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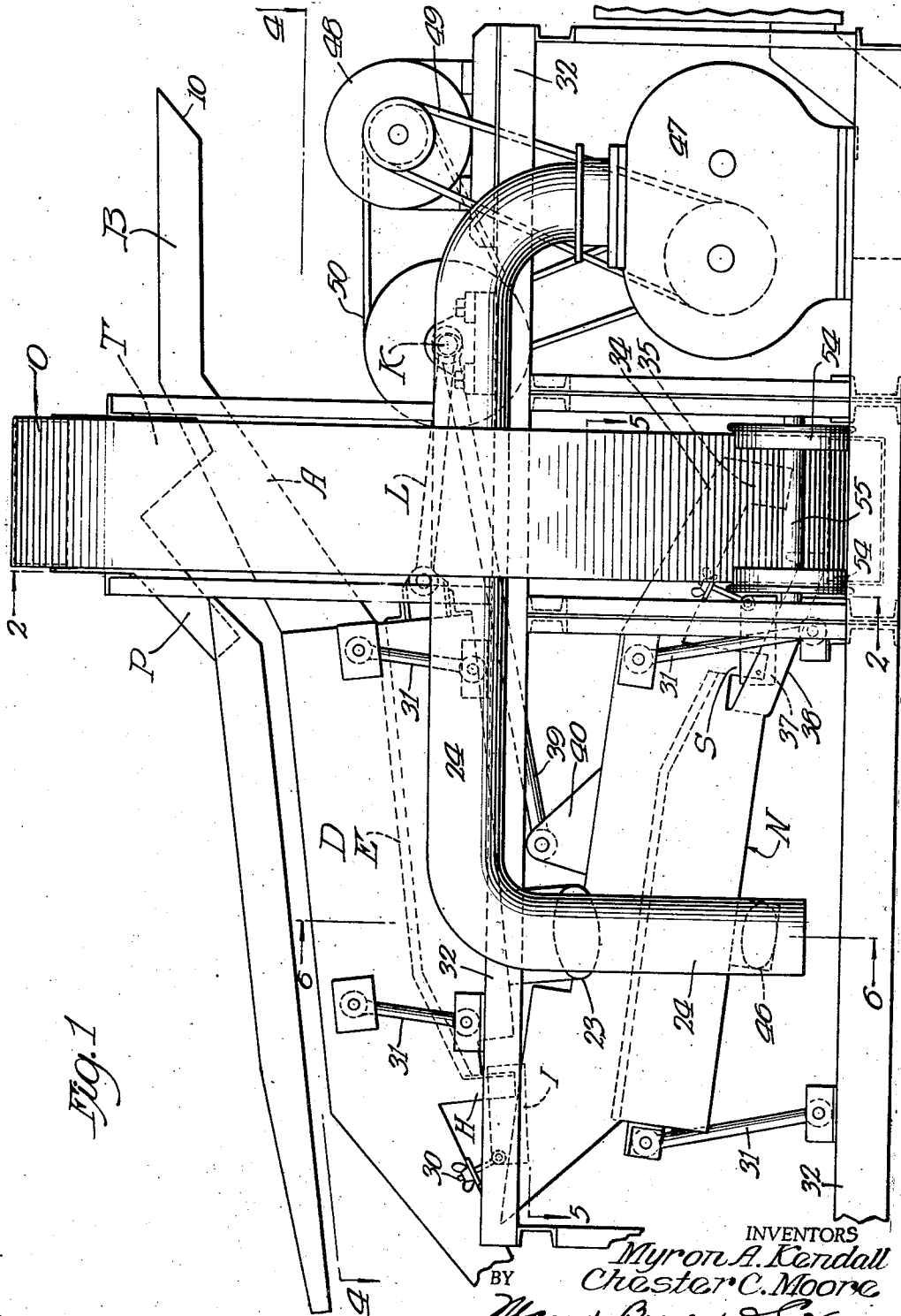
M. A. KENDALL ET AL

