Aug. 11, 1959 W. C. MENZIES 2,899,057

HEAVY MEDIA SEPARATOR APPARATUS

Filed Oct. 28, 1957 6 Sheets-Sheet 1

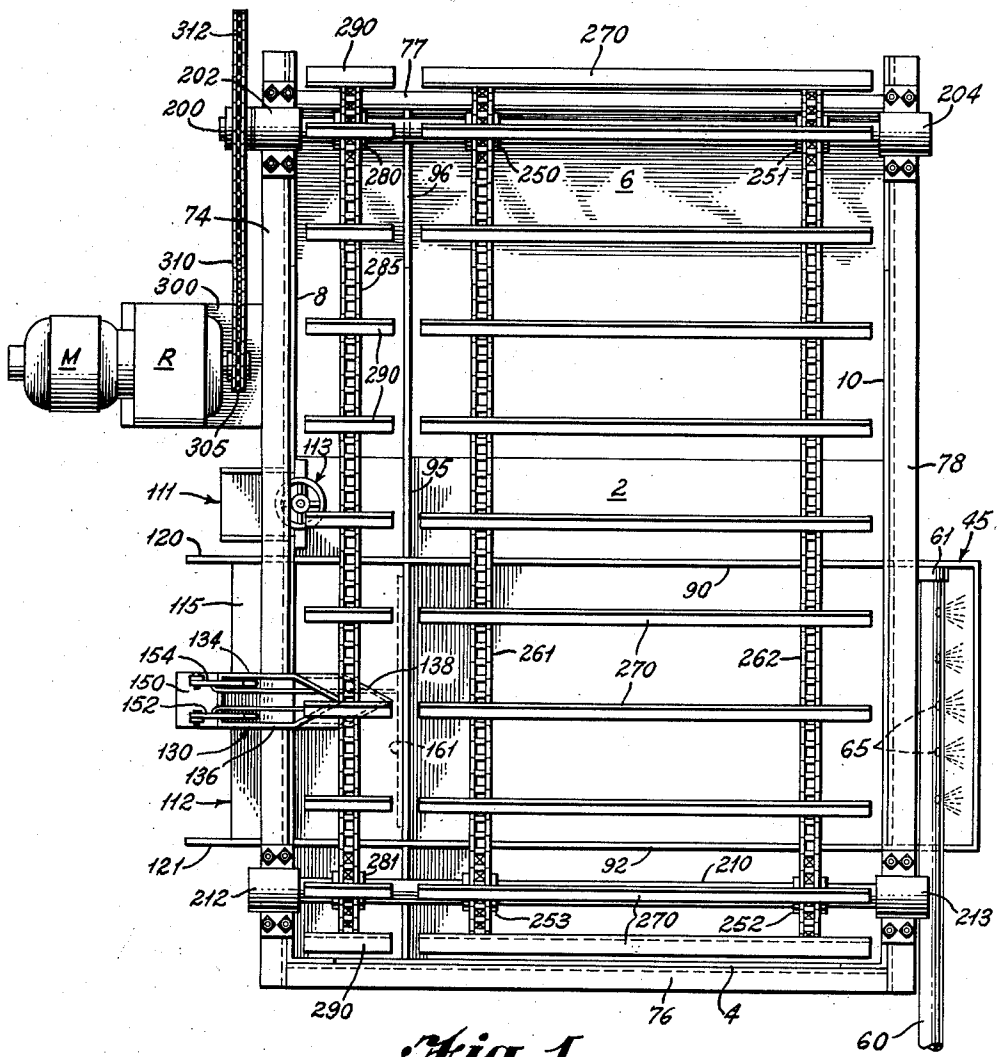


Fig. 1.

INVENTOR
William C. Menzies

BY Thomas, Weisman & Russell
ATTORNEYS

Aug. 11, 1959 W. C. MENZIES 2,899,057

HEAVY MEDIA SEPARATOR APPARATUS

Filed Oct. 28, 1957 6 Sheets-Sheet 2

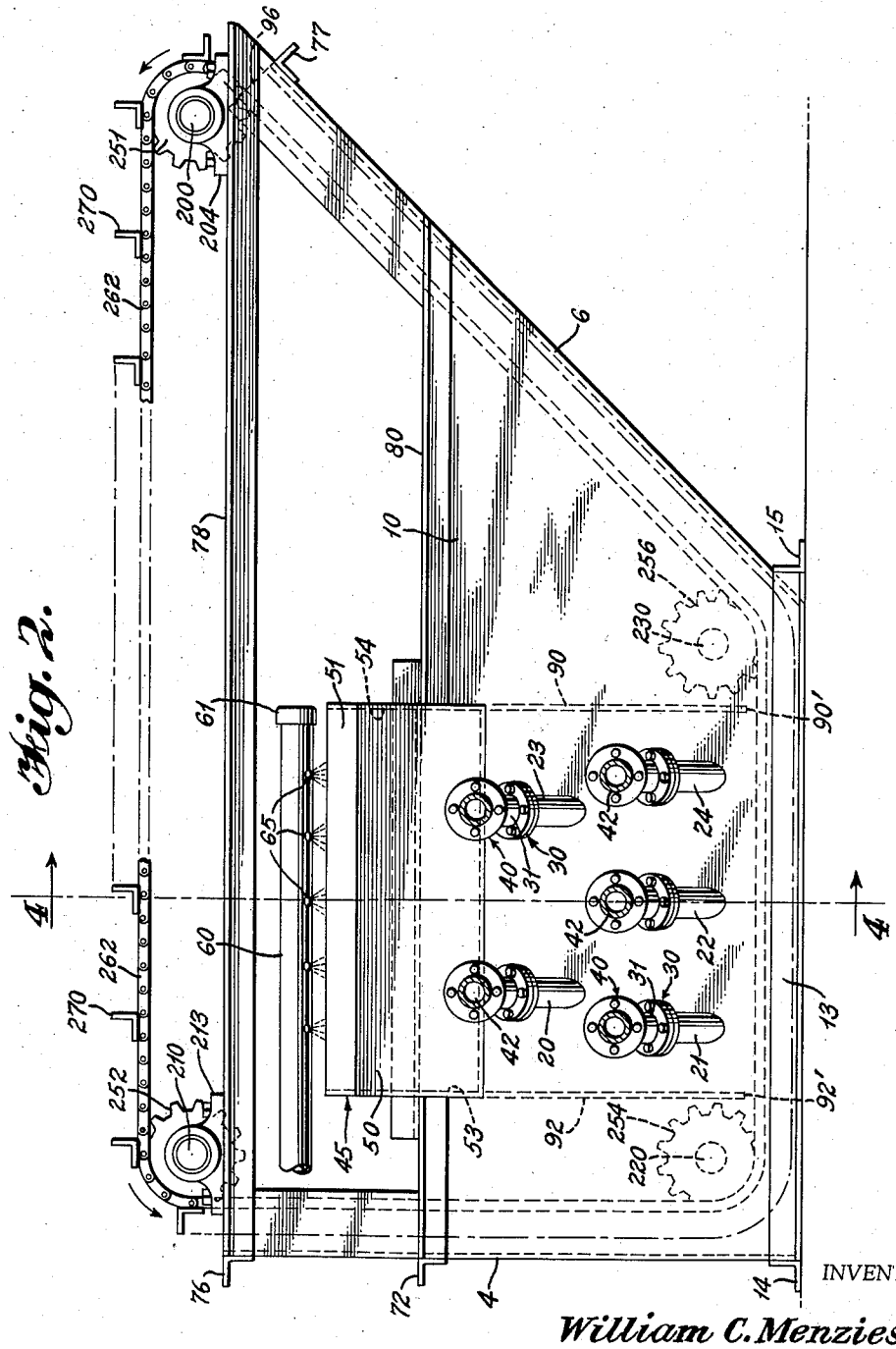


Fig. 2.

