except where other substances are particularly specified, and to the employment of air, except when another fluid is mentioned.

This invention relates, in parts, to the construction and arrangement of that class of machines in which intermittent puffs, blasts, jets, or currents of air, water, or other fluid are projected or forced through a perforated plate, sieve, or porous bottom or bed containing ore or other substance to be separated, so as to loosen and agitate the mass in a manner which has been found to be peculiarly favorable for separating lighter from heavier grains, granules, or particles, the lighter being driven upward, while the heavier particles sink and arrange themselves below in strata, according to their specific gravities. There have been a variety of machines heretofore invented for this purpose; but there have been difficulties experienced in their practical operation which have rendered them unsuccessful, except to a very limited extent. The most important of these difficulties were found in the bellows, in the mechanism for driving the bellows, in the ore-bed, and in the discharge for the separated ore. I estimate their importance in the order above stated.

My improvements consist in providing the means for overcoming these difficulties by, first, a bellows constructed with a flexible diaphragm, capable of receiving a rapid vibratory motion constantly applied for a long time without rendering it liable to wear or injury, in combination with a perforated plate, sieve, or porous bottom used as an ore-bed; second, an air-tight bellows chamber between the ore-bed and diaphragm, with all joints so closed that no air can escape during the vibration of the diaphragm, except through the ore-bed; third, driving mechanism constructed with adjustable forked levers, and provided with adjustable shoes, which bear from opposite sides on eccentrics on the main shaft, in combination with tension or counterbalance springs and connected with the flexible diaphragm by means of adjustable rods, all combined and arranged in such manner that the shoes are held in close contact with the eccentrics, and so that a rapid vibratory motion can be imparted to the flexible diaphragm without causing any blows or shocks, and so that the strokes may be lengthened or shortened at pleasure; fourth, one or more partitions on the top of the ore-bed to prevent the mass of ore in the ore-bed from becoming uneven or broken—a disadvantage which cannot be avoided if the ore-bed exceeds a certain width, the partitions being intended to divide the volume of ore and keep it in a narrow channel as it traverses the ore-bed between the supply and discharge; fifth, an aperture in the bottom of the ore-bed, so constructed that the concentrated or pure ore will be discharged down through the bellows, in combination with double-channeled side discharges, through which will be delivered from the upper channels pure tailings, and from the lower channels middlings, or a mixture of pure ore and tailings, thus producing three qualities in the work of separation—viz., clean separated ore through the bottom, tailings or worthless gangue through the upper side channels, and middlings through the lower side channels, it being necessary with certain classes of ores to produce this mixture and pass it through the machine again to be more perfectly separated; sixth, a roof-shaped partition in the discharge-passage for separated ore, so arranged as to prevent the lower and heavier stratum of ore from being broken and mixed with the upper stratum of middlings or tailings during its discharge, and to insure an even and uniform discharge.

Figure 1 represents a longitudinal vertical section of one of my machines when constructed with bottom and side discharges to produce three qualities in the process of concentration—viz., pure ore, tailings, and middlings. Fig. 2 is a transverse section of the same. Fig. 3 is a plan or top view of one of my machines, when constructed as a double machine with end discharges only, to produce two qualities in the process of concentration—viz., pure ore and tailings. Fig. 4 is a longitudinal vertical section of the same. Fig. 5 is a transverse vertical section of the same. Fig. 6 is an end view of the same. Fig. 7 is a plan or top view of the flexible diaphragm as used in both the single and double machines, represented in Figs. 1 to 6. Figs. 8 8′ are the same when the valves are placed elsewhere, and when the concentrated ore is discharged into the bellows, either through the perforations or meshes, or through an aperture or apertures in the ore-bed. Fig. 9 is a transverse section of the same when the concentrated ore is discharged through a pipe passing from an opening in the ore-bed down through the bellows and diaphragm. Fig. 10 is a plan or top view of an ore-bed like that last mentioned.

Similar letters indicate corresponding parts.

In the drawings, the letter A designates a frame made of metal or any other suitable material, and so constructed that it is capable of supporting the driving mechanism, the bellows, ore-bed, and other working parts.

