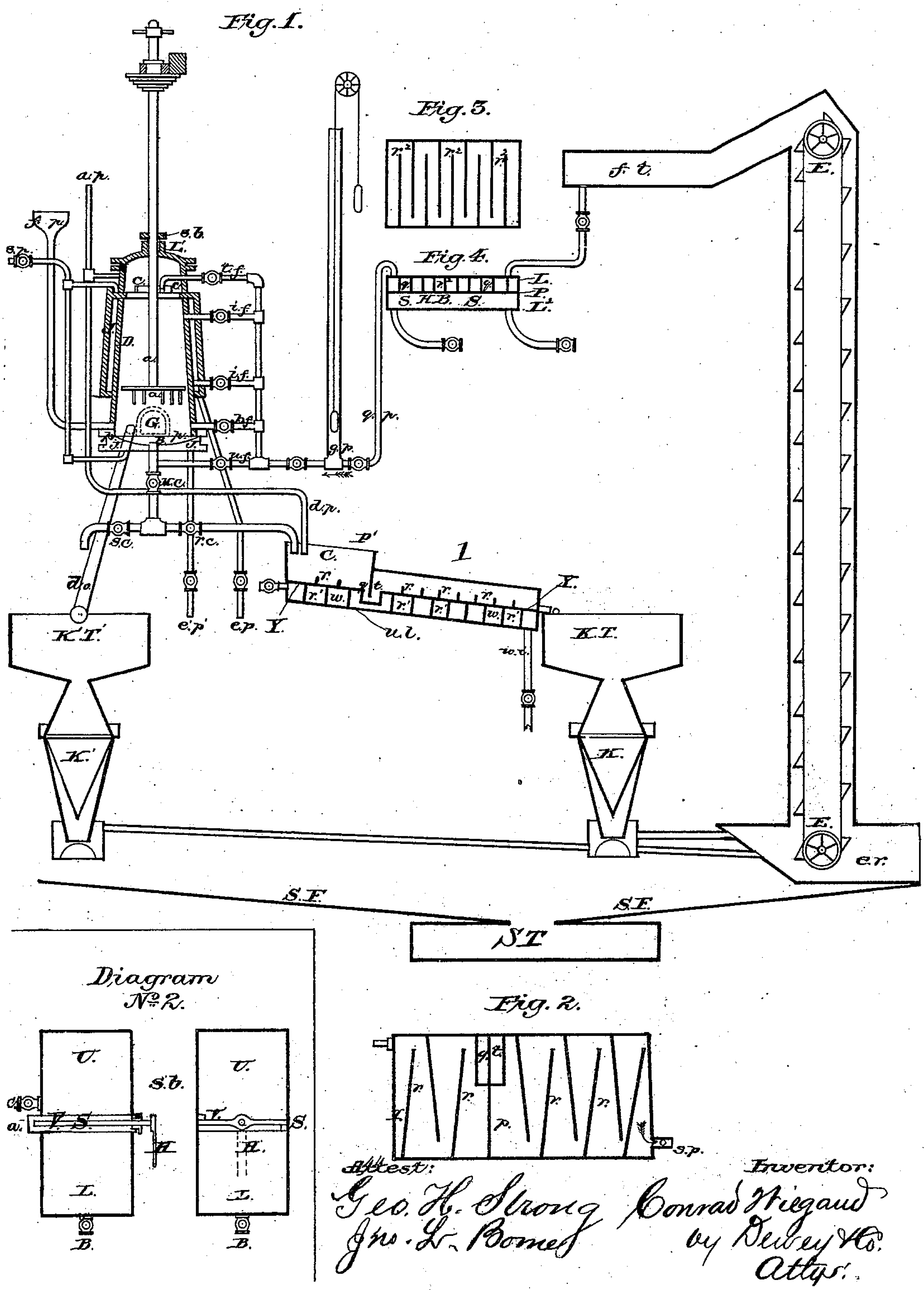
C. WIEGAND.
Process of Separating Metals.

No. 196,848. **Patented Nov. 6, 1877.**



UNITED STATES PATENT OFFICE.

CONRAD WIEGAND, OF VIRGINIA CITY, NEVADA.

IMPROVEMENT IN PROCESSES OF SEPARATING METALS.

Specification forming part of Letters Patent No. **196,848**, dated November 6, 1877; application filed July 28, 1876.