INVENTOR

William C. Menzies

BY Thomas, Weisman & Russell

ATTORNEYS

Aug. 11, 1959 W. C. MENZIES 2,899,057

HEAVY MEDIA SEPARATOR APPARATUS

Filed Oct. 28, 1957 6 Sheets-Sheet 3

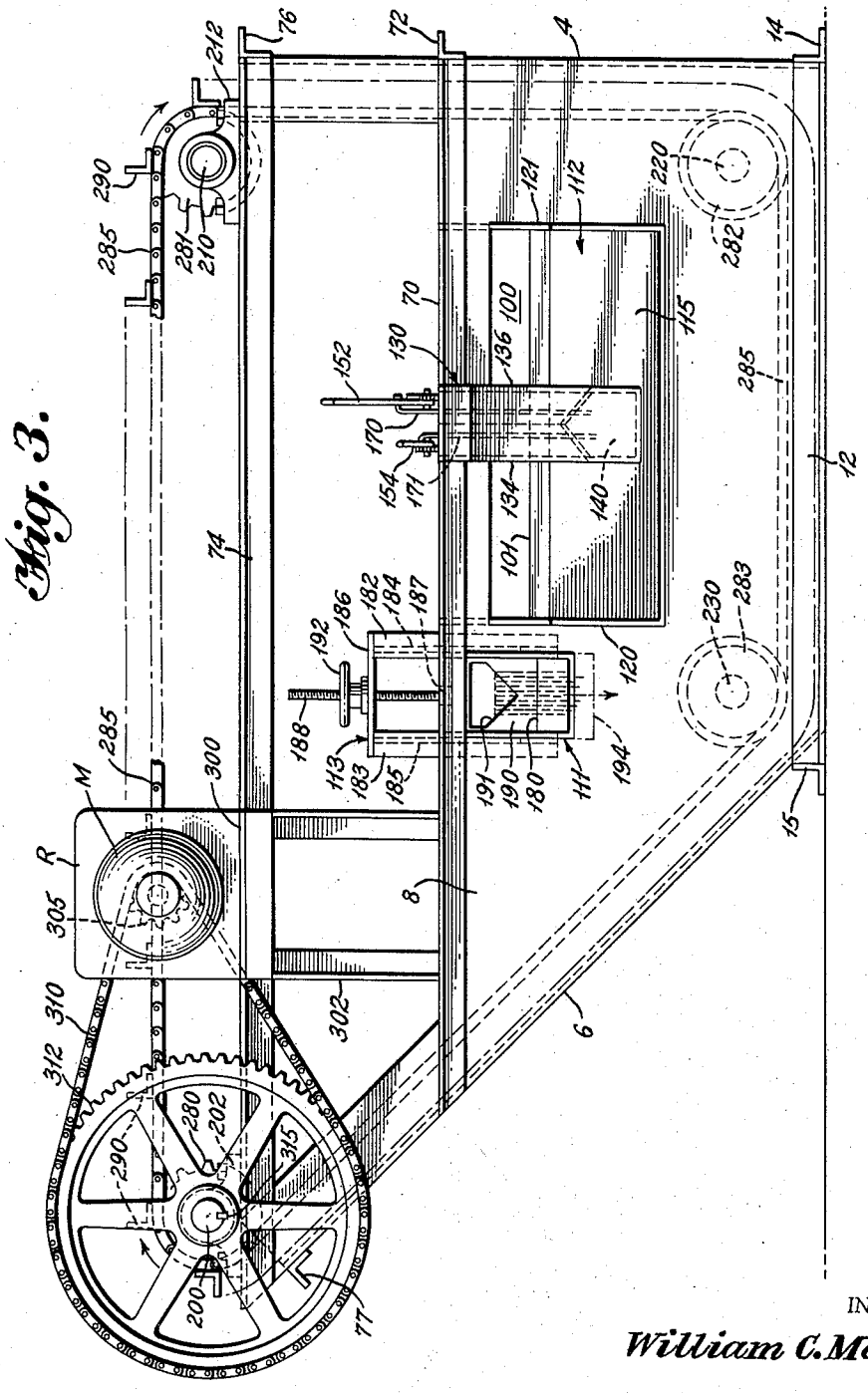


Fig. 3.

INVENTOR
William C. Menzies

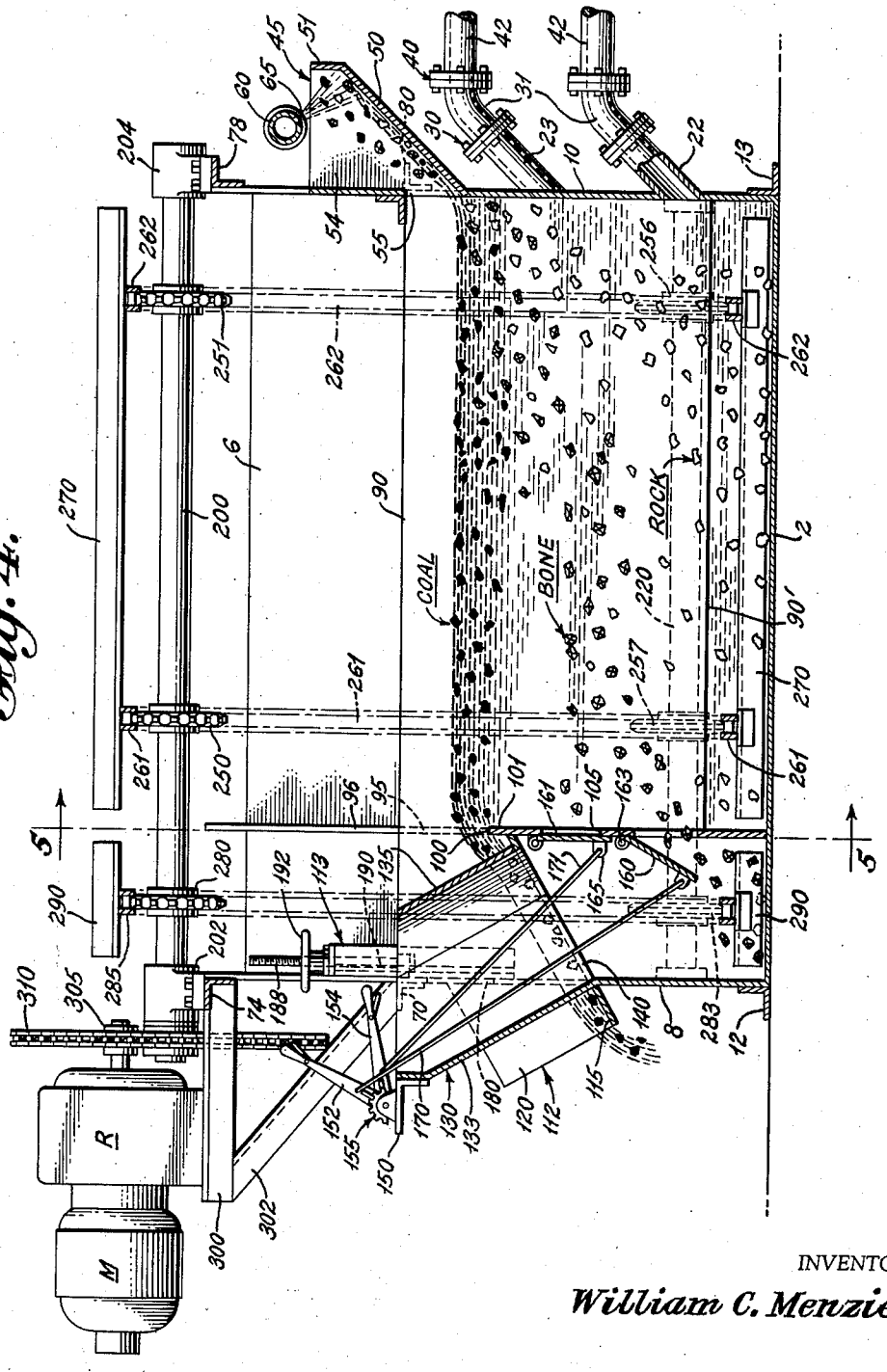
BY Thomas, Weisman & Russell
ATTORNEYS

Aug. 11, 1959 W. C. MENZIES 2,899,057

HEAVY MEDIA SEPARATOR APPARATUS

Filed Oct. 28, 1957 6 Sheets-Sheet 4

Fig. 4.