The ore or other substance to be treated by my machine, if not already in a pulverized or granular condition, is first reduced to the required fineness by suitable crushers or stampers, and it is then fed into the hoppers B, from which it is allowed to run out and to spread over the ore-bed C. This ore-bed is constructed of a perforated plate of sheet metal, or of wire-gauze, or of cloth, buckskin, or other porous material, and it is supported by a grate, D, to the top of which is secured a box, E, which also embraces the hoppers B, such hoppers being separated from the remainder of the box by suitable partitions and adjustable gates. The ore-bed C is clamped between the upper surface of the grate D and the bottom surface of the box E, and a packing-piece, *a*, of india-rubber or other suitable material, is interposed, so as to produce an air-tight joint and prevent the escape of air.

In Figs. 1 and 2 I have represented the hoppers B at the opposite ends of the box E, and in this case the ore-bed slopes down toward the middle, where it is provided with an opening, *b*, which I term the "bottom discharge or delivery," while the box E is provided in its sides with openings *c*, which form the side discharges or deliveries. The ore, on being let out from the hoppers B, spreads on the ore-bed, and it is then agitated by currents or jets of air produced by the bellows situated below the grate D. The bellows which I use in preference to any other are constructed of a diaphragm, F, made of india-rubber or other suitable flexible material, and provided with air-valves *d*, as shown in Fig. 1 of the drawings. This diaphragm is clamped between the supporting-frame of the grate D and the main supporting-frame A, and it is connected to a bellows frame, G, to which a reciprocating motion is imparted by the driving mechanism that will be presently described. The joint between the supporting-frame of the grate D and the diaphragm is rendered air-tight by a packing-piece, *e*, of india-rubber or other suitable material, and this packing-piece also serves to protect the diaphragm from abrasion, wear, or injury by being brought in contact with the frames between which it is clamped. When the ore-bed is constructed with such bottom delivery the diaphragm F is perforated in its middle with an aperture corresponding to such bottom delivery, and a tight joint is produced round this aperture by a cross-bar, *f*, secured to the supporting-frame of the grate D, and pressing the diaphragm down upon another cross-bar, *g*, secured to or forming a portion of the main supporting-frame A, both cross-bars being perforated with apertures corresponding to the bottom delivery, *c*, of the ore-bed, such perforations being somewhat larger than the opening in the ore-bed to allow the free passage of anything that once enters the opening, and thus clogging is prevented. By these means the diaphragm F is divided in two parts, each of which is provided with a separate air-valve or set of valves. Another object of this partition is to prevent one end of the machine from robbing air from the other. If the diaphragm was not partitioned, as shown in Fig. 4, that section or part of the ore-bed which might have on it the thinnest or lightest mass of ore would afford the readiest escape for the air, and it would agitate that section too much, while the other section would be agitated too little. The partition obviates this difficulty and gives a uniform distribution of the air in both sections and in all parts of the ore-bed. The diaphragm thus constructed prevents any fine particles of ore which might pass through the ore-bed from dropping down upon and from injuring the working mechanism, and also affords a means of readily saving and securing such fine ore, owing to the facility of removing the entire top and exposing the diaphragm. This is an important feature, particularly when the machine is employed in separating ores containing precious metals; but I prefer to keep the driving mechanism in a dust-proof casing, as it serves the purpose of keeping out all dust and grit.

The currents of air produced by the action of the diaphragm F pass up through the perforated ore-bed and through the ore spread thereon, and by these means the light parts of the ore are made to arrange themselves on the top, while the heavy parts sink down to the bottom of the mass of ore spread on the ore-bed, so that by the time the ore reaches the middle of the ore-bed the heavy parts will discharge through the center delivery, b, while the light parts discharge through the side deliveries, c.

The work of separation of the heavy from the lighter particles is effected very quickly, almost immediately. A very few vibrations of the diaphragm is all that is required, so that the length of the ore-bed may be quite short and yet do the work efficiently. I prefer to make the ore-bed the proportional length shown on the drawings, so that I can have a compact machine with the driving mechanism conveniently located underneath. This was one object I had in view in adopting the plan of a double machine with the end deliveries.

