

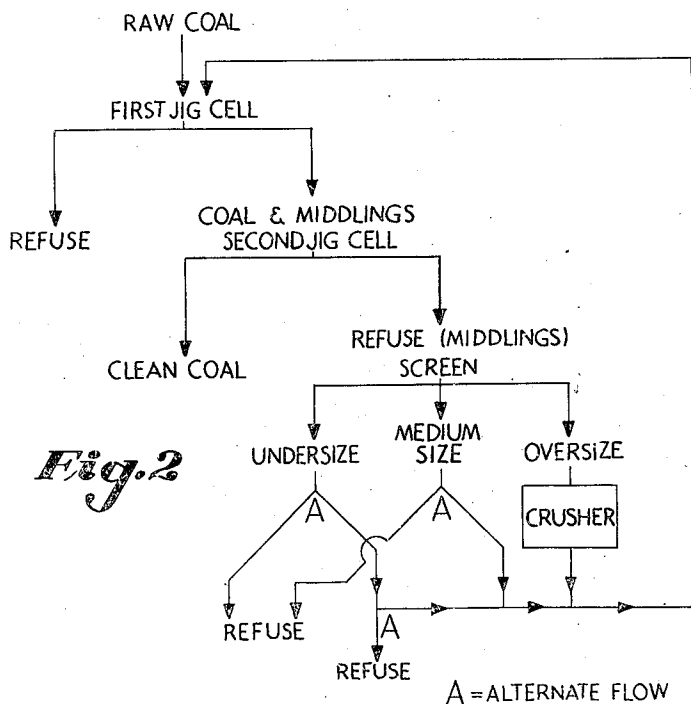
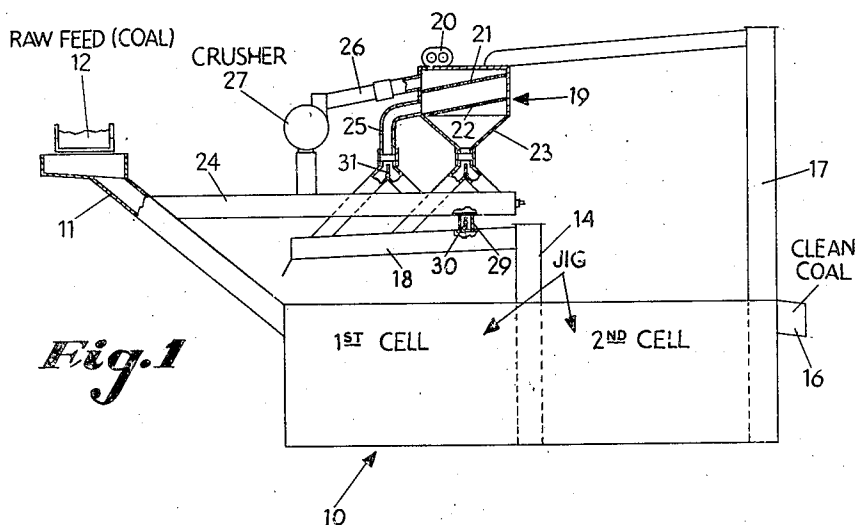
Nov. 15, 1949

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2,487,845

JIGGING APPARATUS AND METHOD

Filed Feb. 21, 1945



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UNITED STATES PATENT OFFICE

2,487,845

JIGGING APPARATUS AND METHOD

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Application February 21, 1945, Serial No. 579,067

8 Claims. (Cl. 241-20)

1

This invention relates to a jigging apparatus and method.

An object thereof is to provide improved apparatus and an improved method of treating materials such as raw coal to separate the low gravity or clean coal from the high and intermediate gravity refuse, such as shale and bony coal.

Another object of the invention is to provide improved apparatus and methods for carrying out the object above set forth in which a heavy or high specific gravity separating medium is developed and is continuously conditioned as to specific gravity by means of the controlled recirculation of one or more different products of high or intermediate gravity material derived by screening or otherwise separating and/or treating the high gravity product of a compartment other than the first compartment of a multiple compartment jig with raw material undergoing treatment in the first compartment of the jig.

In carrying out the foregoing object it is another object of the invention to provide improved material separating apparatus and methods wherein the characteristics of a heavy or high specific gravity separating medium developed from material being separated are controlled by the recirculation of controlled quantities of various size ranges of products of high gravity material derived from high gravity material obtained from any but the first compartment of a multiple compartment jig to the first compartment of the jig to be treated with raw material undergoing treatment therein.