INVENTOR
William C. Menzies

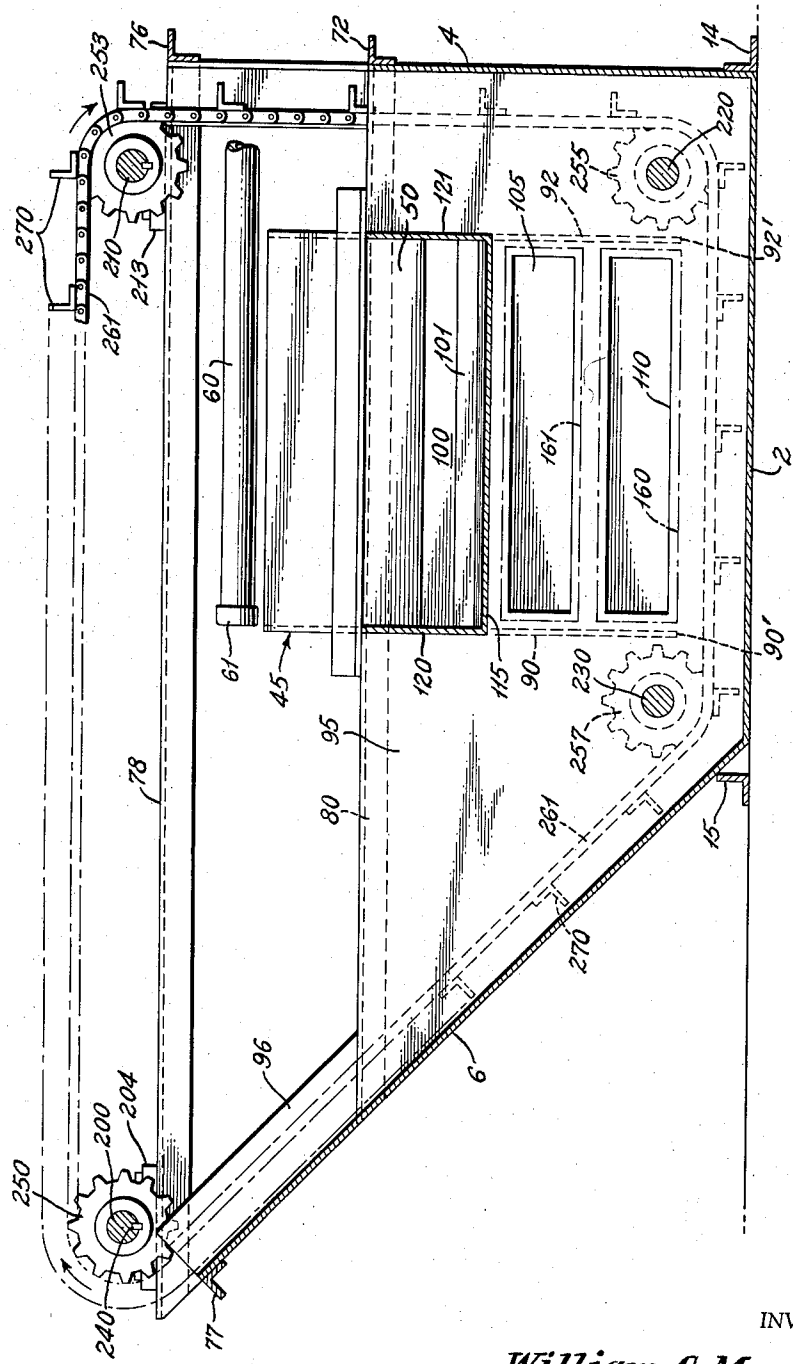
BY Thomas, Weisman & Russell
ATTORNEYS

Aug. 11, 1959 W. C. MENZIES 2,899,057

HEAVY MEDIA SEPARATOR APPARATUS

Filed Oct. 28, 1957 6 Sheets-Sheet 5

Fig. 5.



INVENTOR

William C. Menzies

BY *Thomas, Weisman & Russell*

ATTORNEYS

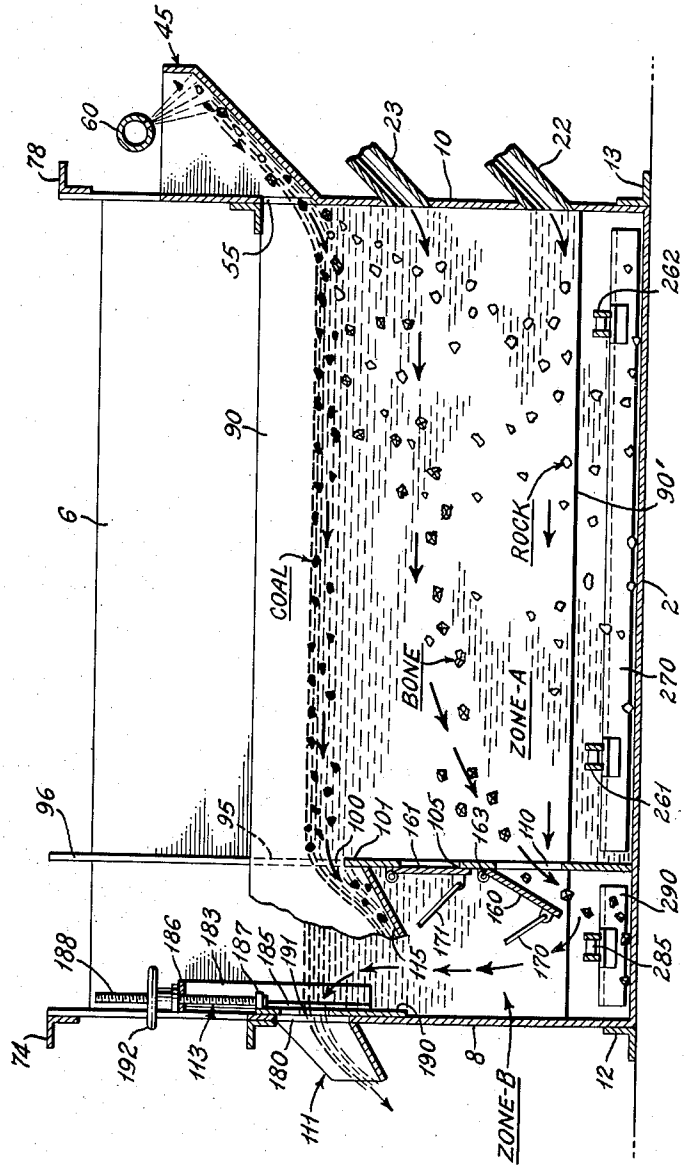
Aug. 11, 1959 W. C. MENZIES 2,899,057

HEAVY MEDIA SEPARATOR APPARATUS

Filed Oct. 28, 1957

6 Sheets-Sheet 6

Fig. 6.



INVENTOR

William C. Menzies

BY

Thomas, Weisman & Russell

ATTORNEYS

United States Patent Office 2,899,057 Patented Aug. 11, 1959

2,899,057

HEAVY MEDIA SEPARATOR APPARATUS

William C. Menzies, Wyoming, Pa.

Application October 28, 1957, Serial No. 692,600

8 Claims. (Cl. 209—172.5)

This invention relates to a heavy media separator for mixed materials and has more particular application to a procedure utilizing a medium of a known specific gravity, the latter being intermediate the specific gravities of the materials to be classified or separated. In the instant case, the invention, although not necessarily limited thereto, is particularly useful in the coal industry for the separation of coal from other impurities to obtain a final, cleaned and pure product.

The background, with respect to the use of various types of heavy mediums in a separating apparatus, has been set forth in my previous Patent No. 2,734,629. As there stated, and as generally understood by those skilled in the art, the heavy medium which is utilized may be of various types. Commercially it can be one wherein the density is increased by the addition of ferrous or non-ferrous particles; if the medium is to be utilized in conjunction with a magnetic purifying means, then ferrous particles are used to increase the density of the medium to the desired extent. Often it has been found desirable to employ magnetite as the additive to the water solution for, by use of magnetic separators the magnetite can be salvaged after use and the density of the medium employed more accurately controlled. Magnetite separators are known and form no part of the instant invention except that it is to be understood that such devices can be utilized in connection with this invention when magnetite solutions are employed and magnetic separators are desired for classification of the same.