The side deliveries are best seen in Fig. 2 of the drawings. They are situated at a certain elevation above the ore-bed, and from each of them extend two channels, h i, one above the other, the lower channel to carry off the middlings and the upper one to carry off the tailings, as already described. The tailings will be worthless. The middlings are to be treated over again. In separating the coarser ores two deliveries, as shown in Fig. 1, will in most cases be sufficient; but for finer ores, and with ores difficult to treat, three deliveries, as shown in Fig. 2, will be often found desirable. The middlings can be taken by elevators back into the hoppers, the pure ore, delivered at the bottom, can be saved as finished, and the tailings will be thrown away.

The discharge of ore through the several deliveries or channels is regulated by a checking-gate, j, under the mouth of the bottom delivery, and by similar checking-gates, j^*, under the discharge-openings of the lower channels, h, of the side deliveries. These checking gates are adjustable, and their position may be regulated by means of a thumb-screw, or of an arm, l, which extends from a rock-shaft, m, to which the required motion can be imparted by a lever, o, and screw-rod n. (Best seen in Fig. 2.) By closing the bottom delivery partially or wholly, either by devices last mentioned or otherwise, the discharge of the heavy ore is checked, and it is dammed up, and the discharge of the middlings and tailings is proportionately increased.

To prevent the mass of ore which is disposed in strata on the ore-bed according to the density or specific gravity of the particles from getting broken and mixed, after being so disposed in strata, I have applied one or more partitions, p, whereby the width of the volume of ore is reduced, and its liability to become uneven and broken is materially diminished. If the mass of evenly-distributed ore becomes shifted and out of level, the air escapes through the thinnest parts of the mass, and the desired effect of the ore-separator is lost, or at least materially reduced. The number and distance apart of these partitions will depend on the peculiarities of the ore.

The mechanism for imparting the required motion to the diaphragm F consists of two eccentrics or cams, q, mounted on the driving-shaft r, and working against shoes s, which are secured in the bifurcated ends of levers t and bear on the eccentrics from opposite sides. For these shoes I use blocks of wood of hard and tough fiber—such as locust—inserted endwise. Here is the point of greatest friction and wear, and wood is preferable to metal. Metal must be carefully fitted and kept fitted to the eccentrics, while wooden blocks will wear and keep worn to a fit. Wooden shoes can be quickly and cheaply replaced, while those made of metal cannot. Besides, wood will take up the tremor and make the machine run smoothly and with very little noise, while two metal surfaces in contact and subjected to such rapid motion and severe friction will produce much jarring and a great clatter. A wooden shoe will, in my opinion, last longer than if made of iron or steel. I attach much importance to this feature of my driving mechanism. My machine without these wooden shoes would occasion me considerable trouble and annoyance.

The levers t have their fulcra in standards u, rising from the bed of the machine, and their outer ends connect by rods v with the bellows-frame G. As the shaft r revolves an oscillating motion is imparted to the levers t and a rising-and-falling motion to the bellows-frame G. The diaphragm F is therefore alternately drawn down so as to admit air through the valves wherever placed, and then it is pushed in, whereby the valves are closed, and the air previously drawn in is forced up through the ore-bed. The motion of the shaft r and of the diaphragm F must neceesarily be very rapid, so as to produce the required effect, and the eccentrics q are liable to produce blows on the shoes s. To prevent such blows I have applied to the lever t tension-springs w, which serve as counter-balances to keep the shoes s always in close contact with the surfaces of their eccentrics, and which also give the machine something to do when the bellows is on its downward motion. As the upward stroke is given, the air forced through the ore-bed meets with resistance, and if the downward motion had nothing to retard it, there would be an irregularity and unsteadiness which would be objectionable. This is completely remedied by the counterbalance-springs. By these means all dead motion is avoided, and a very rapid motion can be imparted to the diaphragm F without difficulty, and at the same time the working parts, particularly the wooden shoes already described, are so constructed that the dust or grit produced by the operation of separating ore is not liable to produce any material injury to the same.