Other objects of the invention will appear hereinafter, the novel features and combinations being set forth in the appended claims.

In the accompanying drawings,

Fig. 1 is a diagrammatic showing of apparatus involving my invention which is capable of carrying out the method of my invention; and

Fig. 2 is a flow diagram illustrating my invention.

In any process or method effecting a separation according to specific gravity the density of the medium developed is highly important. That this is the case may be seen from the following consideration: Suppose particles of two specific gravities are to be separated, one kind being 1.45 specific gravity and the other 1.50 specific gravity. In air the specific gravity of one particle is 1.50/1.45 or 1.034 times that of the other particle. If these particles are immersed in water this ratio of specific gravities becomes $1.50-1/1.45-1=1.50/.45=1.111$.

2

If mixed sizes are being separated according to specific gravity, such as a size range 5" x 0", every particle is buoyed up by the surrounding particles. In other words the surrounding particles form a fluid specific-gravity medium having an effective density equal to the average specific gravity of the particles and the water taken together. In a jigging process or method, for example, the medium density for separation at 1.45 specific gravity might be as much as 1.40 specific gravity. Under these conditions the ratio of the particles being separated becomes $1.50-1.40/1.45-1.40=.10/.05=2.0$.

Carrying this illustration through three more steps will demonstrate an important phenomenon as to the great importance of the last step in increasing the density of the medium to obtain a sharp separation at a predetermined specific gravity. Assume the density of the medium is increased from 1.40 to 1.42, the ratio is $1.50-1.42/1.45-1.42=.08/.03=2.7$. This is only a small increase in ratio over 2.0 obtained from 1.40 specific-gravity medium. If the density of the medium is increased to 1.44, the ratio is $1.50-1.44/1.45-1.44=.06/.01=6.0$. This is a greater increase, but still not an exceedingly great one. However, if the density is increased by another .01, the ratio reaches infinity for $1.50-1.45/1.45-1.45=.05/0=\text{infinity}$. Thus the last .01 increase in density of the medium is of great importance.

In the method or process and apparatus involving my invention a jig or other standard separating or classifying device is used in which the cost of operation is relatively low and provision is made for building up the density of the medium to a point where it just equals the specific gravity of the low-gravity particles to be separated. In other words, in the illustration above used the desired effective density of the medium would be 1.45 specific gravity.

That such a medium is not developed in the course of normal jigging operation can be readily seen. Suppose coal is being separated by jigging and the stratification is complete. At a certain level in the jig bed there is a more or less well defined zone at which a split must be made between the materials that are to flow over as washed coal and those that are to be discharged as refuse. If a separation at this point is very sharp, the particles right at the dividing line are close to 1.45 specific gravity. However, since the interstitial spaces between the particles are filled with water, the medium density of the water and particles considered together is inevitably less than 1.45 specific gravity since the

specific gravity of the water is 1. If the density of the medium is to be raised to 1.45 specific gravity, the interstices must be filled with something of higher density than water. This might be a very heavy liquid such as zinc chloride or calcium chloride, for example, but in the method and process involved in this invention this medium is built up of fine particles, the specific gravity of which is above 1.45, which particles are immersed in water.

One apparatus for applying a heavy medium for jigging operation is illustrated in the accompanying drawings. For example, the raw coal being treated may have a size range of 3" x 0", but it is to be clearly understood that the method or process is applicable to larger size range and to any specific-gravity separation. The important point is the return to the jig feed or to the first jigging compartment of small intermediate gravity refuse particles to form an interstitial medium between the larger particles. As one illustration, these refuse particles may have a size range of $\frac{3}{16}$ " x 0". For a separation at 1.45 specific gravity, this medium should be just 1.45 specific gravity. Under these circumstances the coarser particles being separated in the jig are buoyed up by other coarse particles of 1.45 specific gravity and higher and by the smaller particles of interstitial medium made up of water and high-gravity particles, such as bone, which may range from 2.0 to 2.2 specific gravity.

The method or process here involved is to be carefully distinguished from that sometimes used in jigging practice in the crushing of middlings. In this practice the middlings are usually screened and the fine sizes sent to refuse, only the coarse sizes being sent to a crusher and then back to the jig feed. This is done to avoid a build-up of fine refuse in the circuit which is just the opposite from what is here being done, in which the intent is to build up the medium under carefully controlled conditions.