To all whom it may concern:

Be it known that I, CONRAD WIEGAND, of Virginia City, Storey county, Nevada, have invented an Improved Method or Process for Separating Metals, or the amalgams of metals, from each other; and I hereby declare the following description, with reference to accompanying drawings, to be sufficient to enable any person skilled in the art to which it most nearly appertains to understand and use my said invention, and to avoid an unwitting invasion or infringement of my rights therein or thereunto appertaining.

The method herein described is necessarily a complement of an allied or somewhat similar process for the mercurial separation of silver from other metals, for which process Letters Patent No. 145,265 were issued by the United States to me December 2, 1873, and reissued as 5,934, June 23, 1874. That process can scarcely be successfully operated without a simultaneous action or conduct of the process herein described; nor can either process be plainly described without the use of so many terms and phrases which are similar that a description of either process must be compared closely with that of the other to note the differences. In like manner, the apparatus herein described embraces among novelties certain features which have been described in the above-recited patent and reissue, or in Letters Patent of the United States issued to me October 11, 1875, and numbered 168,695, the same being for a process by which to separate gold from other metals.

The process herein described embraces the following steps:

First, the amalgamation of the metals which are to be separated from each other, and thinning the amalgams to a point of free mobility of particles among themselves, by using an excess of quicksilver as a solvent, without or with heat, howsoever applied, with or without trituration or agitation, and with or without the addition of other metals or amalgams having a molecular tendency to the disintegration, solution, or mechanical suspension in quicksilver of the amalgamated metals which are to be separated from each other; also, in maintaining free mobility of the particles among each other in quicksilver, either by heat or agitation, or by showering, pouring, or otherwise introducing quicksilver (cold or hot) into the vessel containing the thinned amalgam, or by any combination of these resorts with each other, having for its object the separation of the amalgams from each other.

Second, when the differing specific gravities of the amalgamated metals which are to be separated do not lead to a gravitative separation by flotation and subsidence—the lighter amalgams floating, while those denser than quicksilver sink—the maintaining of a regulated current or circulation of quicksilver within and through the vessel containing the thinned amalgams.

Third, the collection (by straining, by crystallization, or by deposition) of such portions of amalgam as may separate by flotation or subsidence, or of such portions as may be separated from each other by the current of quicksilver above slluded to.

Fourth, retorting the separated amalgams, that the metals contained may be melted.

The process above summarily described can be made plain in its operation more readily by a properly-described diagram of the apparatus adapted to it than by other means.

Diagram No. 2 represents a very simple form of apparatus adapted to the separation of mixed amalgams, one of which is lighter and the other denser than quicksilver. S represents a side view of an upright vessel, and S′ a front view of the same. This vessel is furnished with a valve similar to an ordinary stove-pipe damper or a "butterfly" valve, turning on an axis-shaft, *a*, in its middle.

H represents a handle, by which it may be turned from the outside. The axis-shaft *a* passes through a stuffing-box, *s b*, designed to make a quicksilver-tight joint.

B and C represent stop-cocks, through which to draw off the quicksilver and suspended amalgams after a gravitative separation has taken place.

When the valve V is edge up, it is plain that if highly fluid mixed amalgams are placed in the vessel S, and that if it then be filled up with quicksilver, the amalgams which are lighter than quicksilver will float to the top of compartment U, while those which are denser will sink to the bottom of compartment L. The separation having been effected, the valve V may be closed and the contents of U drawn off through C and strained. Afterward the contents of L, drawn off through B, may also be strained.

In practice, the above form of apparatus is less generally useful than that represented in Diagram No. 1. The reason is, but few amalgams are denser than quicksilver. While the densities of different amalgams are unlike each other, with certain exceptions, (not necessary herein to specify,) they are specifically lighter than quicksilver. In consequence, if a number of mixed metals be amalgamated, and the amalgams be reduced to mercurial fluidity, as above, and if in this state the mixed amalgams be fed in at the bottom of a vessel charged with quicksilver, almost all of them would float upward. The specifically lightest would rise most rapidly, and at the surface they would be found measurably arranged in zones, layers, or tires. Copper amalgam, for instance, is specifically lighter than silver amalgam, yet when neither is crystallized both are lighter than quicksilver. Both, therefore, when not affected by crystallization, rise in quiescent quicksilver.

