No. 805,448. PATENTED NOV. 28, 1905.

H. F. CAMPBELL, DEC'D.

J. L. CAMPBELL, EXECUTRIX.

MAGNETIC SEPARATOR FOR ORES.

APPLICATION FILED JAN. 20, 1904.

6 SHEETS—SHEET 1.

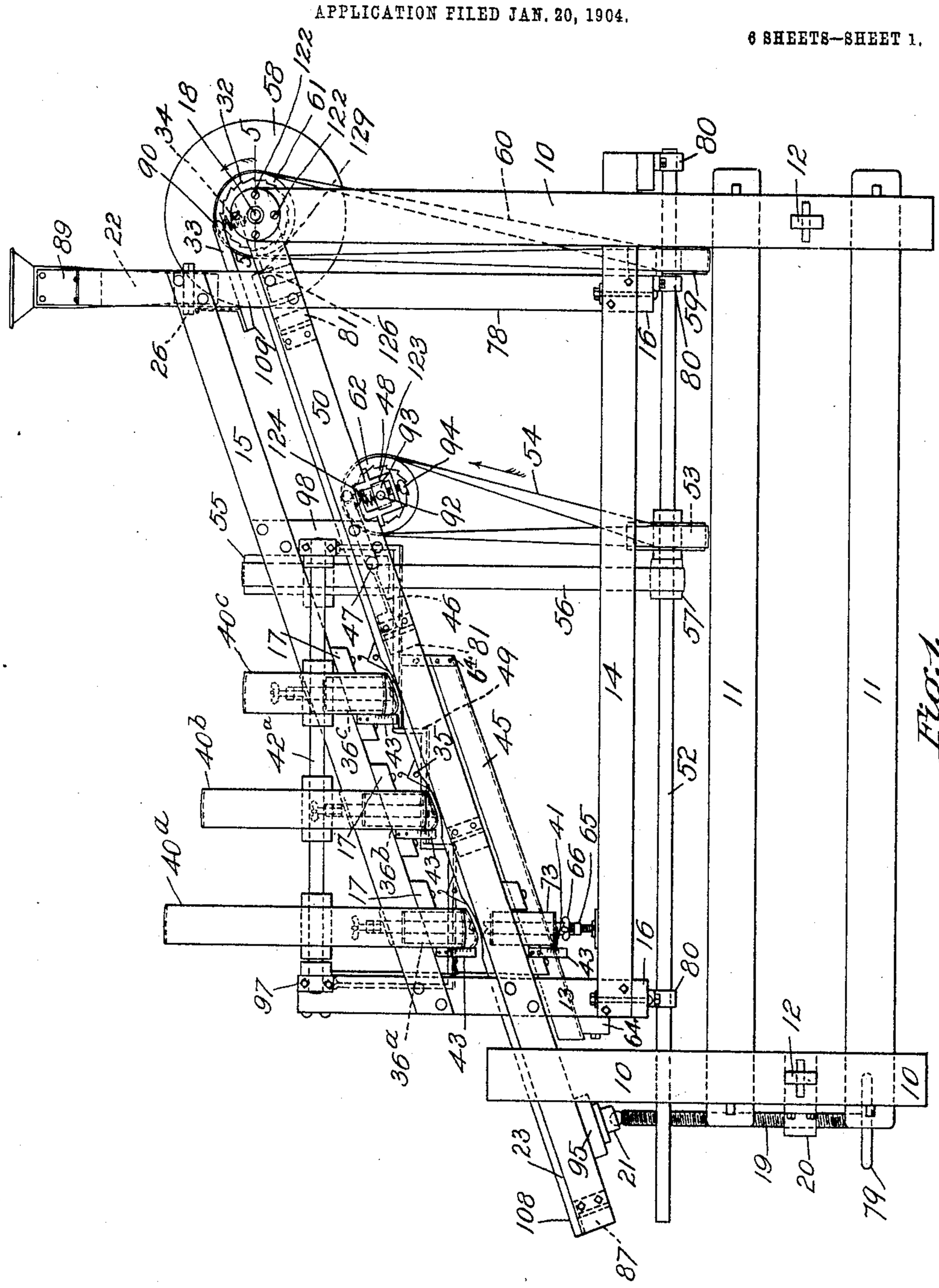

Fig. 1.

Witnesses:
Elmer L. Briggs.
A. G. Sullivan.

Inventor:
Henry F. Campbell
by Chas. F. Perkins
his Attorney

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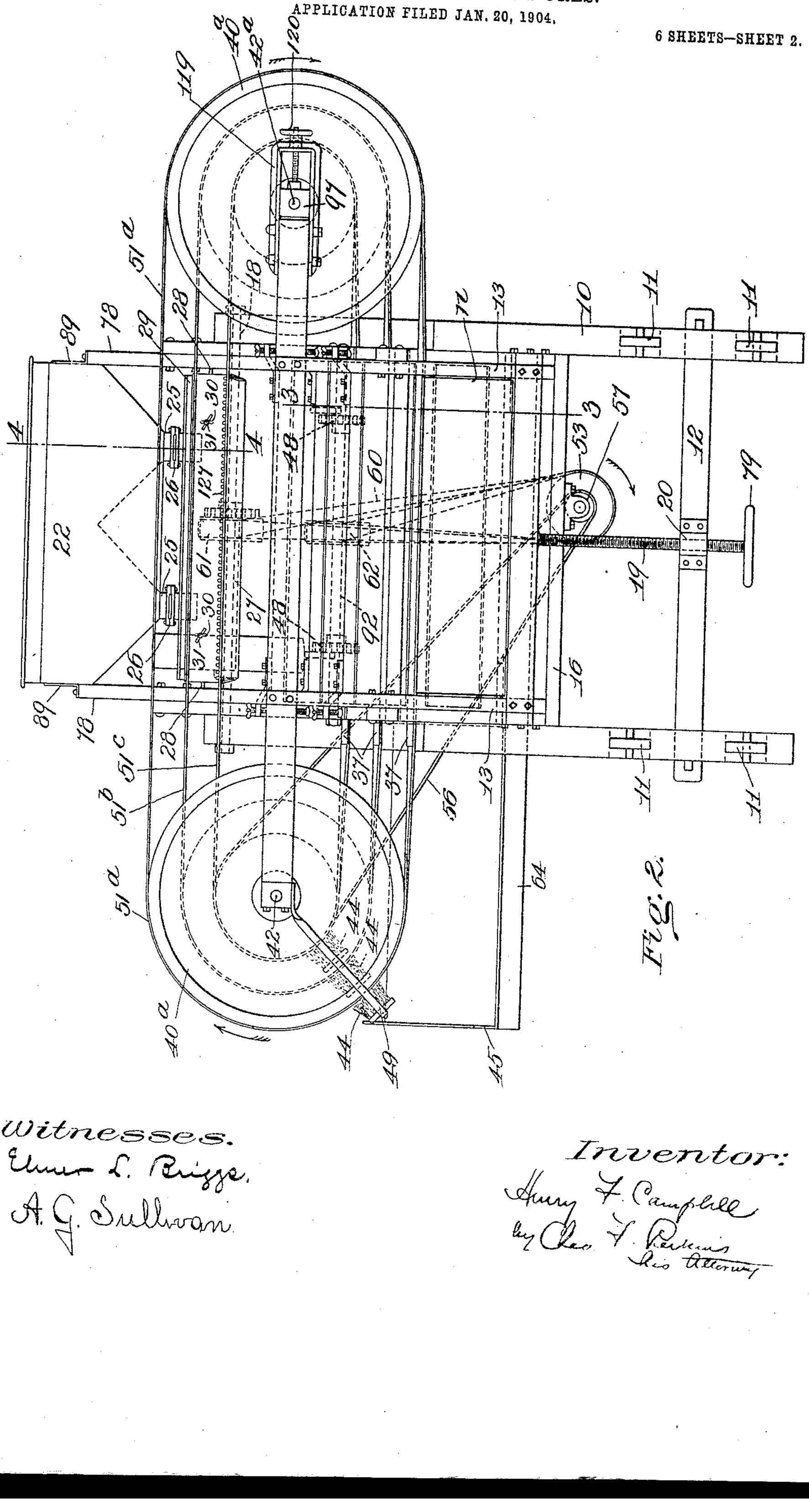