As set forth in my previous patent, it is to be understood that when application of the invention is directed to coal handling the particular aim of the involved apparatus is to make a clear and clean division of the mixed material charged to the separator into three components: the pure coal itself, the bony (which generally has reference to coal bonded with some impurities making it undesirable for certain uses) and slate or rock, the latter comprising non-combustible substances which when removed are discarded. In employing heavy medium separation, at least in application of the invention to this particular industry, the involved specific gravities average 1.70, with a possible range varying from approximately 1.56 to 1.75, depending upon the type of coal being handled. At such predetermined density, the coal floats in the medium, the bony, approximately the same density, is largely suspended within the medium, and the undesirable substances such as pyrite, slate, rock, etc., being of substantially greater density than that of the medium employed, fall to the bottom of the solution. With the apparatus of this invention, and utilizing the heavy medium principle, a proper and efficient separation can be made into these categories of coal, bony and slate.

The instant invention constitutes an improvement over that of the referred to patent. An apparatus is provided which is simplified to the extreme and therefore representative of an installation of comparatively low cost. This is of great significance in a field such as the coal

industry where the smaller operators are unable to invest substantial amounts in complex heavy machinery that will effectuate the required separation, and where the volume of production is of such degree as to not warrant an expenditure for the heavy machinery which is presently available. Hence, the instant invention is designed as a simplified mechanism which may be of a moderate size, and thus of moderate cost, for use in fields where the production is not of too great magnitude. At the same time, it is to be recognized that this apparatus does perform as effectively as, or even superiorly to, known apparatus and techniques of greater complexity.

Before describing this invention at length, it is pointed out that the apparatus here involved is one utilizing a principle of cross-current or cross-flow of the separated materials with respect to the direction of flow of the heavy medium used for separatory purposes. In other words, the medium is introduced upon one side of the apparatus and its introduction at set rates of flow induces a current across the apparatus; on the other hand, the mechanical conveyors adapted to remove the separated materials or stratas of materials functions longitudinally with respect to the heavy medium container. Such conveyors revolve about the entire circumference or periphery of the separator itself. These fundamental aspects are conducive to simplification of the apparatus, in the sense outlined above.

Another basic aspect of this invention which materially contributes to the efficiency of operation of the heavy media separator has to do with structure contemplating use of a comparatively shallow tank or container wherein the actual separation takes place. The shallowness of the tank materially contributes to the maintenance of a uniform specific gravity throughout the depth of the particular medium being employed. In the use of heavy medium separating processes, it is well known that there is a strong tendency for the medium to become non-uniform, with respect to its density, throughout its depth; this is a result of the tendency of the entrained or suspended, density-controlling particles to settle to the bottom of the separator. Hence, during the normal period of operation and in many of the known processes, the problem arises of maintaining uniform density throughout the medium, for with variance in density of the same, clean separation becomes increasingly difficult. Utilizing the shallow tank principle of this invention and the aforementioned cross-current flow, agitation of the medium in the separating chamber is continuous and sufficiently effective to keep the density-controlling particles well dispersed throughout the entire body of the medium.

Furthermore, in the construction of this apparatus, the discharge from the separating chamber of the medium is into an additional zone or chamber which might be termed a settling zone. In this latter zone, the medium of light specific gravity is taken from the top of the body of fluid, and because of its light specific gravity, is not directly re-cycled to the separating chamber, but is magnetized through the usual magnetic separator, cleaned and then added to the medium being employed in an amount to maintain the proper specific gravity in the separating chamber. Both conveyors, traveling along the base of the respective zones tend to encounter only the heaviest of the employed medium. Any density-controlling particles adhering to these conveyors is washed and/or screened therefrom at the top of the cycle of the conveyor and thence recycled to the separator. Although not shown herein as constituting no part of this invention, such steps are known as facilitating continuous operation of the separator.

Having made reference to the general character of the invention, it is to be understood that a primary object

thereof is to provide an improved heavy media separator, employing a cross-current principle of operation whereby the pure coal is effectively separated from the bony and the waste materials such as slate, rock, etc. Such separation may be a continuous, uninterrupted operation.

It is a further objective of the invention to provide an apparatus of the described type, which because of its simplicity of construction and minimum of moving parts, permits a correspondingly minimum cost of construction. At the same time, this simplified construction performs no less of an efficient operation when it comes to the segregation of materials of different specific gravities into several desired components.

It is another object of the invention to provide an apparatus whereby the heavy medium flow, inducing or carrying with it a corresponding flow of the several materials to be separated, progresses in a cross-directional path or in a direction approximately normal, or at right angles, to the direction of travel of the conveyor elements utilized for removal of the separated components from several stratas or layers in the body of the heavy medium.

An additional object of the invention is the provision of an apparatus having means for readily controlling the volume of discharge or rate of flow from the separating container; this is accomplished by a V-notched gate valve which by reason of its construction permits variance in the amount of flow of heavy medium from separating compartment into bony compartment to be regulated within very fine limitations. Hand in hand with this objective is the additional advantage found in the instant invention having to do with regulation of discharge of the bony from the separating chamber. This is accomplished by a mechanism which controls flow of the intermediate product, dependent upon the amount of such intermediate in the material charged to the unit in proportion to the amount of pure and uncontaminated coal in the charge which may be recovered.

A further object of the invention is the provision of a separating apparatus permitting the two extremes found in the medium (i.e., that somewhat lighter than the desired specific gravity, and that somewhat heavier than the predetermined specific gravity) to be separately removed from the apparatus for recycling in such manner as to maintain and preserve that specific gravity which has been determined to be the best under the particular circumstances encountered.

Another object of the invention is the provision of apparatus readily adaptable to the use of a heavy medium consisting of suspended magnetite, thus making the invention adaptable for use with known magnetite separators.

Other objects and advantages of the instant invention will be apparent from the following description, made with reference to the accompanying drawings wherein:

Figure 1 is a top plan view of the invention, particularly illustrating the positioning of the conveyor apparatus;

Figure 2 is a side elevation view of one side of the invention disclosing the positioning of the conveyor drive and the inlet valves for the heavy medium;

Figure 3 is a side elevation view of the side opposite that shown in Figure 2;

Figure 4 is a section view of the invention taken on the line 4—4 of Figure 2;

Figure 5 is a section view of the invention taken on the line 5—5 of Figure 4; and

Figure 6 is a section view similar to Figure 5, but indicating the direction of flow and discharge points of the separating medium, and the coal, bony and rock.

Referring more particularly to these figures, it is seen that the receptacle for the heavy medium is approximately square or rectangular in plan. That is to say, the bottom of same is square in configuration whereas the top is of more rectangular shape. This is because, and as particularly illustrated in Figures 2, 3 and 5, the discharge end of the separator is formed with a slanted end wall substantially angled to the horizontal and so designed as to provide an inclined platform or base upon which the two flight conveyors ride to their respective discharge points.

The separator is provided with the usual base **2**, end walls **4** and **6**, respectively, and upright side walls **8** and **10**, respectively. The referred to slanted end wall **6** (Figure 5) is angled approximately 45° to the base **2**. The supporting base can be maintained in position by any usual means such as the side angle plates **12**, **13** and the end angle irons **14** and **15**.

Referring particularly to Figures 2 and 4, the cross-flow of fluid is found to be induced in part by a series of heavy medium inlets and in this form of the invention, five of such inlets are utilized. These are represented as fittings **20** to **24**, inclusive, consisting of tubular elements angled downwardly toward the base of the separator and opening directly into the interior thereof. Such several fittings are individually connected by means of the usual type of couplings generally indicated at **30** to angle fittings **31**, the latter by another group of couplings, generally indicated at **40**, interconnecting this system with the several heavy medium supply lines **42**.

The feed-in of the material to be separated is accomplished through the use of a hopper device generally shown at **45**, the latter consisting of a slanted side wall **50** that terminates in an upright extension **51**. The inside wall of the hopper in this design comprises the side wall **10**. By means of an appropriate aperture **55** in the side wall **10**, the hopper opens directly into the interior of the separator, it being at a position approximately even with the contemplated fluid level which is maintained during the separation procedure.

An additional feed-in is found in the inlet means which simply takes the form of an inlet pipe **60** capped at one end as at **61** and as shown in Figures 1 and 2. This inlet pipe is provided with a series of openings **65**, such comprising bores in the member **60** which are so angled to the vertical as to permit the discharged fluid to flow in a direction indicated in Figures 4 and 6, or in a direction approximately normal, or at right angles, to the movement of the incoming charge of material.