In the practical operation of the apparatus and the consequent carrying out of the process and method, the operation and method of applying the heavy medium to the jig is accomplished in a relatively simple manner. The jig employed is equipped with automatic control. This in a large measure maintains the medium in the jig without attention from the operator. However, for best results, the tonnage should be kept within reasonable limits and the jig should not be allowed to idle for prolonged periods with no feed, for this may cause a loss of the separating medium, it being discharged as refuse. However, if the medium is lost, it will be recovered and the jig returned to normal operation after perhaps one-half hour's steady operation.

A further help in maintaining the medium is to select a screen having perforations of such size in the first and second compartments of the jig, if a three compartment jig is used, or in the first compartment of the jig if a two compartment jig is used, so that the required amount of medium is retained in the first two compartments in the case of a three compartment jig and in the first compartment in the case of a two compartment jig, rather than being hatched through the screen.

In getting the heavy-medium method into operation, the last compartment is hatched hard to draw through the screen all of the fine bone particles together with some fine coal. This can be done most readily by operating the jig with a relatively long stroke and a minimum of water.

The fine bone and the refuse materials of intermediate specific gravities pass up the last elevator and are screened to separate the medium. This, together with such other parts of the last elevator product as desired, is returned to the jig feed. When the medium begins to build up in the circuit, the length of stroke and the amount of water used in the first compartment are regulated to pass, deliver or feed together with the low gravity separation product of the first compartment a substantial amount of the medium over into the last compartment, but not more than can be hatched out or drawn through the ejector in that compartment. In this way the presence of ample medium in the first compartment is assured and the last compartment is supplied with high specific gravity fluid separating medium from the first compartment which is delivered thereto with the low gravity material separated in the first compartment. In normal operation the last compartment is always operated to hatch some fine coal. This is done to assure that no medium is passed over into the washed coal.

With the above general description in mind, attention is directed to Figs. 1 and 2 of the drawings in which I have diagrammatically illustrated one form of jig and associated apparatus together with a flow sheet which teaches my invention. A jig 10 is provided which may be either of the two compartment or three successive compartment type, but in the drawings I have illustrated a two compartment jig. This jig may take substantially any desired form, but as one illustration of a general construction thereof, which may be employed and which has certain desired characteristics in specific aspects of my invention, reference is made to the patent to O. R. Strawn, No. 2,281,530, for a Jig, dated April 28, 1942. The jig includes a feed chute 11 by which the coal to be treated is delivered from any desired source such as a conveyor or other chute 12. The raw coal delivered to the chute 11 flows into the first treating or stratifying compartment 13 through the feed opening 135 of jig 10 where it is subjected to a stratifying and classifying action and the refuse or high gravity material is withdrawn by way of the refuse elevator or conveyor 14 with the low gravity material or partially cleaned coal being delivered to the successive second compartment 15 where it is again subjected to a jigging action to make the final separation of coal and refuse. Some middlings or intermediate gravity material will pass with the coal from the first compartment 13 into the second compartment 15.

In case a three compartment jig is employed there will, of course, be a third compartment which will effect the final separation, the first two compartments in that case being substantially identical in construction and performing the preliminary and intermediate treatments, respectively. The clean coal from the last compartment 15 is delivered along one path by way of clean coal chute 16 and the intermediate-gravity product from the last compartment is removed and elevated by elevator 17 which has a greater height than elevator or conveyor 14, as hereinafter described. The refuse removed in the first compartment and delivered to the refuse elevator or conveyor 14 flows therefrom by way of a chute 18 to a refuse receptacle or pile. The product from the second elevator 17 or at least a portion thereof is delivered for treatment to a screen 19 which is preferably a double deck re-

ciprocating screen being provided with a vibrating or reciprocating mechanism 20 and spaced upper and lower screen cloths 21 and 22, respectively.

The use of a double deck screen is very desirable in the most complete aspect of my invention because it has been found very effective to remove intermediate size bony coal, which otherwise might build up in excessive amounts. This will be explained completely hereinafter.