Fig. 2.

Witnesses.
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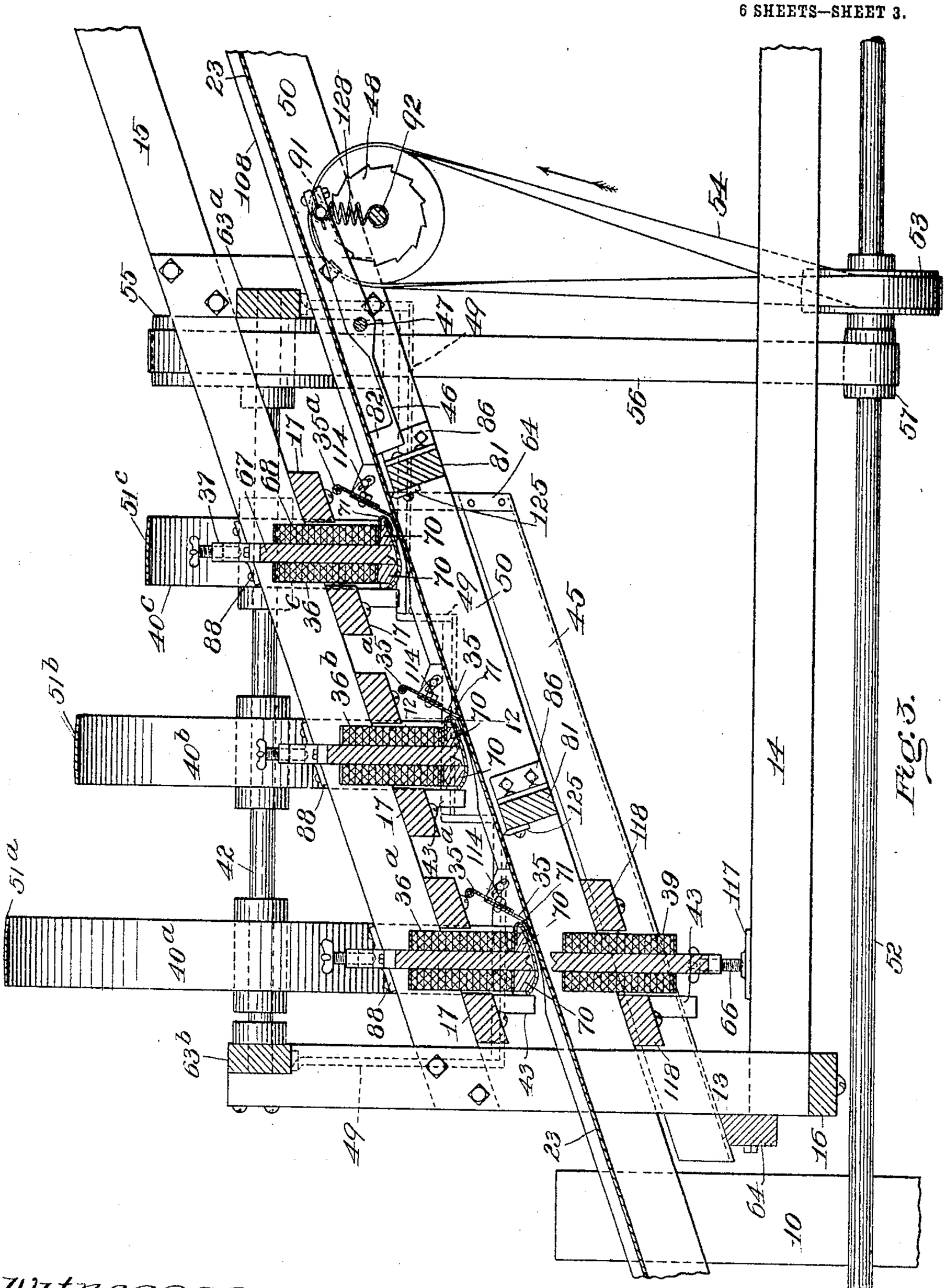

FIG. 3.

Witnesses.