The purpose of this construction of the inlet pipe **60** is two-fold. The first thing is to saturate the feed particles with heavy medium so that the mass will not form a relatively dry or plastic island when it enters the vessel on which rock or bony will flow to the clean coal discharge. The other purpose is to provide a part of the current flow across the bath.

Considering for the moment the apparatus which has just been discussed, it will be seen that with the several inlets **20** to **24**, inclusive, angled in the direction described and shown, the pressure of the incoming medium, so directed, will tend to induce a cross-current flow or flow normal to the direction of movement of the two flight conveyors. It is obvious that the rate of flow may be controlled by the pressure of the incoming fluid. Furthermore, flow at or near the surface of the heavy medium is additionally aided by the medium discharged through the line **60** and openings **65**. The charged materials and water, here forced to descend rapidly and downwardly by the inclined plate **50** or bottom of the hopper, continues its progress across the surface of the heavy medium contained within the separator, and any involved directional impulses will naturally tend to carry the material of least density, such as the coal, across to the appropriate discharge point at the opposite side of the separator.

Although comparatively unimportant to the over-all invention here involved, it is to be appreciated also that certain details of construction may be necessary in the commercial embodiment of the apparatus. For example, in addition to the angle irons surrounding the base of the separator, intermediate strengthening members may be used. These may similarly take the form of angle irons, such as the intermediate ones indicated at **70**, **72** and **80**.

Likewise, the top of the container may additionally be surrounded by several like elements such as shown at **74**, **76** and **78**. At the inclined end, the bracing member **77** is adapted to fit against the plate forming the line or edge of discharge as shown in Figures 2 and 5.

As a preface to further description of the apparatus, it will be noted, as shown in Figure 6, that two separate chambers or zones are indicated as zone A and zone B, respectively. The first might be described as the separating chamber or zone and the second as the settling chamber or zone. Both zones A and B are formed, in part, by two transverse plates **90** and **92** which extend from a point substantially above the contemplated level of the heavy medium, to a point short of the bottom **2** of the separator. In other words, these plates, terminating in the edges **90'** and **92'**, extend downwardly to a depth which is just above the respective conveyor flights, thus permitting passage of the latter underneath such plates. At any rate, the various materials of different specific gravities charged through the described hopper to the first zone, or zone A, are thus maintained within these two plates **90** and **92** during their course laterally across the separator to the several discharge outlets. Despite the longitudinal direction of motion of the conveyor flights, these confining plates also prevent such flights, while in operation, from substantially disturbing or interfering with the induced lateral flow of the body of heavy medium. At the same time, since the rock finally settles to the bottom of the container, such materials then rest at a position where they are picked up by the rock conveyor upwardly for ultimate discharge.

The two referred to plates **90** and **92** are, of course, bounded on the one hand by the side plate **10** of the separator. On the other side they are bounded by an additional longitudinal plate or divider **95** which throughout most of its length is of the same vertical dimension, or that sufficient to match or interfit with the upper edges of the respective transverse plates **90** and **92**. This longitudinal dividing member **95** continues, as seen in Figures 3 and 5, in an extending flange which is angled at approximately 45° to match the angle of the end plate **6**, referred to above. Actually, this dividing plate **95** and its extension **96** comprises a partition which also segregates the two conveyors to be later described, in order that the bony, during its travel to point of discharge, is completely separated and prevented from again intermixing with the rock, slate or other heavy material which has been separated in the main portion of the container for discharge by the adjacent conveyor. Obviously, such dividing member **95** also separates the two zones A and B from each other.

The dividing plate **95** is conformed in such a way so as to perform the function of a weir, permitting the buoyant coal to flow through an appropriate opening into a discharge chute generally indicated at **112**. To this end, the plate or divider **95** is provided with a cut-out portion **100**, and by reference to Figure 4 it is seen that the heavy medium with the segregated coal flows over the edge of weir plate **101** and thence through the discharge structure.

Again, two appropriate openings **105** and **110**, of rectangular configuration, and successively lower than the weir-plate **101** provide points of discharge for the material of intermediate specific gravity, i.e., the so-called bony.

An auxiliary discharge point for the heavy medium is found in a discharge spout generally indicated at **111** in direct interconnection with zone B, and controlled by a V-notch weir gate, the latter regulating somewhat the amount of flow of heavy medium through the apparatus. Prefatory to a more particular description of the apparatus just referred to, reference is made to Figure 6 for explanation of the manner in which the separated materials, and the heavy medium itself, are continuously discharged through the apparatus. Here it is seen that separation fundamentally occurs in zone A with the rock proceeding to the bottom where it is picked up by the rock conveyor. The coal, floating on top of the medium, is discharged through the discharge spout **112**, the flow of coal and some heavy medium proceeding through, but sealed off from, the filled chamber or zone B. The bony or intermediate material progresses through the two openings **105** and **110**, gradually descending, in zone B, to the bottom thereof where this is in turn picked up by the bony conveyor and transported to an appropriate discharge point.

The discharge trough **111**, is in direct communication, as stated, with zone B. Flow therethrough is controlled by the referred to V-notch gate valve. By the time the medium reaches zone B through the bony outlets, and by the time it has remained for a period of comparative quiescence in zone B, the density-controlling particles will have settled to some extent in that chamber with the result that the medium at the top of the body of fluid is of substantially lighter density. When removed at this point, this lighter density medium is not directly recycled to the apparatus, for having a specific gravity of perhaps 1.1 or an extremely low specific gravity, it would tend to upset the density of the medium in the main separating chamber if it were directly recycled. Instead, it is directed to the dilute medium sump and usual magnetic separator and thence to the medium storage sump to maintain a proper density for use in zone A. On the other hand, some of the heavy medium is necessarily removed during discharge of both the bony and rock or slate. Since these two components are removed from the bottom of the respective zones A and B, the heavy medium at these lowermost positions will tend to be of higher specific gravity, for reasons heretofore explained. Hence, once removed from the rock and bony, by suitable vibrating screens or other mechanism, it is necessary to recycle this medium through the medium storage sump thence to the separating chamber; in this way the proper density will be maintained for the particular separating problem at hand. As a matter of fact, with respect to the handling of either the dilute medium taken from the surface or the heavy medium taken from the bottom of the separator, the recycling procedures and apparatus set forth in my aforesaid Patent No. 2,734,629 are generally applicable.

The coal is discharged, obviously together with some of the heavy medium in which it is more or less submerged, through this referred to spout or tray construction **112**. In this embodiment of the invention, the same consists of two side plates **120** and **121**, as well as the bottom member **115**.

Referring back to the bony discharge means, elements are provided for aiding in the adjustment of the amount of flow through the bony discharge openings **105** and **110** in the dividing member **95**, and this means takes the form of a flap valve arrangement. Adjustment of same is made possible by use of a jacket generally indicated at **130**, the latter being located in the path of flow of the discharge medium but neither substantially interfering with such flow nor permitting leakage into the chamber so provided for the bony discharge controls. This jacket, as stated, is located in the center of the discharge tray or spout **112**. Bounded by front and back walls **133** and **135**, respectively, the side walls **134** and **136**, the jacket rests upon the base **115** of the discharge spout **112**. Through opening **140**, it provides a clear passageway for the control elements of the flap valves, and since the jacket is narrow and pointed as at **138** on the side towards the interior of the separator, it has little effect in retardation of flow of the buoyant coal and accompanying heavy medium out of the apparatus through the coal discharge tray **112**.

As further clarification of the description of the discharge means **112** for the coal, it is seen that the sides

of this tray or spout, extending upwardly from the base **115** thereof, comprise extensions of the two transverse plates **90** and **92**. These extensions are so shaped as to extend downwardly from the sides of this discharge spout. The base **115** of the coal discharge means **112** also extends from the dividing plate **95** downwardly to the point of discharge. It is to be further understood that although the separated coal accompanied by a certain proportion of the heavy medium is indicated as simply passing out of this discharge means for this lighter of the separated materials, this separated component may be subjected to further treatment. For example, it is usually screened over a vibrating screening mechanism aimed at removing the heavy medium. The latter, as explained herein, and if of the required specific gravity, may be recycled directly to the separator during the continuous operation of the mechanism.