In certain broader aspects of my invention it is to be understood that a single deck screen 19 may be employed. With a double deck screen 19 it is obvious that three size ranges of refuse will be produced thereby. The fines will pass through both the screen cloths 21 and 22 and be delivered by bottom chute 23 to a longitudinally extending screw conveyor 24 by which said fine sizes of refuse or intermediate gravity material will be conveyed forwardly. The intermediate size material which passes only through the large mesh screen cloth 21 and cannot pass through the small mesh screen cloth 22 is delivered to a bifurcated chute 25 which feeds into the previously described refuse chute 18 and is delivered to the refuse receptacle or pile, previously mentioned, or to conveyor 24, depending on the position of a control valve 31. The reason for this selective alternative flow is explained later. This intermediate size product will be largely true bone, i. e., finely disseminated coal and shale. The oversize material from the screen 19 will flow by way of chute 26 for treatment in a crusher or grinder 27 which reduces it in size to liberate coal from refuse and normally delivers it to the screw conveyor 24, where this fine product together with refuse in the conveyor 24 derived from the fines of screen 19 will be conveyed forwardly and delivered to the feed chute 11 of the jig 10. It is to be understood that all or part of the intermediate size from the screen may be selectively recirculated either alone or with all or part of the fines from screen 19. To this end I may employ a bleeder chute 29 provided with a control valve 30 in connection with the conveyor 24 and similar bleeding devices may be provided individually to the crusher 27 and the chute 23 for selectively bleeding them, if desired. Bleeder chute 29 and valve 30 co-operate to form a control means for controlling the return of the small size screened material or the products passing through screen 21 and they may be operated in conjunction with other control means hereinafter described for selectively controlling the return of these materials to the feed chute 11 and consequently to the first jiggling compartment 13 of jig 10.

In certain broader aspects of the invention the grinder 27 may be eliminated entirely and the fines of screen 19 alone relied upon. In this case the screen 19 will probably be a single deck screen. The double deck screen is particularly effective to remove the intermediate size bone because of the following effects: Material particles formed in part of pure coal and part of bony coal of relatively large size will normally appear as refuse in the draw of second compartment 15 and thus be delivered to the screen 19 by elevator 17. These relatively large particles will be delivered to the grinder 27 and when crushed will liberate the pure coal from the bony coal. As a consequence, as this reduced material passes through the jig the second time, the liberated clean coal will pass over the final clean coal chute 16 and the bone coal will again reappear in the elevator

17. This time some of the bony coal which has been freed of the pure coal will be of intermediate size and will pass through the coarse screen 21, but such of it as is coarser than screen 22 will be delivered to the chute 25 and to the refuse receptacle or pile. However, some of this intermediate size may, under certain circumstances, be selectively recycled, a point that will now be explained.

If a medium is to be effective, it must be retained in the interstices between the larger particles. If this is to be the case, the jig must be operated according to well established principles. For instance, considerable water may be used in combination with a relatively short stroke. This type of stroke gives a separation according to size as well as according to specific gravity, as in a hydraulic classifier, for example. Such a method of operation would wash the medium out of the interstices and so cannot be used. A stroke must be used that will avoid this classifying action. Such a stroke comprises (1) a sharp initial upward acceleration of the water, (2) a short period at approximately uniform velocity, and (3) a downward movement of the water. During the first or upward phase, the bed is lifted in a mass. During the second, the particles become completely mobile so that they are free to separate. During the third or downward phase, they are separated according to specific gravity.

If this type of stroke is to be applied effectively, I have found that the screen analyses of the jig feed should be controlled to assure a reasonable percentage of intermediate sizes. For instance, in a jig feed 3" x 0", this means a reasonable percentage of 2" x 1" sizes. These intermediate sizes, by locking against each other on the up stroke and during the period of opening of the bed, assist greatly in retaining a heavy medium in the jig bed. Thus, if there is a deficiency of intermediate sizes, this may be offset by selectively recirculating some intermediate sizes from the double-deck screen.

Although the type of stroke just described has been found to give the most satisfactory results in applying the heavy medium, it is not essential to my invention in certain broader aspects thereof. The prime requisite is a method of operation that will keep the medium in the interstices between the larger particles. This requirement is, of course, fundamental.

To provide for the selective recirculation or discharge, that is, the control of the return of intermediate size products of screen 19 to chute 11 and compartment 13, bifurcated chute 25 is a bleeder chute having two legs, one leading to chute 18, the other to conveyor 24. Valve 31 co-operating with the legs of bifurcated chute 25 forms a control means that controls the flow of said products to chute 18 or conveyor 24 or a division thereof between them.