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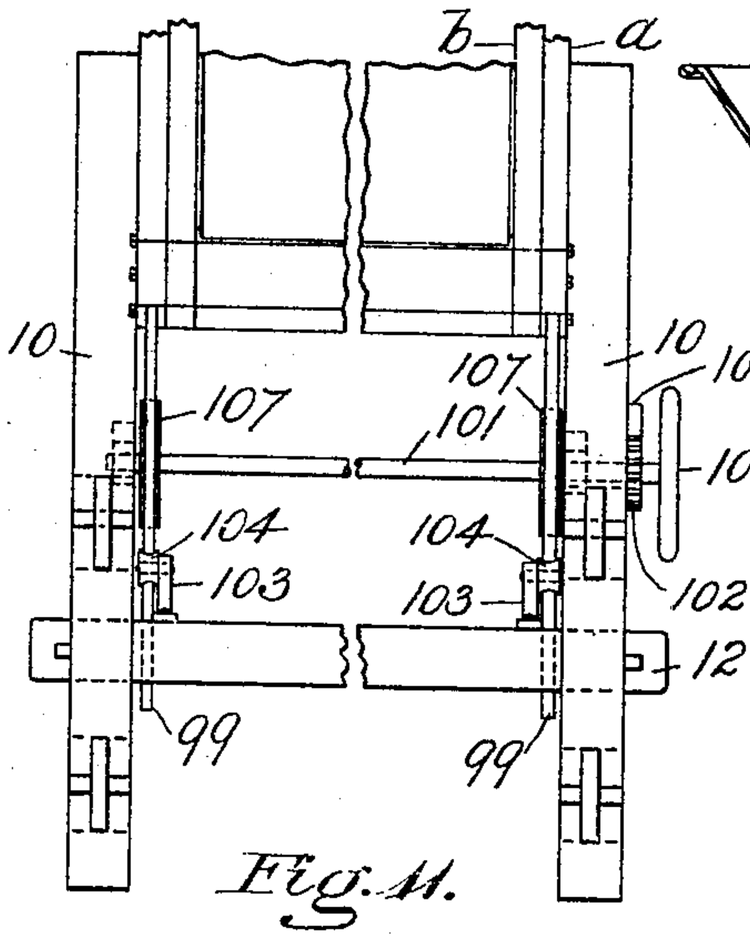

Fig. 11.

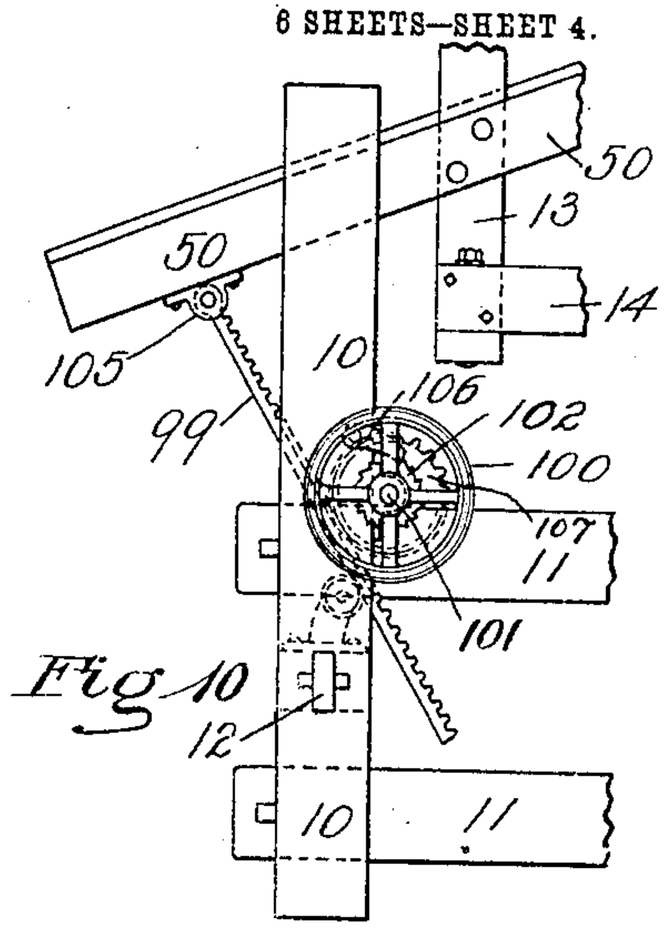

Fig. 10

Fig. 4.

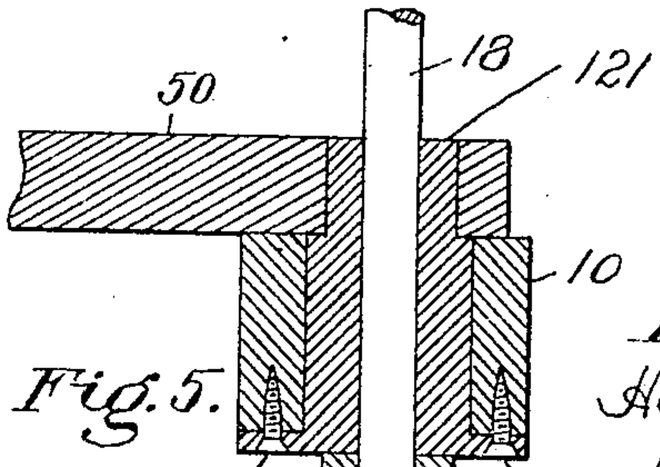

Fig. 5.

Witnesses:
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6 SHEETS—SHEET 5.