2,358,293

COAL CLEANER

Filed June 20, 1940

6 Sheets-Sheet 1



INVENTORS

Myron A. Kendall
Chester C. Moore

Chester C. Moore

BY *Chester C. Moor*
Mann, Brown & Co.
ATTORNEYS

Mann, Brown & Co.
ATTORNEYS

ATTORNEYS

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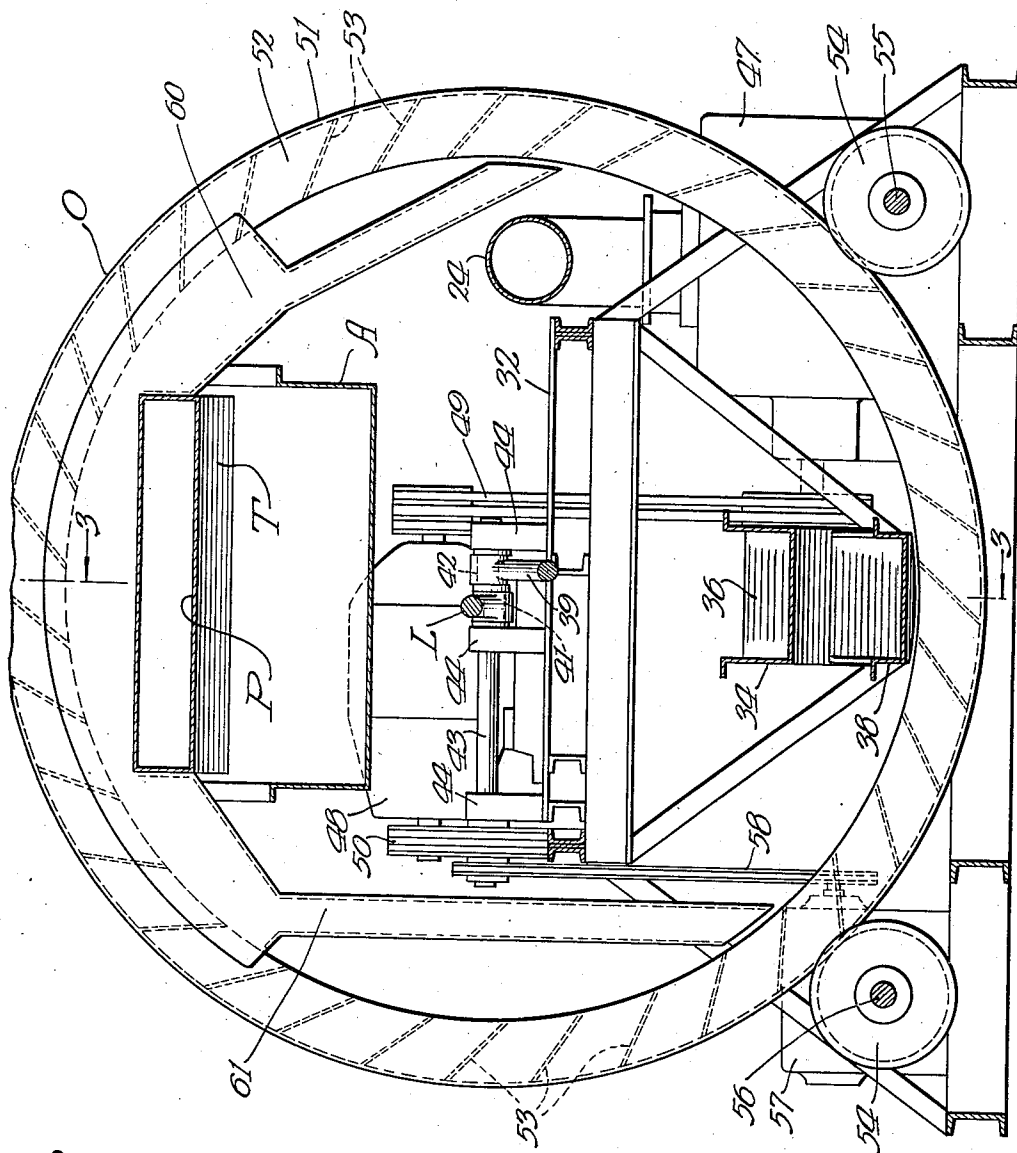


Fig. 2

INVENTORS
Myron A. Kendall
BY Chester C. Moore
Mann, Brown & Cox
ATTORNEYS.