Added controls for regulating flow of the medium and hence of the intermediate, the bony, that is present in such medium, are positioned above the upper opening **140** of the jacket. Located upon a suitable support **150**, the levers **152** and **154** provide a means for closing or opening the respective flap valves **160** and **161**. These described levers, capable of being locked in the desired open position by a suitable ratchet mechanism, such as that indicated at **155**, are interconnected to the described valves through rods **170** and **171**. Such control rods extend through the described jacket **130**, and angled ends of the rods being secured to the two flap valves by appropriate apertures in the control levers and in the lugs such as that shown at **165**. The lugs are shown as secured to the lower portion of each flap valve. As seen in Figure 4, the valves **160** and **161** are simply pivoted as at **163** to the dividing plate **95**. Also, as shown in Figure 4, the upper of these valves is closed and the lower partially opened, hence forcing flow of the intermediate or bony through the described lower opening **110**, and thence to the conveyor flights which convey the bony from this position on the floor of the separator to the point of discharge.

From the foregoing it is seen that under certain conditions the upper gate may be closed, the lower gate open full; under other conditions both gates may be open full. Furthermore, it is to be appreciated that such gates, in regulating the flow of liquid through the described openings, consequently regulate the amount of bony passing into zone B. Actually, the rate of fluid flow is more directly controlled by the V-notch weir gate **180**, to be described.

The upper valve **161** is here shown as closing the bony outlet **105**. However, and as indicated above, adjustment of each valve to open to a full or intermediate position is dependent largely upon certain variables, as for example, amount of bony in the materials charged to the separator, speed of separation, rate of flow of heavy medium, etc.

An additional means is provided to not only control rate of flow of the heavy medium, but also height of fluid within the separator. Such controls are necessary for the rate of flow, relative proportions of the materials being separated, over-all speed of operation, among other factors, are all variables dependent one upon the other and adjusted by the operator to meet the requirements of different mixed materials. At any rate, this additional control takes the form of a V-notch weir gate valve, generally indicated at **113**, and fitted to accurately adjust the size of the discharge opening **180**, the latter, formed in the side wall **8** of the separator, opens zone B thereof to the exterior. The gate valve is supported upon two guides **182** and **183**. It is vertically positioned and fitted with slides or races **184** and **185** for reception of the gate valve itself, **190**. The gate valve is adapted to be raised and lowered upon the referred to slides and the means for doing so takes the form of a threaded member **188**, fitted within an adjoining cross brace **186** that is appropriately tapped for this purpose. By means of a suitable swivel or pivot structure **187**, the gate is affixed to the end of the threaded knob **192** which, when turned in one direction, will raise the gate and when rotated in the opposite direction will lower the same. The construction of the gate valve **190** is peculiar in this respect: such valve is provided with an opening **191** which is of the configuration shown in Figure 3, i.e., the discharge opening in the valve has lower converging edges which form a V-shape. The purpose of this is to provide a construction wherein the amount of flow can be controlled within very fine increments. It is to be appreciated that were the aperture **191** square in shape, even opening the valve a slight degree might create flow at a greater rate than desired; whereas with the V-notch construction, discharge is controlled in very fine and accurate amounts. In Figures 3 and 6, the gate valve **190** is shown in partially opened condition, and in Figure 3, the extent of its downward movement is indicated by dotted line **194**. Actually the weir opening **180** and the gate therefor controls rate of flow of a small proportion of heavy medium out of the separator, in this case such medium being discharged through opening **110** and then out of zone B. The described gate structure has a dual purpose. Its main function is to control the volume of liquid discharged from the bone conveyor compartment, whatever volume discharged through the V-notch being approximately equal to the volume of liquid that passes through the bony gates from the separating compartment of the vessel or bath to the bony compartment and conveyor. The other function of the V-notch gate is to remove the very light specific gravity liquid from the top of the bony conveyor compartment, the said light specific gravity liquid being passed to the dilute heavy media portion of the recovery shaker mechanism and thence to the magnetic separator for recovery of the magnetite and elimination of water.

The following example may further clarify the comparative rates of flow, in operation of this apparatus, through respectively, the bony gates, the coal discharge opening and the V-notch weir gate. If it is to be assumed, as an example only, that 600 gallons per minute of heavy-media fluid, plus 30 gallons per minute of clear water which comes in the saturated feed, is delivered to the separating chamber through the various inlets **20** to **24**, inclusive, the series of openings **65** and with the saturated feed, is fed to the separating chamber with the charge of materials to that chamber, then it is seen that approximately 630 gallons per minute flow through the separating compartment. In operation of the apparatus, approximately 20 gallons per minute of the separating medium is discharged with the conveyors. Of the remaining liquid, the great portion thereof is discharged out of the apparatus with the coal and in example of consideration, about 580 gallons per minute would come out of the apparatus through the coal discharge opening or spout **112**. Only a relatively small proportion of fluid is discharged out of zone B through the V-notch weir gate **190** and in most instances, that amount would not exceed 30 gallons per minute. At any rate, the latter amount is sufficient to materially aid in creating the flow of that proportion of the medium carrying the bony from zone A to zone B. It is of course to be understood that the referred to amounts are generalizations only; they will vary depending on the velocity required to transfer the bony from zone A to zone B and upon other conditions such as the specific nature of the materials being charged to the separating apparatus. As further explanatory of the operation of the invention, it can be stated that the specific gravity of the separating medium will generally approximate 1.70. At the bottom of zone A, the specific gravity may be somewhat increased, e.g., to 1.71; whereas at the top of zone A, where the medium is carrying the buoyant coal, the specific gravity may be lowered to 1.69. On the other

hand, in zone B, where the fluid is in a relatively quiescent state, the medium at the top may be substantially lighter and of a specific gravity as low as 1.1. Again, the figures just mentioned are relative and by way of example only, obviously subject to variation depending upon the operative conditions encountered in use of the apparatus.

Again, referring to Figure 6, the discharge opening **180** permits flow into any usual type of discharge spout, as that generally indicated at **111**. In the description of this invention, mention has been made of the further processing of the heavy medium so discharged from zone B of the separator. Such medium, coming from the so-called settling chamber or zone B, will always be of a lighter density than the medium in the separator since it is taken from the top of the fluid mass, and as indicated above, it may approximate a density as low as 1.1. Since the direct recycling to the separating chamber or zone A of this lighter density fluid would materially affect the predetermined density of the medium in that chamber, such discharge fluid is ordinarily run through the usual magnetic separator for recovery of the ferrous particles, remixed in the medium storage sump to maintain the predetermined density for separatory purposes and then recycled into the separating chamber.

More particular reference will now be made to the two conveyor systems which separately propel two of the separated constituents of the mixed charge, i.e., the bony and the rock, to a point of discharge above the liquid level of the bath, conveying the same along the inclined bottom plate **6**, as may be appreciated by reference to, e.g., Figure 5. These conveyor mechanisms are supported and driven upon a series of four shafts; one of which is located in each of the corners of the container or tub of the separator. Thus, the shaft **200**, the driven shaft, and located at the discharge end of the separator, is maintained transversely across this end in suitable bearing or pillow blocks **202** and **204**, such blocks being secured to the unit upon the angle members **74** and **78**, respectively, which have been heretofore described. All of these shafts are positioned in parallel alignment with each other, the shaft **210** being similarly mounted in opposed bearing blocks **212**, **213** affixed in any suitable manner to the upper edges of the separator and in the upper inby corner of same, as indicated in Figure 5.

The shaft **220** is positioned immediately beneath shaft **210**, is thus in the opposite corner of the separator, and suitably mounted for rotation in this position by any common media, and in this instance not shown in the drawings. The shaft **230**, also positioned on the bottom of the container, provides the turning point for the two conveyors in their propressive movement along the bottom of the separator, up the angular incline to the point of discharge. This shaft also is positioned, as indicated in Figure 5, by ordinary bearing means well known to the art.