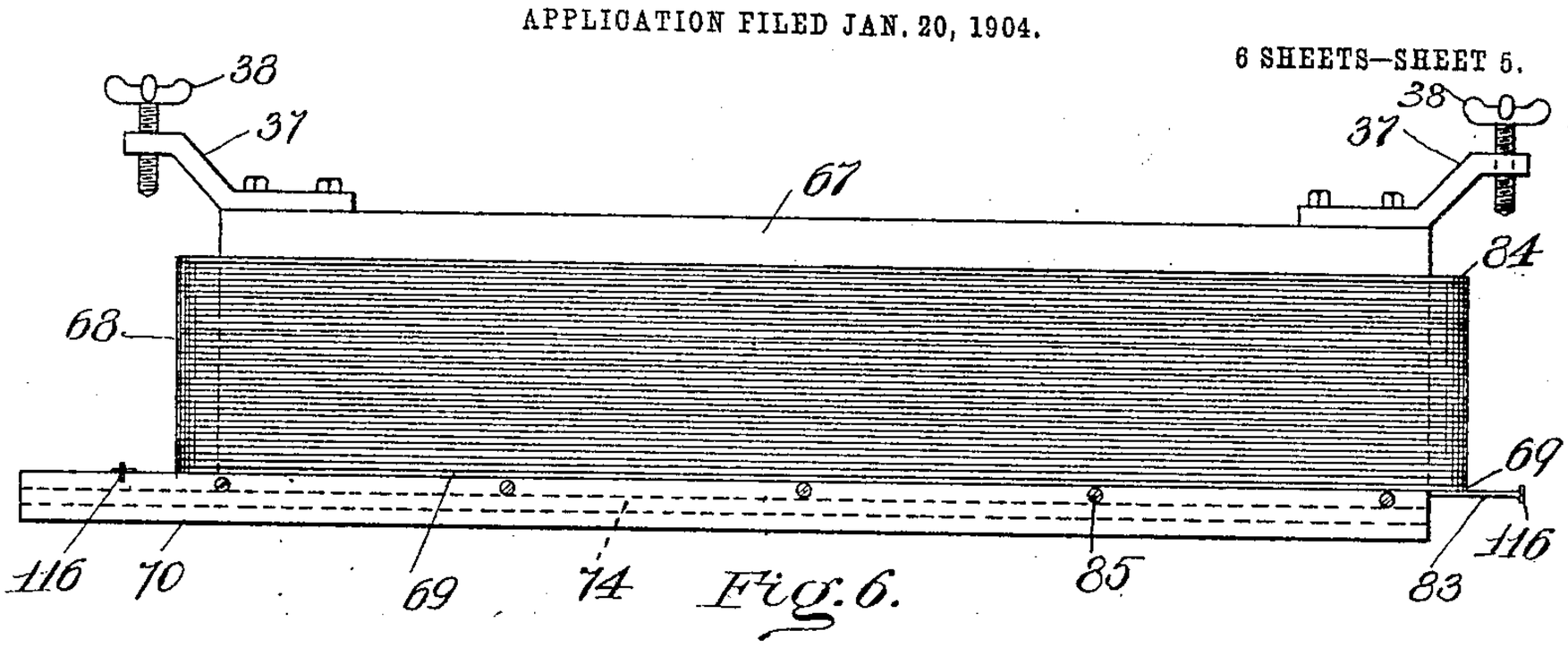

Fig. 6.

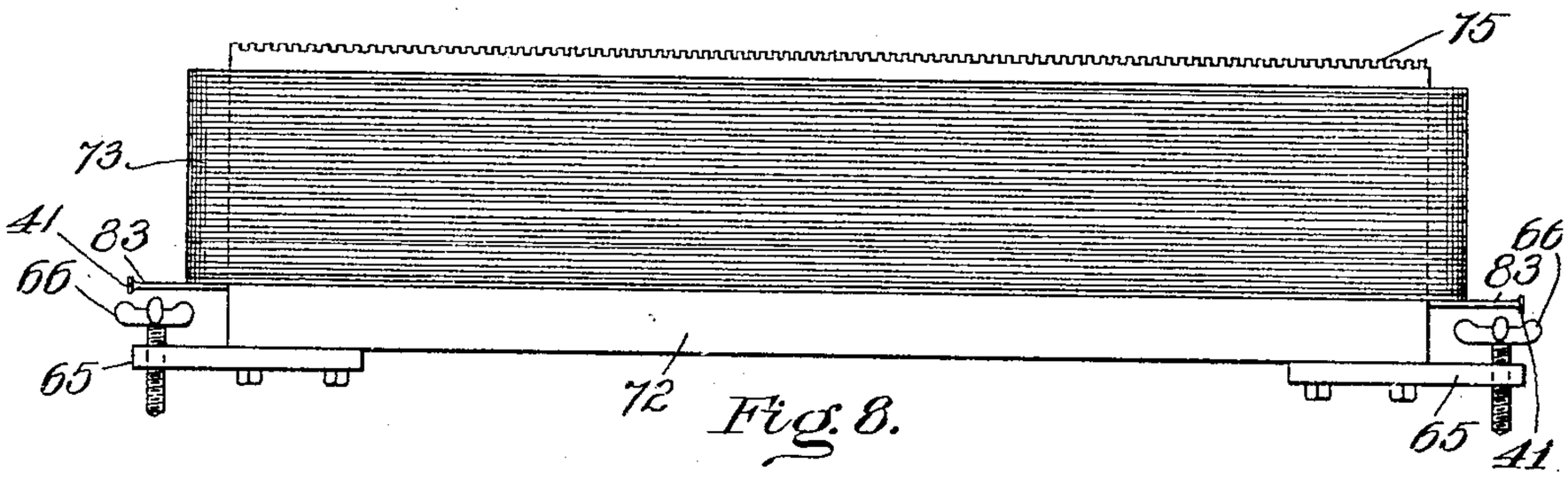

Fig. 8.

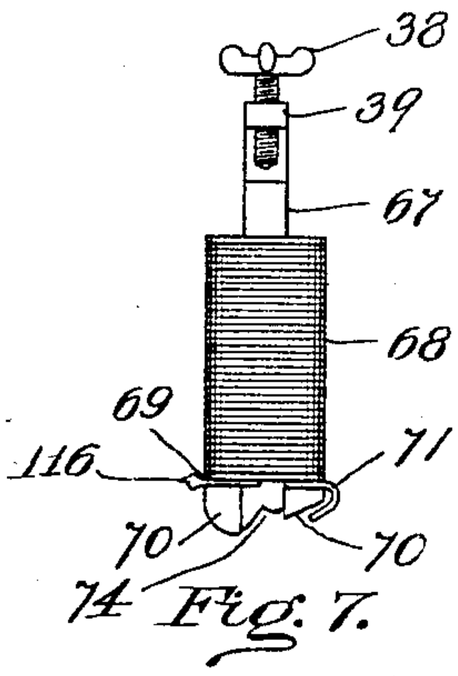

Fig. 7.

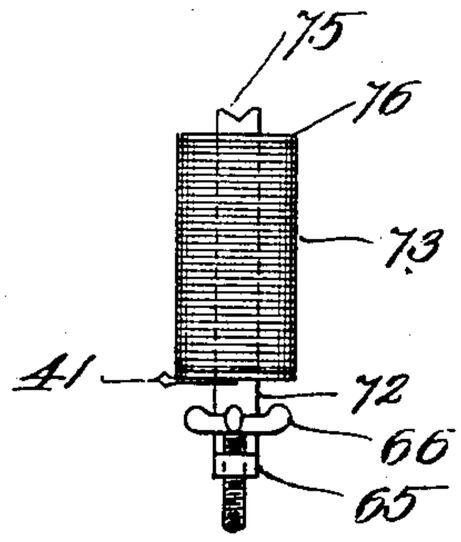

Fig. 9.

Witnesses:
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A. G. Sullivan.

Inventor:
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by Chas. F. Perkins his Attorney

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H. F. CAMPBELL, DEC'D.

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MAGNETIC SEPARATOR FOR ORES.

APPLICATION FILED JAN. 20, 1904.