Although the intermediate size product is sometimes recycled in the manner above described, the normal procedure is to send it to final refuse. Therefore, it is to be distinctly understood that the method of and apparatus for removing the intermediate size bone or finely disseminated coal and shale is an important step in the process or method of my invention and the apparatus for doing it is an important part of the apparatus invention.

It is further to be understood that while I have sometimes referred to the recirculated fine material as high gravity material, it is only relatively high gravity material, and is generally re-

ferred to as intermediate gravity material, as it is largely material of specific gravity of 2.0 to 2.2 and this will be represented largely by fine bony coal rather than fine shale. It is, of course, evident that the shale, both large and fine, will be removed very largely in the first compartment 13 and will be discharged as refuse by the elevator 14 and chute 18, so it is actually intermediate gravity fines which are employed as a so-called heavy gravity medium. In an installation in which a three compartment jig is employed the refuse which is screened and/or crushed as above described is preferably that derived from the third compartment and the first and second compartment have their refuse discharged to the refuse pile. It is to be understood, however, that in certain broader aspects of the invention, in such a situation the refuse from the second and/or the second and third compartments may be screened and/or crushed and all or desired quantities thereof may be selectively recirculated to control concomitantly the specific gravity of and the ratio or relative quantities of pieces of high gravity material of different size ranges in the high gravity medium developed from the material being separated.

In the specific illustration of my invention, above described, the separation of refuse from coal was used. It is to be understood, however, that it is not limited to the cleaning of coal, but may be used to separate substantially any granular materials of different specific gravities, of which the treatment of iron ore to separate the concentrate from the gangue is another illustration.

From the foregoing it will be obvious that I have provided improved apparatus and methods for separating mixed granular materials of different specific gravities according to their specific gravities in a plurality of successive treatments in separate fluid separating media, the effective density of which is controlled by the amount of high gravity material therein derived from material being separated, and that I have provided apparatus and methods for maintaining the effective density of the separating medium at a desired specific gravity by the treatment of adequate quantities of high gravity material separated in one of the successive treatment compartments to produce or obtain therefrom fine high gravity material, adequate quantities of which are returned under control to the separating medium for maintaining the effective density of the separating medium in the treating compartments at a desired specific gravity.

Obviously those skilled in the art may make various changes in the details and arrangement of parts without departing from the spirit and scope of the invention as defined by the claims hereto appended and I wish therefore not to be restricted to the precise construction herein disclosed.

Having thus described and shown an embodiment of my invention, what I desire to secure by Letters Patent of the United States is:

1. Separating apparatus of the type wherein a high gravity separating medium is developed from materials being separated and the ratio of different size range constituents in the high gravity separating medium and the specific gravity of the latter may be controlled, the apparatus including a gravity separator having a plurality of compartments for successively treating material to separate it according to specific gravity, means for removing the high gravity material

constituent from said first compartment, means for removing the high gravity material constituent from a succeeding compartment, means for screening said last mentioned high gravity material into products of three different size ranges, and means for crushing at least part of the largest size range of screened material and delivering it and at least part of the smallest size range screened material to the first of said compartments for controlling the ratio of said screened and crushed material in the high gravity medium and the specific gravity of the latter.

2. The method of controlling the specific gravity of a high gravity separating medium obtained from materials being separated while separating the materials by jigging into constituents of different specific gravities therein, the method including the successive stratification of a bed of materials of different specific gravities by jigging in said high gravity medium in a plurality of separate jigging treatments, directing the stratified materials in each treatment along different paths including delivering the low gravity material from the first treatment for the successive stratifying treatment, and returning a fine intermediate gravity material derived from the second treatment to be treated with raw material undergoing the first treatment, said returned fine intermediate gravity material being produced at least in part by reducing large intermediate gravity material derived from said second treatment and at least in part by fine intermediate gravity material derived directly and without reduction from said second treatment.

3. The method of controlling the specific gravity of a high gravity separating medium obtained from materials being separated while separating the materials by jigging into constituents of different specific gravities therein, the method including the successive stratification of a bed of materials of different specific gravities by jigging in said high gravity medium in a plurality of separate jigging treatments, directing the stratified materials in each treatment along different paths including delivering the low gravity material from the first treatment for the successive stratifying treatment, and returning a fine intermediate gravity material derived from the second treatment to be treated with raw material undergoing the first treatment, said fine intermediate gravity material including fine intermediate gravity material derived directly and without reduction from said second treatment.