The upward motion of copper amalgam might be denoted by ten units per minute. The flotative tendency (or upward motion in quiescent quicksilver) of silver amalgam should then be denoted by about two units per minute. In quiescent quicksilver, therefore, time and opportunity afforded, copper amalgam will ride higher than silver amalgam in a separating-vessel containing quicksilver. In such a vessel as that shown by Diagram No. 2 both would be found in compartment U. Such a vessel, therefore, could not effect a perfect—scarcely a useful—separation of copper and silver amalgams. But it is obvious that if, while both the copper and silver amalgams are rising with respective speeds, ten and two, they should be compelled to rise through sinking quicksilver—that is, through a slow downward current of quicksilver—instead of through standing quicksilver; and if the downward current or sinking of the quicksilver be five units per minute, the net upward motion of the copper amalgam in the vessel would be reduced from ten to five, while the upward motion of the silver amalgam would be entirely overcome, and it would be carried out of the vessel in the current with a speed of three degrees per minute, and thereby be separated from the copper amalgam.

To effect a separation of fluid amalgams, therefore, provided their specific gravities differ from each other, it is only needful to submerge them in a slow current of quicksilver. If both amalgams are lighter than quicksilver, or if one is lighter and the other is heavier or denser, the current should be directed downward. If both are denser than quicksilver, the current should be directed upward, as will more fully appear hereinafter. The downward current should be speeded at a less rate than the flotative speed of the lighter amalgam, while at the same time at a greater speed than the flotative speed of the denser. When an upward current is necessary, it should be speeded at a greater rate than the subsiding tendency of the less dense amalgam, but at a slower rate than the subsiding tendency of the denser amalgam.

An apparatus designed both to create and regulate these currents, and to control them in either direction, is represented in diagram No. 1 herewith.

D represents an upright vessel, which may be termed the "digester." Its sides are impervious to quicksilver—preferably of iron, smoothed inside—and furnished with a movable lid, L′, bottom B, and gate G, this gate opening sidewise.

Between the lower end of the digester and bottom B a perforated iron plate, *p*, is represented, the joint being made quicksilver-tight, as is more fully described and represented in the patents hereinbefore referred to. This plate does not arrest the passage of quicksilver, or of amalgam in chemical solution, or of amalgam finely comminuted; but it does prevent any lumps of amalgam finding egress. In this respect it operates as do the meshes of a straining-cloth when inserted at this point. Provided the amalgams to be separated are lighter than quicksilver, if a large excess of quicksilver is maintained in the digester, no straining-cloth or perforated screen or plate is necessary, although in general it is desirable.

Both the digester D and the bottom B should be furnished with jackets J J J, designed to heat and cool by. Water or steam, of regulated temperature, or hot air or oil admitted therein and caused to circulate through the pipe *s p* and exhausting through the exhaust-pipes *e p* and *e′ p′*, will heat the digester, and, when desired, a current of cold water will cool it.

Through the gate G the residuary amalgam, after a separation has been effected, may be removed. For the same purpose, when found more convenient, a draw-off pipe, *d o*, may be inserted in or near the bottom of the digester, through which, aided by the agitator *a a*, as represented, and assisted by a shower or stream of quicksilver, as provided for by the elevator E E, &c., the residuary amalgam may be, in good part, washed out, without opening the side gate G.

The lid L′ should also be furnished with a stuffing-box, *s b*, through which the shaft or spindle of a revolving and adjustable agitator may pass. (See *a a*.)

Beneath the lid it is desirable to introduce a perforated iron plate, in the middle of which a rim is raised to form a central colander, *c c*, so that quicksilver, when fed in at that point, is showered into the digester, and so, also, that crystals of amalgam at proper times may be put therein to be dissolved by the stream of hot quicksilver which may be fed in there.

The digester should also be furnished with a top feed, *t f*, a bottom feed, *b f*, and an under feed, *u f;* also with a feed-pipe, *f p*, for feeding in dissolved amalgam at the bottom, and a stand-pipe or gage-pipe, *g p*, designed to carry a float, which can be made to show the level of the quicksilver and amalgam in the digester. This pipe should be attached to the quicksilver-pipe *q p*, in such a way that the inward flow of quicksilver to the digester across the foot of the pipe will prevent amalgam backing from the digester, which would derange the indications of the float by clogging the pipe *g p*.