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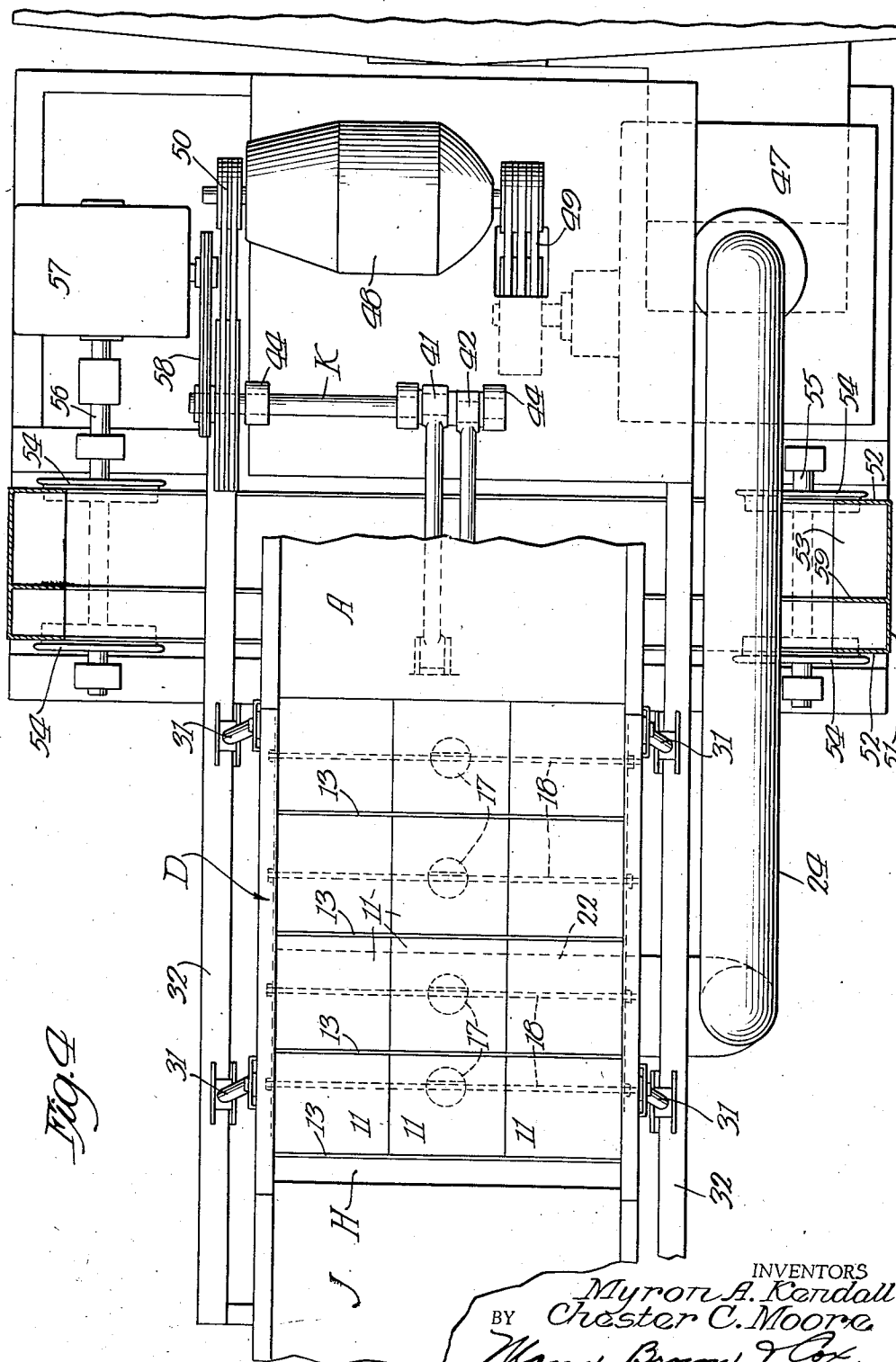


Fig. 4

INVENTORS
Myron A. Kendall
Chester C. Moore
BY
Mann, Brown, & Cox
ATTORNEYS.