Dry-ore separators are required to do very heavy work. Their constant use in the rough operations of mining renders it necessary that there should be great steadiness of motion, otherwise the wear and tear would be so great that frequent repairs would become necessary, and the machine might soon become permanently disabled. The fly-wheel y aids greatly to produce this steadiness of motion.

Figs. 3, 4, 5, and 6, which represent the double machine, show the hoppers B in the middle of the ore bed C and the deliveries c^* at the ends. These end deliveries, c^*, are best seen in Figs. 1 and 2, each end delivery being provided with two channels, h^* i^*, one above the other. The middlings and tailings, as already stated, discharge through the upper channels, i^*, and the heavy ore through the lower channels, h^*. In the last-named channels or passages I have arranged roof-shaped partitions x. (Best seen in Fig. 5.) These partitions, as already stated, prevent the stratum of separated ore, while the same discharges, from getting broken and mixed with tailings and render the discharge uniform, so that the stratum of separated ore on the ore-bed in close proximity to the discharge will not lose its uniform depth and evenness.

A detached plan or top view of the flexible diaphragm is given in Fig. 7 of the drawings. If the ore is discharged or allowed to sink through the perforations or meshes of the ore-bed down into the bellows and to lodge on top of the diaphragm, I introduce a tube, b^*, which is fastened in the middle of such diaphragm by a flange, which may be circular, as shown in Fig. 8′; or there may be a bottom delivery with a pipe or tube passing from an opening in the ore-bed down through the bellows and diaphragm, as shown in Figs. 9 and 10, in which case no ore would enter the bellows nor touch the diaphragm, unless, perhaps, fine particles, as hereinbefore intimated.

I will now proceed, at the risk of some repetition, to allude more particularly to that feature which I conceive to be most important in my invention—viz., the bellows or blowing device.

To render a dry-ore separator valuable it is indispensable that the air used should be perfectly under control, and that the machine should be so constructed as to allow the operator to introduce currents, puffs, blasts, or jets of air through the material to be separated with more or less force, and with longer or shorter strokes, and with faster or slower motions, at pleasure. These variations are necessary. If, for instance, the material to be treated is magnetic iron ore containing quartz, it is to be prepared by roasting and coarsely-granulating, as ordinarily done by stamps or crushers when the old-fashioned water-separator is used. The mass of such ore on the ore-bed may be several inches—say five or six—in depth, and the strokes may be three hundred per minute, and, say, two inches in length. If, on the other hand, the material is quartz containing free gold in very fine particles, it should be pulverized quite fine, and then the mass should be spread out much thinner—say one inch, or perhaps half an inch, in depth—and the strokes should be more rapid in number—say four hundred to six hundred per minute—and much shorter—say one inch, and perhaps half an inch, in length. If the air-chamber is not perfectly air-tight, so that the air cannot by any possibility escape except through the mass on the ore-bed, the machine will wholly fail to separate some kinds of ores capable of being separated, will do its work imperfectly on any kind of ore, and the operator will not be able to employ short strokes at all.

The bellows is liable to collapse or wear out rapidly if constructed with leaves like those used in an organ. If constructed with a diaphragm to work like a piston, the rapid motion and friction will soon rub off so much of the wearing-surface that repeated and frequent repairs and new packing for a close joint will become necessary, and even then the air-chamber will not be air-tight. If the blowing contrivance is hung to swing on a rock-shaft, the diaphragm will still allow wind to escape around its circumference, and the side farthest from the rock-shaft will describe too great an arc, and travel so much farther than the side attached to the shaft that the diaphragm will come up with a flirt and produce a shock with every motion, which shocks are calculated to get the mechanism out of order.