As an adjunct for heating, the feeding quicksilver, as it passes from the feeding-tank *f t*, may be passed through one or more heating-boxes, H B, Fig. 4, one side of which, *s s*, is a steam-chamber. On the other side of the partition P, in *q q*, Fig. 4, the quicksilver circulates by pressure from the feeding-tank *f t*. A top view of this heating-box is shown in Fig. 3, showing ribs underneath the lid L.

The bottom of the digester is furnished with a pipe bearing the main stop-cock M C, by which the flow of quicksilver from the digester can be arrested without deranging speed-adjustments elsewhere. Besides this main cock, on branches of the same pipe are two smaller stop-cocks. One, *s c*, is a sampling-cock, designed to draw off a sample of what is passing with the quicksilver to the cooler, so that the nature, quantity, and quality of amalgam passing at any moment may be determined without arresting the operation of the apparatus. This cock may be located elsewhere than as represented in the diagram. The other small cock *r c* is the regulating-cock, by means of which the downward speed of quicksilver in the digester may be controlled. This stop-cock delivers quicksilver to an iron cooler, C.

The cooler C is an iron tank. Ribs or partial partitions *r r r r*, in Figs. 1 and 2, and which run part way across the cooler, are set on the upper side of its bottom, so that the quicksilver running from *r c* into the cooler at I must traverse the cold-iron surface before finding outlet at O, Figs. 1 and 2.

Water confined by the partition P′—itself furnished with a trap, *q t*—covers at least a portion of the cooler-surface. The intention of confining this water is to prevent fumes of mercury rising in the air. It is discharged hot beneath the surface of the water, whose temperature is kept low.

On the under side of the cooler *w w* cold water is made to circulate, so that after passing through the cooler the quicksilver from *r c*, bearing in or with it amalgam, is ready to be strained in the sack or collector K. The amalgam remains in the sack, and the quicksilver runs through to the elevator-reservoir *e r*, whence it is carried by the elevator-buckets to the feeding-tank *f t*, and thence to the digester, as rapidly as it flows out of *r c*.

The quicksilver, when preferred, may be lifted to the feeding-tank by a properly-adapted pump.

By the foregoing appliances the circulation of quicksilver is continued at a duly-regulated speed, and at proper points of inflow, until the desired separation of amalgams is completed, or till carried to a point at which a further separation ceases to be profitable.

The prompt separation of amalgams depends largely upon comminution of the mixed amalgams. The simplest method for this is to grind cold, with a covering of water in an amalgamating-pan. The addition of a small amount of sodium, or of sodium amalgam, or of zinc amalgam while grinding is helpful when the amalgams to be separated have formed themselves into hard cakes. When ground fine, it should be diluted with quicksilver, and fed into the digester as soon as possible after grinding, in order to avoid the reformation of cakes and crystals. For ordinary working, before amalgam is introduced the digester should be charged with heated quicksilver.

S F, in Diagram No. 1, represent an iron (or an iron-covered) floor, shedding toward and emptying into a safety-tank, S T, and more particularly described in the patents hereinbefore referred to.

Fig. 3, in Diagram No. 1, represents a top view of the cooler C; and *q t*, in Figs. 1 and 2, represent the quicksilver-trap for water, through which quicksilver flows freely, but water cannot, because buoyed away by the quicksilver from the aperture. *w i* represent the water-inflow beneath the bottom of the cooler. r^1 r^1 r^1 r^1 represent ribs on the under side of the cooler-bottom Y Y, which, in connection with the under lid *u l*, form a water-channel, and compel the cooling-water to move under the entire surface of the cooler-bottom. *o* is the outflow of the spout or pipe through which the cooled quicksilver is delivered to the collector-tank K T, which tank is made capacious to guard against accidents or breakage in the apparatus above it.

Several straining-sacks or collectors may be attached to the same collector-tank to avoid delay in cleaning up. Common wooden plugs are sufficient to arrest the flow of quicksilver into any collector.

Figs. 3 and 4, Diagram No. 1, represent top and side views of the heating-box H B for heating quicksilver on its way to the digester. The partition between the quicksilver-compartment *q q* and the steam-chamber *s s* is marked P. The upper lid is marked L, and the lower lid L^2. The quicksilver-channel, as also the steam-chamber, is formed by bolting the upper and lower lids to each other and firmly against the ribs r^2 r^2 r^2. Similar ribs could advantageously be cast on the steam side of the partition.