6 SHEETS—SHEET 6.

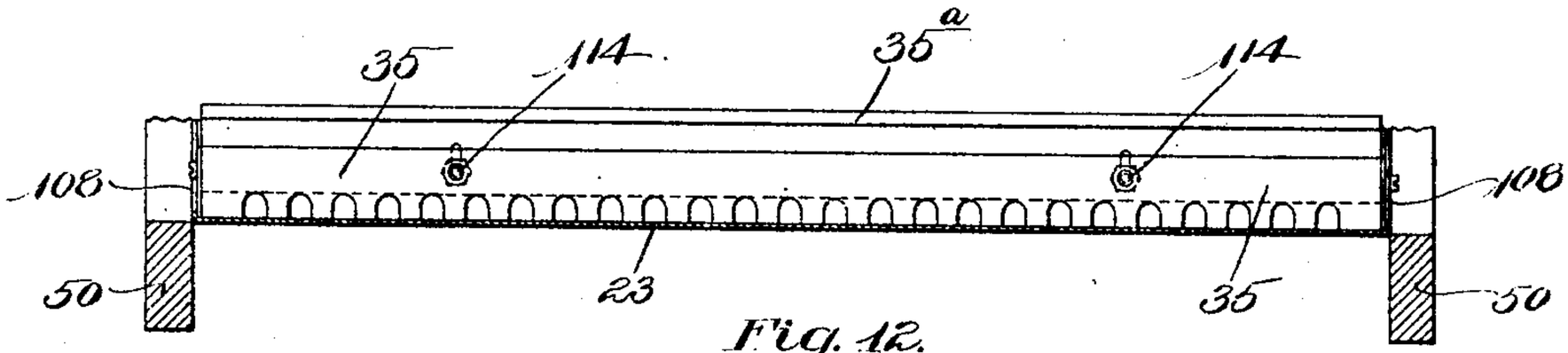

Fig. 12.

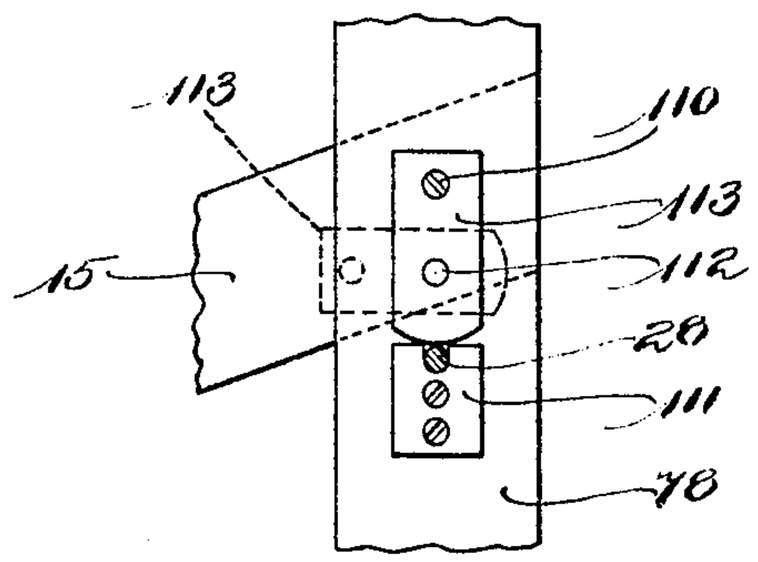

Fig. 13.

Witnesses:
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Edwin A. Curtis

Inventor:
Jeannette L. Campbell, Executrix
of the will of Henry F. Campbell
by Chas. F. Perkins Attorney

UNITED STATES PATENT OFFICE.

HENRY F. CAMPBELL, OF MELROSE, MASSACHUSETTS; JEANNETTE L. CAMPBELL EXECUTRIX OF SAID HENRY F. CAMPBELL, DECEASED.

MAGNETIC SEPARATOR FOR ORES.

No. 805,448. Specification of Letters Patent. Patented Nov. 28, 1905.

Application filed January 20, 1904. Serial No. 189,818.

To all whom it may concern:

Be it known that I, HENRY F. CAMPBELL, a citizen of the United States, residing at Melrose, in the county of Middlesex and State of Massachusetts, have invented new and useful Improvements in Magnetic Separators for Ores, of which the following is a specification.

My invention relates to apparatus for the magnetic separation of pyritiferous and other ores; and the objects of my invention are to adjust at various angles the table over which the ore passes without disturbing the relative positions of the table and the magnets, to agitate and conduct the ore over the table without movement of the same, to provide convenient and accurate adjustments of various parts of the machine, and to acquire strength and economy of construction. I attain these objects by the mechanism illustrated in the accompanying drawings, in which—

Figure 1 is a side elevation of my apparatus, the supply or rear end of the same appearing at the right. Fig. 2 is a front end elevation. Fig. 3 is a longitudinal section of a portion of my apparatus on line 3 3, (see Fig. 2,) showing the magnets, belts, table, and portions of the frame. Fig. 4 is a cross-section of the hopper on the line 4 4 in Fig. 2 and showing certain adjacent parts in elevation. Fig. 5 is a cross-section of the bearing of the main shaft through the line 5 5 in Fig. 1. Fig. 6 is a front elevation of one of the magnets located above the table. Fig. 7 is an end elevation of the magnet shown in Fig. 6 looking from the right. Fig. 8 is a front elevation of the magnet below the table. Fig. 9 is an end elevation of the magnet shown in Fig. 8 looking from the right. Fig. 10 is a side elevation of the front portion of the machine, showing a modification of the means for varying the inclination of the table. Fig. 11 is an end elevation of the portion of the machine shown in Fig. 10. Fig. 12 is a section on line 12 12 of Fig. 3 looking up the table 23 and showing the distributers 35 in elevation. Fig. 13 is a side elevation showing details of plate 111 and button 113.

Referring to the drawings, the main frame of the machine may be of any suitable material and of any desired construction and is here shown as rectangular in shape and composed of four wooden corner-posts 10, supported by two stringers 11 on each side and a cross-piece 12 at each end, all of which are mortised together, as shown, or secured in any desired manner. The adjustable frame is composed of the four uprights 13 and 78, two horizontal stringers 14 at the base, two inclined ones, 50, to support the table, and two inclined stringers 15 above the same to support the magnets, end strips 16, stiffeners 98, and cross-bars 63^a 63^b. The adjustable frame is pivoted at 18, and its lower end may be raised or lowered for the purpose of changing the inclination of the table by means of the screw 19, operated in the nut 20 by the hand-wheel 79. The point of the screw terminates in a ball which is seated in a socket formed in the casting 21, which is secured to the under side of the cross-bar 95 between the inclines 50 of the adjustable frame.

22 is a hopper which is secured by the angle-irons 89 to the top of the uprights 78 on the rear end of the adjustable frame. (See Figs. 1 and 2.)

23 is a flat table or tray for supporting the ore, having flanged edges 108. The table is composed of aluminium, zinc, or other suitable non-magnetic material and lies loosely upon the knife-edge supports 125, three in number, secured to each of the lateral supports 81. These means of supporting the table enable it to vibrate freely in response to the hammer-strokes upon it. The upper extremity of the table 23 is provided with a downwardly-extending flange 129, that hooks over a cross-bar 126, or it may be hinged to it in any ordinary manner.