To avoid these evils and secure a perfectly air-tight chamber I have devised the flexible diaphragm hereinbefore described. In a large machine constructed by me upon this plan I have used and prefer a rubber plate about one-half inch in thickness; but leather and any other strong, air-tight, and flexible material can be made to answer the purpose. Whatever is used the thickness of the material ought to be graduated to the superficial extent of the surface of the diaphragm, and ought to be as thick as its free vibration and use will permit. Beside making the chamber air-tight there are other advantages secured by such a flexible diaphragm. The outer edge of the rubber being clamped and secured tightly between the framework of the air-chamber and the supporting-frame below, and the connection of the driving mechanism to the diaphragm being near its center, the vibrations of the diaphragm are confined chiefly to such center, so that when there is a stroke one inch in length such center will vibrate that distance, while the diaphragm, near the outer edge so clamped, will move or vibrate very little—say one-sixteenth of an inch—thus preventing abrasion and wear at points where the piston and rock-shaft diaphragms would be sure to be worn. By my method there is no friction in the bellows. I have run my machine thus constructed steadily for several weeks, concentrating iron ore at the rate of more than five tons per hour, and on removing the top and exposing the bellows I found it as clean and sound as it was when first put in. There was no abrasion or wear whatever, while with a machine containing a piston-bellows, and operated by me, I found that its diaphragm required new packing almost daily, and even with these constant repairs it worked very imperfectly, owing to the air escaping around its circumference. Another advantage is the facility with which such a rubber plate may be adapted to separators of diverse patterns, especially with reference to discharging the separated or heavy particles after the action of the air has driven out the lighter. For example, the heavy particles may be discharged through an aperture or apertures in the ore-bed down into the air-chamber and allowed to lodge on top of the diaphragm. In such case the rubber plate would be left entire, without any opening cut out of it for the valves, as shown in Fig. 8, and the valves would be inserted in the sides, or in some other convenient part of the air-chamber. The ore lodging on the diaphragm may then be made to pass through an opening in or near its center, the edge of this opening to be secured to the flanged end of a pipe by clamping the flange on the top of the rubber with a flanged screw-nut encircling the pipe and working in a thread cut around it for a proper distance below the upper flange of the pipe. Thus clamped and secured, as shown in Fig. 9, with the other end of the pipe fastened to make it stationary and firm, there would be no impediment to the free vibration of the diaphragm, as the center frame, which is attached to the driving mechanism, would be far enough off from the opening to allow the rubber to give when the diaphragm moves up and down. The diaphragm being dishing, the ore lodged upon it would readily pass through the opening, and no air would escape out of the pipe, because its lower end would be arranged so as to keep its contents checked or dammed up with a sufficient accumulation of the discharged ore to prevent such an occurrence. Again, this pipe, instead of opening into the air-chamber, may have its upper end extended above the upper flange, up through the ore-bed, as shown in Fig. 9. By this means the separated ore would be discharged directly from the ore-bed down through the pipe and out at its lower end. In short, it is immaterial what may be the peculiar construction of the ore-bed, whether in manner and form as shown on the drawings, or with its perforations or meshes large enough to let the separated ore pass down, either directly through such perforations or meshes, or first through the interstices of a stratum of ore or other substance too coarse to pass through such perforations or meshes. The diaphragm and pipe, constructed and adjusted in combination as first described, will discharge the contents of the chamber as they accumulate there. I have invented an ore-bed of this description, and intend hereafter to make application to have the same secured to me by Letters Patent. Instead of constructing the ore-bed with two end discharges, I have also contemplated a machine with a circular ore-bed, having its discharge all round the periphery of such bed, which will also form the subject of a subsequent patent. In such case the diaphragm may be circular, as shown in Fig. 8′.

There is still another advantage which my bellows possesses. The driving mechanism may be applied in a variety of ways. For most ores and substances I prefer the method shown on the drawings; but for several others it will suffice to attach the bellows-frame to a crank-motion by means of rods or pitmen extending above or below and connected to a crank-shaft or to eccentrics on a shaft, and this shaft may be in the same room, or in a room overhead or underneath; and the same shaft may have a series of cranks or eccentrics to drive a number of machines at the same time. Again, my bellows may brought down by means of a trip-wheel, and thrown upward to force the air through the mass on the ore-bed by means of a spring or springs. For such springs I prefer rubber, so applied that when the trip-wheel brings the bellows down to admit air through the valves the descent will compress the rubber springs, and their expansion will throw the bellows up. Rubber will retain its elasticity when used in this way, while it may lose its elastic power if pulled on the downward motion and allowed to spring back to produce an upward throw. If metal springs are used in a machine put to such severe trials as ore-separators are, they may give out. Hickory or other wooden springs are preferable to metal; and I will add that my driving mechanism already described, and shown on the drawings, may be detached from my machine and placed at a distance—for instance, in a room above or below—and may be employed, by proper adjustments and connections, to drive not only one machine, but a number of machines at the same time. The connecting-rods may be multiplied in number and increased in length.