When it is desired, by means of this apparatus, to separate amalgam denser than quicksilver from such amalgams as are lighter or rarer, the bottom feed of the digester is chiefly used. When the separation of amalgams, both of which are lighter than quicksilver, is aimed at, the top feed must chiefly be used, enough being fed in at the bottom to prevent a failure of indications on the gage-pipe. When it is designed to separate amalgams whose specific gravities are both greater specific gravity than that of quicksilver, but which differ from each other, an upward current of quicksilver must be provided. This upward current is secured by causing the quicksilver to flow in by the pipe *u f*, (under feed,) the main cock having been previously closed. The outflow in this case is by the pipe which connects with the air-pipe *a p* and discharge-pipe *d p*.

The lighter amalgam having been borne off in the upward current, the remaining dense amalgam may be taken from the digester in either of two ways. One is to cut off the inflow of quicksilver, and then speed the agitator *a a* sufficiently to diffuse the remaining amalgam throughout the quicksilver. That effected, communication is opened to the base collector-tank K′ T′ by opening a stop-cock in the draw-off pipe *d o*. The contents of the digester will thereupon vent themselves to the collector, where the quicksilver will strain off and leave the amalgam in K′.

The other method is admissible when the digester-bottom is furnished with a screen, as described. In that case, after cutting off the inflow of quicksilver, open the main cock and allow the excess of quicksilver to drain through the digester-bottom to the cooler C. When drained, the gate G is opened and the amalgam removed. The same course is pursued, also, when lighter amalgams have been stripped of denser ones by a downward current.

The process, as described in this paper, is largely mechanical, and as such, to a certain extent, it can be carried on cold; but as heating in quicksilver causes amalgam to dissolve into its ultimate molecules more rapidly than it will cold, thereby effecting separation, heating is recommended for practical working. As agitation also expedites prompt solution, an initial agitation is also commended, of a brisk character, as also a continuous but gentle agitation of the amalgams at the top of the digester. Both of these resorts will be greatly aided by a preliminary trituration of lumps and crystals, whether by a pestle in a mortar, or by grinding in a pan or mill, or by any other resort having the aim of comminution in view.

The trituration of amalgam, in order to cleanse it of dirt, iron, and other non-amalgamable adhesions and foreign matters, is not new, and I do not claim that application of trituration or grinding; but the mechanical comminution of amalgam by whatever means, as a preparation for a speedy solution of amalgam in mercury, as related to the mercurial separation of amalgams, is a novel application of grinding or trituration for which I claim protection.

Having thus described my process and my apparatus, and sufficiently the proper procedure for operation, what I claim, and desire to secure by Letters Patent, is—

1. The process of separating mixed amalgams, as described, consisting in diluting the mixed amalgams to quick fluidity in quicksilver, then allowing the mixture thus obtained to stand, whereby the suspended amalgams will separate according to their specific gravities, then drawing off and straining separately, substantially as set forth.

2. The process of aiding the separation of amalgams of different specific gravities, as herein described, which consists in passing through these amalgams mixed with quicksilver to quick fluidity and free mobility of particles among themselves, a regulated continuous downward current of quicksilver, the velocity of which is greater than the rising tendency of the heavier amalgams, and at the same time less than that of the lighter amalgams, substantially as set forth.

3. The process for keeping the stand-pipe free from amalgam, which consists in causing a part of the feeding-stream of mercury to flow continuously beneath its foot to the digester, substantially as herein set forth.

4. The apparatus for operating the dynamic form of the process, consisting, essentially, of the digester D, provided with the gate G and perforated plate *p*, and furnished with the jackets J J J and pipes *s p*, *e p*, and *e′ e′*, in combination with the revolving and adjustable agitator *a a*, colander *c c*, feed-pipes *t f*, *b f*, *u f*, and *f p*, gage-pipe *g p*, quicksilver-pipe *q p*, heating-boxes H B, feeding-tank *f t*, cooler C, and partition P, provided with the trap *q t*, all constructed and arranged substantially as described.

In witness whereof I have hereunto set my hand and seal.

CONRAD WIEGAND. [L. S.]

Witnesses:

E. Q. BUCKINGHAM,

S. MOORE.