The hopper 22 is constructed with an inverted-**V**-shaped bottom or division 24 at or about the middle thereof, which divides the hopper into two compartments, each having a spout 25 leading therefrom. (See Fig. 2.) It is apparent that the hopper may be made with more compartments, if desired, and each provided with a spout to discharge the ore into the intermediate hopper 27. Each spout 25 is provided with a joint 26, in which is a horizontal opening to receive the thin sheet-metal valve 77, (see Fig. 4,) which slides freely in said opening to regulate the flow of the material from the hopper.

27 is an intermediate hopper having pivotal studs 28 secured to its ends near its upper edge. (See Fig. 2.) Secured to the inner side of each upright 78 is a plate 111, having a re-

cess cut in its upper edge to form a bearing for the stud 28 on the intermediate hopper 27, in which it may freely turn.

113 is a flat metal button pivoted at 112 to the inner side of each upright 78 and fastened by the screw 110 for the purpose of confining the stud 28 in its bearing. When it is desired to remove the intermediate hopper 27, the screw 110 is withdrawn and the button 113 is swung upon its pivot 112 sufficiently to release the stud 28 and permit it to be removed from the recess in the plate 111.

While I have shown and particularly described a convenient form of device for hanging the intermediate hopper and removing the same, I do not limit my invention to the specific means shown.

The front wall of the intermediate hopper 27 is provided with perforations 127 near the bottom, through which the ore descends onto the shelf 109.

29 is a gate adapted to regulate the flow of the ore from the intermediate hopper. The gate 29 is secured to the inside of the front wall of the intermediate hopper 27 by the bolts 31, extending through the slots 30 and secured therein by means of nuts. The gate 29 may be raised or lowered by releasing the nuts on the bolts 31 and sliding them up or down in the slots 30.

The intermediate hopper 27 is given a rocking motion by means of the ratchet 32, which contacts with the roll 90 on the end of the arm 33, extending from the bottom of the intermediate hopper. The spring 34, having one end secured to the arm 33 and the other to the shaft 18, serves to retain the arm in contact with the teeth of the ratchet 32. The ratchet 32 is secured to or made integral with the pulley 61, which is mounted on and driven by the main shaft 18. It is obvious that other means for rocking the intermediate hopper 27 may be employed without departing from the substance of my invention.

Mounted on the table 23 are distributers 35, which are three in number, each of which consists of a strip of wood or other non-magnetic material extending transversely across the table between the flanges 108 and having perforations therein through which the material may sift along the table. There is one distributer located just above each magnet.

35^a is a gate provided for each distributer 35, which is secured to the same by means of bolts 114 extending through the slots in the distributers 35, said bolts being headed on the outside and provided with a nut on the inside, whereby the gates 35^a may be adjusted and secured upon the distributers so as to regulate the quantity of material flowing through the perforations therein.

The distributer 35 aids in distributing the material uniformly over the surface of the table 23. It is of the greatest importance in the successful separation of magnetic particles from ore that the material should be spread in the thinnest possible layer over the table while within the magnetic field, so that each particle may be free to roll or turn upon the table and to be exposed to the action of the magnet to be influenced by the magnetic field to the best advantage. If but a single layer of material is spread upon the table, all the particles are uncovered, and at the moment they enter the magnetic field they turn or roll in response to the influence of the magnet so as to present their most magnetic point toward the magnet, whereby the entire mass becomes polarized and the particles of ore as they pass under the magnet are presented in the most favorable position to its poles to be lifted out of the mass. If the material in passing under the magnets were several layers deep, not only would the particles underneath be prevented from becoming polarized, but even if they were presented in the most favorable direction to the magnet they would often pass under the pole of the magnet and escape being lifted from the ore by reason of being covered by other layers of material of weaker magnetic character.

36^a 36^b 36^c are electromagnets consisting of the core 67 and the spool 68, connected with a suitable source of power, an enlarged view of which is shown in Fig. 6. To the top of the core 67 and at each end is secured an arm 37, composed of non-magnetic material, by which the magnet is suspended upon the inclined stringers 15. Secured to the upper edge of the inclined stringers 15 are cast pieces 88, having a recess therein in which the point of the screw 38 rests. By means of the thumb-screws 38 the magnets may be raised or lowered with relation to the surface of the table 23, and thereby a very accurate adjustment of the distance may be made of the poles of the magnet from the film of material on the table. The spool 68 is provided with a brass or other diamagnetic plate 84 at the top of the spool and a similar one, 69, at the bottom. (See Fig. 6.) The magnet-poles are provided with wooden guards 70, which are secured to the magnet-poles by brass screws 85, as shown in Fig. 6.

116 is a pointer secured to each of the upper magnets, which serves, in connection with the scales 43, secured to the block 17, to enable the operator to adjust the magnets at a precise distance from the material and to adjust both ends of the magnet equally.

17 represents blocks of wood secured to the under side of the inclined stringers 15 for the purpose of retaining the magnets in a proper position and to prevent them from swinging on their supports. The wooden guards 70 extend slightly below the extremity of the magnet-poles and provide a smooth bearing-surface for the belts 51^a 51^b 51^c and to protect them from being worn or cut by the corners of the magnet-poles. The three upper

magnets are possessed of different degrees of intensity, the magnet 36^a being the strongest, 36^c the weakest, and 36^b of intermediate strength. By this arrangement it is apparent that the most strongly magnetic material in the ore will be lifted out by the magnet 36^c, and the weakest magnetic material remaining in the ore will be removed by the magnet 36^a. After the material passes the magnet 36^a it is practically non-magnetic.

Secured near the lower end of each of the magnets 36^a 36^b 36^c is a shield 71, made of non-magnetic material, to prevent the magnetic material from becoming attached to the magnet by being lifted out of the material before it arrives under the pole. If any of the particles of material during the passage through the magnetic field have a tendency to leap from the ore around the edges of the belts 51^a 51^b 51^c, the shield 71 will prevent it from becoming attached to the magnet and will cause it to fall back upon the table, so that it will be lifted against the belt and carried to one side, as hereinafter described. The magnets 36^a 36^b are wound so as to have a north polarity and the magnet 36^c so as to have a south polarity.

39 is a magnet located beneath the table and constructed in the same manner as the magnets above the table. Secured to the upper surface of the horizontal stringers 14 are castings 117, having a recess therein to receive the point of the screw 66, which is fitted to the arm 65, that is secured to the under side of the pole 72 of the lower magnet 39.