4. The method of controlling the specific gravity of a high gravity separating medium obtained from materials being separated while separating the materials by jigging into constituents of different specific gravities therein, the method including the successive stratification of a bed of materials of different specific gravities in said high gravity separating medium in a plurality of separate jigging treatments, directing the stratified materials in each treatment along different paths including delivering the low gravity material from the first treatment for the successive stratifying treatment, separating intermediate gravity material derived from said second treatment into three different size ranges, crushing at least part of the largest size range material derived by said separation, and returning at least part of the said crushed material and at least part of the smallest size range material derived by said separation to the first treatment to be concomitantly treated with raw material undergoing the first treatment and for controll-

ing the specific gravity of the high gravity separating medium.

5. The method of maintaining a high specific gravity separating medium obtained from materials being separated by jiggling at a desired specific gravity while separating the materials by jiggling into constituents of different specific gravities, the method including the successive stratification by jiggling of a bed of materials of different specific gravities in said high gravity medium in a plurality of separate jiggling stratifying treatments, directing the stratified materials in each treatment along different paths including delivering the low gravity material from the first treatment to a successive jiggling stratifying treatment, treating intermediate gravity material separated in a successive stratifying treatment to obtain fine intermediate gravity material, and returning said treated fine intermediate gravity material to said first stratifying treatment for maintaining said high specific gravity separating medium at a desired specific gravity.

6. Apparatus for separating granular materials of different specific gravities according to specific gravities by successive separations in a high specific gravity fluid separating medium including a first separating compartment, a successive separating compartment, jiggling means for applying a jiggling action to the materials in said compartments to stratify said materials, said compartments being adapted to contain high gravity fluid separating medium which is maintained in suspension by said jiggling means and the density of which is controlled by the percentage of fine intermediate gravity particles therein derived from material being separated, means for feeding mixed granular material to said first separating compartment, means including said jiggling means for separating said mixed materials therein according to specific gravities, means directing the high gravity materials separated in said first compartment along one path, means feeding low gravity materials separated in said first compartment to a successive compartment for separation according to specific gravities therein, means delivering the low gravity product of said successive compartment along one path, means for treating intermediate gravity material separated in said successive compartment to produce fine intermediate gravity material therefrom, and means for returning said treated fine intermediate gravity material to the separating medium in at least one of said compartments for maintaining the specific gravity thereof at a desired value.

7. Apparatus for separating granular materials of different specific gravities according to specific gravities by successive separations in a high specific gravity fluid separating medium including first and successive separating compartments adapted to contain high gravity fluid separating medium the density of which is controlled by the percentage of fine intermediate gravity particles therein derived from material being separated, jiggling means for applying jiggling action to the materials in said compartments to stratify said materials and to maintain said high gravity medium particles in suspension, means for feeding mixed granular material to said first separating compartment, means including said jiggling means for separating said mixed materials therein according to specific gravities, means directing the high gravity materials separated in said first compartment along one path, means feeding

low gravity materials separated in said first compartment to a successive compartment for treatment therein, means delivering the low gravity product of said successive compartment along one path, means including a grinder for treating high gravity material separated in said successive compartment to produce fine intermediate gravity material therefrom, and means for returning said treated fine intermediate gravity material to the separating medium in said compartments for maintaining the specific gravity of said intermediate specific gravity fluid separating medium at a desired value.

8. Apparatus for separating granular materials of different specific gravities according to specific gravities by successive separations in a high specific gravity fluid separating medium including a first separating compartment, a successive separating compartment, said compartments being adapted to contain a high gravity fluid separating medium the density of which is controlled by the percentage of fine intermediate gravity particles therein derived from material being separated, jiggling means for applying jiggling action to the materials in said compartments to stratify said materials and to maintain said high gravity medium particles in suspension, means for feeding mixed granular material to said first separating compartment, means including said jiggling means for separating the mixed materials therein according to specific gravities, means directing the high gravity materials separated in said first compartment along one path, means feeding low gravity materials separated in said first compartment to said successive compartment for treatment therein together with substantial quantities of high specific gravity separating medium for supplying said successive compartment with separating medium, means delivering the low gravity product of said successive compartment along one path, means including a screen for treating intermediate gravity material separated in said successive compartment to produce fine high gravity material therefrom, and means for returning said fine intermediate gravity material to the separating medium in said compartments for maintaining the specific gravity of said high specific gravity fluid separating medium at a desired value.

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