I have invented a machine with the bellows propelled by a trip-wheel and springs, and with a different ore-bed and different devices for discharging the ore and tailings; and I intend hereafter to make application to have the same secured to me by Letters Patent.

My bellows possesses other advantages which are worthy of mention.

Owing to the facility and certainty with which the operator may regulate the length and frequency of the strokes, and the consequent diminution or increase in force of the blasts, he may separate the substances treated without the necessity of first sifting or sizing them. The mass on the ore-bed may contain a mixture of various sizes and shapes, from particles like dust to lumps like pebbles.

By increasing the area of the diaphragm and enlarging the size of the air-chamber relatively to the size of the ore-bed a surplus of air may be obtained and allowed to escape through suitable pipes, ducts, or channels in such manner as to drive off and out of the building in which the machine is located all dust and impalpable powder rising into the surrounding atmosphere of the room when the mass on the ore-bed is agitated, and thus save the machinery from the injury and relieve the operator from the annoyance which such dust might otherwise occasion. The same result may be accomplished by constructing the diaphragm and air-chamber with a partition, as shown in Fig. 4, and substituting a tight covering for a perforated or porous bed, thus reducing the double machine described to a single machine with only one end discharge; or a separate and independent tight-top air-chamber, with the diaphragm and without the perforated or porous bed, may be constructed for the special purpose of carrying off, through suitable pipes, ducts, or channels, all dust arising from one or more of the machines; and such blowing device, for the purpose last mentioned, may be driven by an attachment to the driving mechanism already described, or by an independent motion by crank or otherwise. For blowing off the dust the same care, in respect to the length and rapidity of the stroke, is not to be observed as when the bellows is used in the work of separation.

My bellows will also permit the size of the machine to be indefinitely expanded from one worked by hand to one requiring several horse power. The size most suitable to be adopted will depend on the quantity, quality, and peculiar character of the ore or substance to be separated, and due regard should also be had to the place where the machine is to be transported, and to the locality where it is to be operated. I propose to construct one capable of treating one ton of ore an hour, which may be worked by one man and carried by one mule, and I might construct one, if deemed advisable, to be operated on alluvial deposits containing gold, and in other very heavy work, which would dispose of such enormous quantities as to compete with, if not wholly supersede, the hydraulic means now employed on such deposits in California and elsewhere; but for crushed or stamped ores, which constitute the great bulk of substances to be separated, I prefer to multiply the number of machines to giving to them dimensions which might render them difficult to handle.

Other fluids may be substituted for air by immersing the valves in a reservoir abundantly supplied with the fluid so substituted. With some ores and substances water, also solutions and even quicksilver, may be found preferable to air. The substituted fluid may be used over and over again; and, finally, the machine can be employed to separate any minerals or other substances already possessing, or requiring to be reduced to, a pulverized or granular condition, including cereals and various kinds of seeds, whenever and wherever any of these may be found to contain particles or grains of different specific gravities which it may be desirable to separate; but for "shine ores" I prefer another machine which I have invented, and which I intend to have patented.

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

1. The flexible diaphragm F, constructed of an india-rubber plate or other suitable flexible material, for forcing air through dry substances of different specific gravities, substantially as described.

2. The central discharge in the flexible diaphragm F, substantially as and for the purpose described.

3. The arrangement of one or more partitions, *p*, on the perforated bed, substantially as described.

4. The forked levers *t*, provided with adjustable shoes *s*, bearing on eccentrics *q* on the driving-shaft, in combination with tension-springs *w*, connecting-rods *v*, and flexible diaphragm F, substantially as shown and described.

5. The roof-shaped partitions *x* in the passage *h**, substantially as shown and described.

6. The arrangement of side deliveries, *c*, each provided with two passages, *h i*, in combination with the bottom delivery, *b*, and with the bed, substantially as described.

WILLIAM HOOPER.

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