118 represents a pair of blocks secured to the under side of the inclines 50 of the adjustable frame for the purpose of retaining the lower magnet in proper position and to form a vertical guideway in the adjustment of the lower magnet, which is accomplished by means of the screws 66.

The pole of each of the upper magnets is so presented to the table that the distance between it and the table at the point where the material arrives under it is greater than at the point where the material emerges, so that the material enters the magnetic arc at its weakest point and leaves it at its strongest. By this means the more sensitive ore is first polarized and lifted from the mass and the effort of removing the magnetic material is distributed more uniformly over the face of the magnet-pole. At the same time the whole mass is so affected by the magnet that the particles are all polarized preparatory to being lifted and are turned into such position as to be lifted with the least energy.

The magnet-poles have a V-shaped longitudinal groove (see Figs. 7 and 9) and also transverse grooves close together to form serrations, as shown in Fig. 8. The effect of this arrangement is to create projections upon the poles of the magnets having a common polarity, with spaces between them, whereby the tendency is to pull apart any particles of the ore which are attached together and to more effectually separate the magnetic particles and to free the non-magnetic particles which are lodged between or attached to them. The lower magnet 39 possesses an opposite polarity to that of the upper magnet 36^a, whereby the magnetic field of the magnet 36^a is intensified or diminished, as desired, by raising or lowering the lower magnet 39. The lower magnet is provided with an index-finger 41, which in conjunction with the scale 43 enables the magnet to be accurately adjusted in the manner described for the upper magnets.

42 is a shaft mounted in bearings secured to the extremities of the cross-bars 63^a 63^b. In the opposite extremities of the cross-bars 63^a 63^b are adjustable boxes 97, in which the shaft 42^a is journaled. The box 97 is fitted to a bracket 119 so as to slide therein and is adjustable by means of the screw 120, so as to take up the slack in the belts 51^a 51^b 51^c and to keep them taut. On the shaft 42 are mounted three wooden pulleys 40^a 40^b 40^c, and on the shaft 42^a are mounted similar wooden pulleys, over which run, respectively, the belts 51^a 51^b 51^c. These belts are composed of canvas, rawhide, or other suitable material and serve to carry the magnetic material to one side of the table after it has been lifted therefrom. It will be observed that the pole of each of the upper magnets is provided with an extension-piece 37 of magnetic material, which projects beyond the edge of the table on one side, so as to insure the attachment of the magnetic material to the belts until after it has been carried well beyond the edge of the table. The pole of each upper magnet extends to the edge of the table on the other side, but not beyond, so that the entire width of the table is at all times covered by the magnet-pole. I am able to do this with a stationary table. If the table were oscillated laterally, the material for a narrow space at one side of the table would not be constantly under the magnet-pole, but only intermittently, unless the magnet extended beyond the edge of the table on both sides. In the former case some of the magnetic material would escape the magnet, and in the latter the material would have a tendency to leap over the edge of the table and be lost. After the material has been carried by the belts out of the influence of the magnetic field it drops into the receptacle 45, which is hung from the under side of the adjustable frame by the support 64 or in any other suitable manner. The receptacle 45 is supported in an inclined position, so as to insure the discharge of its contents by gravity. The receptacle 45 is made of sufficient length to catch the material from all the belts. It is desirable to keep the belts taut in order to preserve a fixed distance between the surface of the material upon the ta-

ble and the surface of the belts. I desire to emphasize the importance of this feature in connection with the construction of the table, whereby no movement is imparted to the table which will vary the distance between its surface and the surface of the magnet-poles or the belts which run over the same. I am enabled by these means to preserve at all times during the passage of the material over the table a fixed distance between the material and the magnet-poles and can predetermine this distance to a nicety.

The shaft 42 is driven by the pulley 55 and the belt 56 and the pulley 57, mounted on the shaft 52.

58 is the main pulley, which is mounted on the driving-shaft 18, from which the shaft 52 is driven by the belt 60.

44 represents three brushes mounted upon a frame 49, and thereby supported in contact with the belts 51^a 51^b 51^c, respectively, for the purpose of removing the ore from the belts which may cling thereto and would otherwise be carried beyond the receptacle 45. The adjustable frame is hinged to the upper posts 10 by means of a bearing provided at the ends of the inclined stringers 50, which is fitted to the bushing 121, which is provided with a flanged head secured to the upper posts 10 by the screws 122. (See Fig. 5.) By this arrangement the weight of the adjustable frame is not carried upon the shaft 18, but is borne by the bushing 121.

Mounted on the shaft 92 are two ratchet-wheels 48, the teeth of which engage with a roll on the end of a hammer 46, which is pivoted on a rod 47, extending between the inclined stringers 50 beneath the table 23. The hammer 46 is composed of any suitable material, but preferably of wrought-iron or steel, the handle of which is thin and flexible between the head 82 and the pivot 47. The said pivot may be journaled in an adjustable box supported in a bracket and secured beneath the table in the same manner as the shaft 92 is journaled in the box 93 and secured by suitable means to the inclined stringers 50, as hereinafter set forth. The head 82 of the hammer 46 is normally maintained in contact with the under side of the table by the spring 128, which is connected with the shaft 92 and with the stud 91 on the end of the hammer. The rotation of the ratchet 48, coöperating with the spring, produces rapid strokes of the head of the hammer upon the under side of the table, thereby causing the table to be jarred without actually lifting or moving the table itself. It produces a strong vibration in the metal forming the bottom of the table, which causes a violent agitation in various directions of the material passing over it, thereby aiding in distributing the material over the table in a thin layer or film, causing it to gradually descend over the table and facilitating the polorization of the magnetic particles of the ore by permitting a freedom of movement in response to the influence of the magnet. Heretofore it has been my practice to impart to the table or tray over which the ore is conveyed a reciprocatory movement. The arrangement of the table whereby it is fixed against movement in any direction insures more reliable means of preserving a fixed distance between the poles of the magnets and the material on the table than any arrangement in which the agitation of the ore depends upon a reciprocating movement of the table itself.

I do not limit my invention to the particular form of the devices employed for causing the table to be jarred or vibrated, as it is obvious that a great variety of forms of devices may be employed for that purpose, the chief requisite being that it is capable of imparting a rapid succession of blows upon the table sufficient to agitate the ore without moving the table appreciably.

The shaft 92, on which the ratchet 48 is mounted, is journaled in a box 93, which is arranged to slide vertically in the bracket 123, which is secured to the under side of the inclined stringers 50. A spiral spring 124 is confined between the box 93 and the end of the bracket 123, and the box 93 may be raised by the screw 94, thereby varying the intensity of the stroke imparted by the hammer 46 to the table 23.