This series of four shafts provide the means of support for the two conveyor systems, both of which are driven in unison by a common power source. The flight conveyor system for the rock is of the greater width and extends approximately three-fourths of the way across the separator unit. The flights of this conveyor are driven through a series of sprockets, all keyed as by key **240** to the respective shafts described above. For example, the shaft **200** carries two sprockets **250** and **251** equally spaced from each other and adapted to drive two drag chains **261** and **262** which in turn carry the respective flights **270**. The chain may be of the ordinary closed link or roller chain type, and the flights in this embodiment of the invention are merely shown as angle irons welded to such chain at spaced intervals, with the upright of the angle being positioned vertically to the chain. The two drag chain and flight assemblies, as can be appreciated, are carried through the separator along the bottom thereof, up the inclined side to a point of discharge, and repeatedly back through this same cycle by means of additional sprockets.

The several additional sprockets which carry the referred to drag chains **261** and **262** are located as follows: on top of the separator unit, and mounted on the shaft **210** are found the sprockets **252** and **253**, keyed to the shaft in the usual fashion. Similarly, immediately under those just described and at the bottom of the separator, mounted upon the shaft **220**, are placed the sprockets **254** and **255**. In like fashion, the transverse shaft **230**, located as stated, at the point of inclination of the end plate **6**, carries the two sprockets **256** and **257** also keyed thereto in the usual manner.

The conveyor assembly for the bony, located in the so-called settling chamber or zone B of the apparatus, is of similar construction except that only one sprocket is used on each shaft to maintain and drive the several flights, here designated with the numeral **290**. This second conveyor system is much smaller in dimension than the rock conveyor and adapted to remove the bony as it penetrates to zone B during the course of separation. Accordingly, the drag chain **280** which supports the several flights **290** of the bone conveyor is mounted upon a similar series of four sprockets. In this instance, the drive shaft **200** carries the sprocket **280**, the sprocket **281** is keyed upon shaft **210**, sprocket **282** upon shaft **220**, and sprocket **283** upon shaft **230**. The result is that when both conveyors are driven in unison as stated above, the operation of the bony conveyor is identical to that of the rock conveyor—the bony is picked up along the bottom of the settling chamber or zone B and carried up the inclined end plate **6** to the point of discharge.

It can be appreciated from the structure just described that these conveyors assure complete separation of the three divided materials: coal, bony and rock. The rock and bony conveyors are separated by the dividing wall **95** so that once the heavy medium has accomplished separation, these two components are carried to their respective points of discharge without further intermingling. The coal, discharged in the manner described above, is also completely segregated from the other two components from the time it rises to the surface of the heavy medium and without further chance of intermingling with the impurities contained in the original charge.

These two flight conveyor systems can be driven in any usual manner, here shown as by means of an electric motor M. Preferably the motor runs through some known type of reduction gearing R, the motor and reduction gearing being supported upon a base **300** as shown in Figures 1 and 4. Such base can be strengthened by any usual means such as the brace **302** extending between the base and the side wall **8** of the separator.

The driving spur gear **305** of the motor powers the apparatus through a common type of drive chain **310**, the latter in turn rotating the ring gear **312**. It is of course manifest that motor speed, nature of reduction gearing, size of spur and ring gears, can all be designed within the skill of the art to regulate the speed of the travel of the two conveyor systems at a rate commensurate with the desired purpose. In other words, speed of motion of the flights would in large part be controlled by the relative size of the unit, the material being separated, the nature of the heavy medium, and such other variable factors.

The referred to ring gear by means of key **315** is secured to the shaft **200**, and hence the conveyors are set in motion in a direction indicated by the arrows appearing in Figures 2, 3, and 5.

Mention has been made of the manner of recycling in order to provide for continuous operation of the invention. It can be appreciated that the apparatus is conducive to maximum use of the density-controlling particles in the medium, in this sense: since the separator bath is constantly agitated by reason of the input of the heavy medium thereto, and also by reason of the cross-

current motion imparted to that bath by the rock conveyor, the suspended ferrous particles are effectively dispersed throughout the body of the medium with a resultant, necessary and constant specific gravity at the desired point throughout the medium. In the so-called secondary zone or settling chamber, there will develop some change in density of the medium with the lower density fluid naturally being near the top. Upon discharge, this may be densified through the usual mechanism such as a magnetic separator, proper density re-established, and then recycled through the several inlets **22**, **23**, etc., at a rate to create the desired cross-current flow. At the same time, and as suggested above, those particles which do settle to the bottom of the chamber, at least in sufficient amount to create a heavier density at the bottom of the bath, are conveyed to the discharge point by both the rock and bony conveyors. These two separated materials are drained of loose, undiluted magnetite which is then deposited in the medium storage sump to help maintain an established density. Then the same separated materials are washed free of all magnetite, the latter being recovered by a magnetic separator and deposited in the same medium storage sump to also help maintain a uniform density in the system by recycling to the main separator chamber through the inlets **20** to **24**, inclusive.

In the referred to embodiment of the invention, the design of the apparatus is of that size to accommodate a flow of the heavy medium through the separator at the rate of approximately 600 gallons per minute, this rate being sufficient to impart a substantial lateral flow that will effectively carry the coal and bony across the width of the separator to their respective points of discharge. As a main figure, it is contemplated that the dimension of the separator will be such that separation of coal is accomplished at a rate of approximately 20 tons per hour, per foot of width of the apparatus. Reducing these estimates to size dimensions, if the separator is of a three-foot width the amount of coal cleaned and separated would approximate 60 tons per hour. The relatively great capacity of the invention is thus demonstrated when it is observed that despite the relatively small size of the unit the capacity is nevertheless sufficient to accommodate substantial commercial quantities. Those factors materially contributing to the simplicity and functional effectiveness in operation, involve, inter alia, a two-fold concept: cross-current flow in the manner described, and secondly, ability to achieve effective separation with such cross-current flow by means of conveyor systems which move in a roughly circulatory path all the way through the linear dimension of the separator, above the same and back to the floor of the container in a continuous or repeated cycle.

With a calculated input of the heavy medium to create a cross-current flow of material, the conveyor systems are operated at a speed which will be commensurate with the amount of materials fed to the unit. Obviously, the greater the cross-current flow, the greater the charge of materials to be separated that can be handled, and in such instance, it is to be assumed that the conveyor systems will function at higher speeds. The converse is true when the charge to the separator is of a materially lesser rate.

Certain accompanying apparatus which would normally be employed with a unit of this type forms no part of the invention herein but is mentioned as demonstrating the applicability of the invention for commercial use in conjunction with other mechanical phases of e.g., the clarifying and separation of coal. For example, the nature of the heavy medium has been mentioned. If a magnetite solution is employed to obtain the predetermined and requisite specific gravity required for the separation, then a magnetic separator of the type generally referred to in my Patent No. 2,734,629, would be employed.

Furthermore, and especially if a magnetite-type of heavy medium is utilized, it is ordinarily necessary to preserve such medium over as long a period as possible. This objective is achieved, in part, by the use of a magnetic separator as just referred to. It is further obtained by the re-cycling of the medium at its discharge point, and possibly after it has gone through a magnetic separation phase, to the various inlets herein described such as those shown at **20** to **24**, inclusive. Thus, the mode of operation generally indicated in Figure 4 is to be considered by way of exemplification only; here the separated and floating coal is shown as being discharged through the spout **112** together with a substantial quantity of the heavy medium. As stated above, this step would ordinarily be accomplished by an additional phase wherein the coal is removed from the medium and subjected to possibly a further washing procedure, etc., and the medium is recycled as mentioned before. Thus, although not shown, it is understood that the coal at its discharge point from the spout **112** would be subjected to a screening or equivalent operation that would efficiently separate it from its carrying fluid.

It is thus seen that I have provided a simplified and effective means of accomplishing a triple separation of mixed materials. The apparatus lends itself to a continuous and uninterrupted procedure, and one which can be conducted at an extremely low cost. Despite the comparatively large output, the relatively diminutive size of the apparatus comprising this invention lends itself to the needs of the medium or moderate sized operator. Furthermore, a distinct advantage of the invention is found in the ability of the apparatus to maintain a uniform and predetermined specific gravity in the medium storage sump by returning the total amount of medium of various specific gravities from all discharge points. The system is kept in balance because the excess water that comes in with the feed is removed by V-notch weir **180** and sent through the magnetic separator. Such features, coupled with the shallow structure of the separator, enables a quick return of medium and hence assures maintenance of the required specific gravity of the medium with a minimum addition of magnetite.

I claim:

1. An apparatus for the continuous heavy-medium separation of mixed materials of different specific gravities comprising an elongated receptacle having upstanding side walls and opposed end walls, means to feed and maintain a flow of said medium and said materials across said receptacle, said receptacle having longitudinal dividing member forming two longitudinal chambers, one of said chambers being provided with a first flight conveyor system to remove the heaviest of said materials by movement longitudinally of said one chamber, means to admit the materials of intermediate specific gravity to the other of said chambers, a second flight conveyor system in said other chamber to remove said intermediate materials by longitudinal movement in said other of said chamber, means to remove the lightest and buoyant of said materials from said one chamber, said last named means comprising a trough member positioned in and through said second chamber and in line with said flow of said medium, and driving sprockets mounted in each corner of said receptacle, said first and second conveyors being mounted in driving relationship with said sprockets, said conveyor systems being arranged for movement in a direction right angularly to the direction of flow of said medium and materials.

2. An apparatus for the continuous heavy-medium, triple separation of mixed materials of high, low and intermediate specific gravities, said apparatus including a heavy medium elongated receptacle having side walls and opposed end walls, means to charge said materials and said heavy-medium at right angles to the longitudinal axis of said receptacle, means to maintain flow of medium and materials across said receptacle, said receptacle having a

dividing member extending longitudinally thereof to form two longitudinal chambers, said chambers having a plate disposed right angularly to said member forming a separation zone and a settling zone for materials of intermediate specific gravity, said separation zone being provided with a flight conveyor system to remove the heaviest of said materials, means to admit the materials of intermediate specific gravity to said settling zone, a flight conveyor system in said settling zone to remove said intermediate materials, means to remove the lightest and buoyant of said materials from the top of said medium in said separation zone, said last named means being positioned in and through said settling zone and in line with said flow of said medium, and driving shafts having opposed sprockets in each corner of said receptacle, said conveyor systems being mounted for movement longitudinally of said receptacle on said sprockets.

3. An apparatus for the heavy-medium separation of mixed materials consisting of coal, bony and rock, comprising an elongated receptacle, having upright side walls and opposed end walls, means to charge said materials and said heavy-medium across said receptacle, said receptacle having a dividing plate positioned parallel to said side walls to form two longitudinal chambers, one of said chambers being provided with flight conveyor means to remove said rock in a direction parallel to said side walls and normal to the flow of said heavy-medium, means to discharge said bony across said receptacle from one chamber to the other of said chambers, a flight conveyor means in said other chamber to remove said bony in a direction parallel to said side walls, and trough means to remove the coal from said one chamber, said last named means being positioned in and through said second chamber and in line with said flow of said medium.

4. An apparatus for the continuous heavy-medium separation of coal, rock and bony comprising an elongated receptacle having upstanding side walls and opposed end walls, means to charge said materials with a portion of said heavy-medium across said receptacle in a direction at right angles to said side walls, said receptacle having a dividing member disposed longitudinally with respect thereto to form two longitudinal chambers, one of said chambers being provided with flight conveyor means adapted to remove rock therefrom in a direction right angularly to the flow of said heavy-medium, means to maintain said flow of the medium laterally with respect to said elongated receptacle and comprising a plurality of heavy medium inlets on one side of and directed across said receptacle, a heavy medium discharge means on the opposite side of said receptacle, a passage-way in said dividing member to permit bony from said one chamber to enter the other of said chambers, a flow control in said passage-way, a flight conveyor means in said other chamber to remove said bony in a direction at right angles to the direction of flow of said medium, and means to remove the coal from the top of said medium in said one chamber, said last named means being positioned in and through said second chamber and in a direction complementary to the direction of said flow of said medium.

5. An apparatus for the heavy-medium separation of coal, rock and bony comprising an elongated receptacle having parallel side walls and opposed end walls, means to charge said materials and said heavy-medium to said receptacle in a direction at right angles to said side walls, said receptacle having a dividing member forming two longitudinal chambers, one of said chambers being provided with flight conveyor means to remove rock therefrom in a direction right angularly to the flow of said heavy-medium, an adjustable passage-way to permit bony from said one chamber to enter the other of said chambers, a flight conveyor means in said other chamber to remove said bony in a direction right angularly to the flow of said medium, means to remove the coal from the top of said medium in said one chamber, said last named means being positioned in and through said second chamber and in line with the direction of flow of said medium, means to maintain medium flow from one side of said receptacle to the other side thereof, said last named means comprising an outlet in said other side, and a flow control for said outlet comprising a V-notch gate valve.

6. An apparatus for the continuous heavy-medium, triple separation of mixed materials of high, low and intermediate specific gravities, said apparatus including an elongated heavy medium receptacle having upstanding side walls and opposed end walls, means to direct said materials and said heavy-medium across said receptacle, means to maintain flow of medium and materials from one side to the other side of said receptacle, comprising a plurality of heavy-medium inlets in one of said side walls of said receptacle, said receptacle having a longitudinal dividing member forming two longitudinal chambers, said chambers having a lateral dividing plate disposed in a direction parallel to said end walls and forming a separation zone and an adjacent settling zone for materials of intermediate specific gravity, said separation zone being provided with a flight conveyor system to remove the heaviest of said materials, a passage-way connecting said zones to admit the materials of intermediate specific gravity to said settling zone, a flow control in said passage-way, a flight conveyor system in said settling zone to remove said intermediate materials, said conveyor systems being aligned in a direction right angularly to the said flow of said medium, means to remove the lightest and buoyant of said materials from the top of said medium in said separation zone, said last named means comprising a trough positioned in and through said settling zone and in line with the direction of flow of said medium, driving sprockets in each corner of said receptacle, said conveyor systems being mounted for movement longitudinally of said receptacle on said sprockets, and a heavy medium discharge means on the side of said receptacle opposite said inlets, said discharge means being provided with a V-notch gate valve to control flow therethrough.

7. In an apparatus for separating materials of heavy, intermediate and light specific gravities, a horizontally positioned separating receptacle having upright side walls and opposed end walls, one of said end walls being angularly slanted outwardly from base to top with respect to the horizontal, two partitions between said side walls and a dividing member between said end walls, said partitions and said member forming a separating chamber and a settling chamber, a flight conveyor means in each of said chambers, an interconnection between said chambers, a sprocket drive means in each corner of said receptacle to drive each of said conveyor means, each of said conveyor means being mounted to progress along the bottom of said receptacle, up said slanted end wall and in reverse direction over said chambers, means to admit said materials across said receptacle into said separating chamber, and a discharge trough through said settling chamber, whereby said materials are separated in said separating chamber, said heavy materials being removed by said conveyor in said separating chamber, said intermediate materials progress through said interconnection to said settling chamber and are removed by the conveyor therein, and said light materials are discharged through said discharge trough.

8. In an apparatus for separating materials of heavy, intermediate and light specific gravities, a horizontally positioned separating receptacle having upright side walls and opposed end walls and adapted to receive a heavy medium, one of said end walls being angularly slanted outwardly from base to top with respect to the horizontal, two partitions between said side walls and a dividing member between said end walls, said partitions and said member forming a separating chamber and a settling chamber, means to admit said medium and said materials across said receptacle, a flight conveyor means in each of said chambers, intermediate receiving passageway be-

tween said chambers, a sprocket drive means in each corner of said receptacle to drive each of said conveyor means, each of said conveyor means being mounted to progress along the bottom of said receptacle, up said slanted end wall and in reverse direction over said chambers, a discharge trough through said settling chamber and regulating means to regulate rate of discharge through said trough, whereby said materials are separated in said separating chamber, said heavy materials being removed by said conveyor in said chamber, said intermediate materials progress through said passageway to said settling chamber and are removed by the conveyor therein, said

light materials are discharged through said discharge trough, and rate of operation of said apparatus may be controlled by said regulating means.

References Cited in the file of this patent

UNITED STATES PATENTS

2,139,047	Tromp	Dec. 6, 1938
2,349,528	Trostler	May 23, 1944
2,465,220	Garber	Mar. 22, 1949

OTHER REFERENCES

"Colliery Engineering," January 1939, pages 18–22.