In Figs. 10 and 11 I have shown a modification of the means of raising and lowering the table which are illustrated in Fig. 1. Referring to Figs. 10 and 11, 101 is a shaft journaled in brackets secured to the posts 10 and carrying thereon the hand-wheel 100, the ratchet 102, and the pinions 107. The teeth of the pinions 107 mesh into the teeth of the rack 99, which is pivoted in the bracket 105, that is secured to the under side of the inclined stringers 50. An idler 104 is mounted on a bracket 103 for the purpose of sustaining the teeth of the rack in contact with the pinions 107. This arrangement is readily accessible to the operator and furnishes a convenient means for accomplishing the result.

In the operation of my machine the ore is finely comminuted and charged into the hopper 22, from which it is delivered through the spout 25 into the intermediate hopper 27. My machine is especially adapted for the separation of pyritiferous ores which have been rendered magnetic by artificial heat, although it is adapted to the separation of ores which contain magnetic constituents of whatever origin. To accomplish the best results, it is necessary to ascertain the precise constituents of the ore and to adjust the mechanism with reference thereto. Sometimes the waste materials in the ore are highly sensitive to the influence of a magnetic field by reason of being combined with infinitesimal particles of magnetic material that are not worth saving

at the expense of carrying with them so large quantities of waste material, and to avoid this it becomes necessary to diminish the strength of the magnetic field, which is accomplished either by raising the upper magnets from the surface of the table or lowering the magnet beneath the table, or both. With the various provisions contained in my machine for adjusting the different parts I am able to adapt it to the separation of a given ore so as to attain the most profitable results. Having adjusted the magnets to the peculiarities of a given ore, the material is allowed to descend from the intermediate hopper from which it is shaken in a fine shower onto the shelf 109, thereby spreading it thinly thereon, from which it falls upon the table 23, which is being jarred and vibrated by the blows of the hammers, so as to cause an agitation of the particles of ore the moment they alight upon the table 23, which agitation is continued during the passage of the ore along the entire length of the table. The combined effect of delivering the material from the intermediate hopper upon the table in a well-separated state and in a fine shower, the vibration of the table, and the action of the distributers is to cause the material to be spread across the entire surface of the table in a single layer by the time it reaches the field of the first magnet and to be in the same condition when passing through the fields of the second and third magnets and presenting the appearance of emery-paper, but with the particles in a quivering state. If the material has any tendency to form into reefs or windrows before reaching the first distributer, this tendency is overcome by the distributer, which arrests the material and redistributes it through its perforations, so that the material passes under the first magnet 36^c in a single layer and the strongest magnetic particles are lifted therefrom and carried aside by the belt 51^c and discharged into the receptacle 45. The same operation takes place under each of the magnets 36^a and 36^b, and the non-magnetic material is discharged from the end of the table 23.

What I do claim as my invention, and desire to secure by Letters Patent, is—

1. In a magnetic ore-separating machine the combination of a magnet, a flat table composed of non-magnetic material located beneath said magnet and secured against movement in the plane of the surface of said table, means for jarring the table without bodily raising the same and means for causing a film of comminuted ore of substantially uniform thickness to travel along said table and for presenting the said ore to the action of the magnet while separated from its poles by an intervening space.

2. In a magnetic ore-separating machine the combination of a magnet, a flat table composed of non-magnetic material located beneath said magnet and secured against movement in the plane of the surface of said table, means for jarring the table without bodily raising the same, said means for jarring consisting of a hammer pivotally mounted and normally held in contact with the table by a spring and moved from it by the teeth of a ratchet, and means for causing a film of comminuted ore of substantially uniform thickness to travel along said table and for presenting the said ore to the action of the magnet while separated from its poles by an intervening space.

3. In a magnetic ore-separating machine the combination of a magnet, a flat table composed of non-magnetic material located beneath said magnet, said table resting freely upon knife-edge supports and secured against movement in the plane of the surface of said table, means for jarring the table without bodily raising the same and means for causing a film of comminuted ore of substantially uniform thickness to travel along said table and for presenting the said ore to the action of the magnet while separated from its poles by an intervening space.

4. In a magnetic ore-separating machine the combination of a magnet, a flat table composed of non-magnetic material located beneath said magnet and secured against movement in the plane of the surface of said table, means for jarring the table without bodily raising the same, and means for causing a film of comminuted ore of substantially uniform thickness to travel along said table and for presenting said ore to the action of the magnet while separated from its poles by an intervening space, the said magnet extending across the entire width of said table and projecting beyond one edge only thereof.

5. In a magnetic ore-separating machine the combination of a magnet, a flat table composed of non-magnetic material located beneath said magnet and secured against movement in the plane of the surface of said table, a main hopper for the material located above the table at its receiving end, and an intermediate hopper pivotally supported beneath the main hopper and above the table, and means for rocking the intermediate hopper consisting of an arm projecting therefrom and maintained in contact with the teeth of a ratchet-wheel by a yielding pressure, means for jarring the table without bodily raising the same, and means for causing a film of comminuted ore of substantially uniform thickness to travel along said table and for presenting said ore to the action of the magnet while separated from its poles by an intervening space.

6. In a magnetic ore-separating apparatus, a magnet, a stationary table beneath the magnet, means for jarring the table consisting of a hammer pivotally mounted in a bearing provided with means for adjusting the bearing toward and away from the table.

7. In a magnetic ore-separating apparatus, one or more magnets, a table secured against

movement in the plane of its surface, said table being located beneath the said magnets and separated from the poles thereof by an intervening space and means for jarring the table and agitating the particles of ore thereon, consisting of a hammer pivotally mounted, the handle of said hammer being flexible between the head and its pivotal point, and rigid beyond the same.

8. In a magnetic ore-separating apparatus, a magnet, a table secured against movement in the plane of its surface, said table being located beneath the said magnet, means for jarring the table consisting of a hammer mounted upon a pivot, said pivot being journaled in a box supported in a bracket secured beneath the table, a spring confined between said box and the inside of said bracket, and a screw connected with said box and adapted to adjust the same vertically within the bracket.

9. In a magnetic ore-separating apparatus, a magnet, a table beneath the same, a main hopper for the material located above the table at its receiving end, and an intermediate hopper pivotally supported beneath the main hopper and above the table in a recess formed in a plate secured to the inner side of an upright, said recess being closed against the removal of the hopper by the button secured to said upright, said button being arranged to swivel for the purpose of releasing the intermediate hopper when desired.

In testimony whereof I have hereunto set my hand, in presence of two subscribing witnesses, this 7th day of January, 1904.

HENRY F. CAMPBELL.

Witnesses:
CHARLES C. BARTON,
A. G. SULLIVAN.