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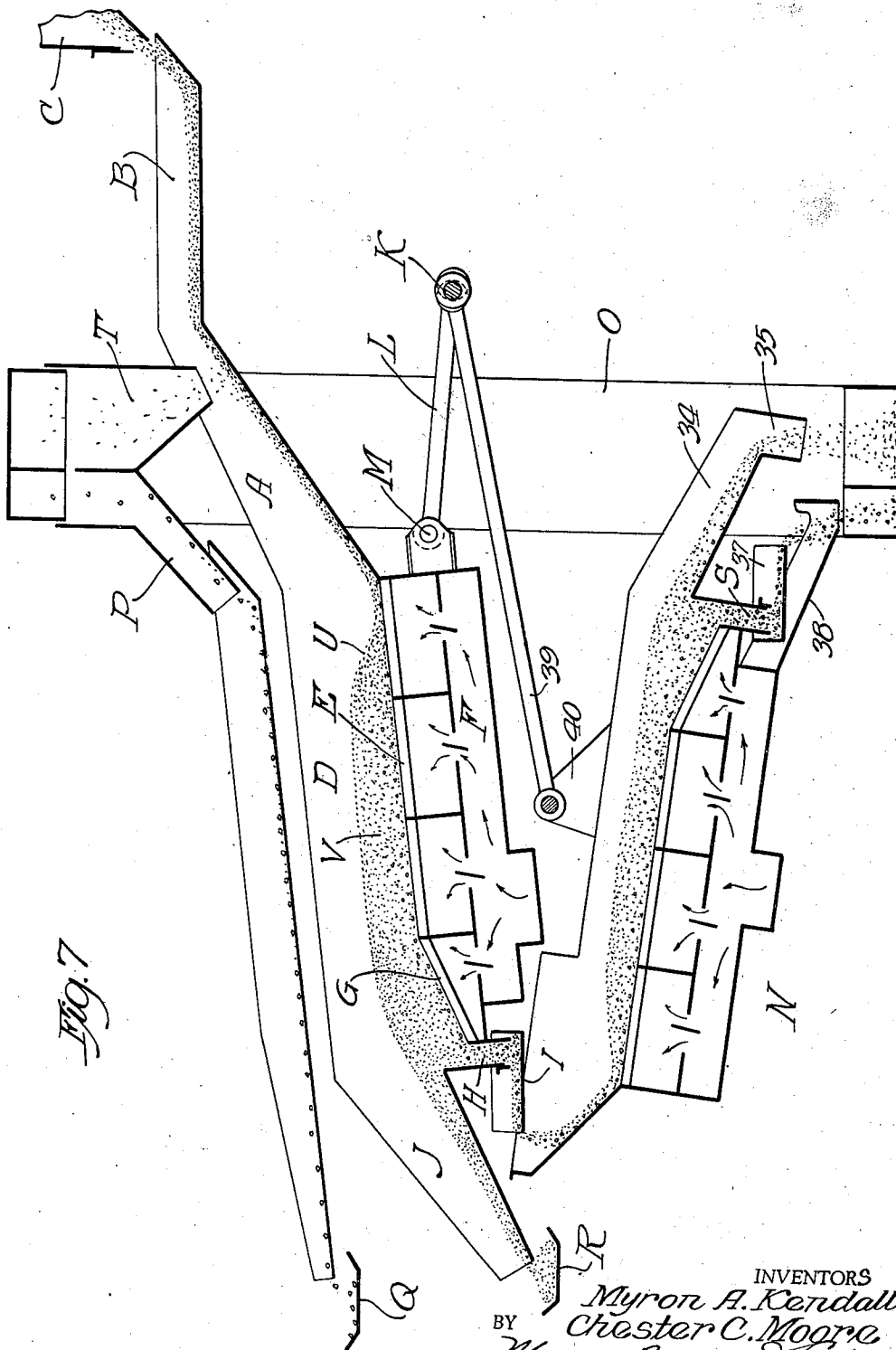


Fig. 7

INVENTORS
Myron A. Kendall
Chester C. Moore
 BY *Mann, Brown & Cox,*
 ATTORNEYS.

UNITED STATES PATENT OFFICE

2,358,293

COAL CLEANER

Myron A. Kendall and Chester C. Moore, Aurora,
Ill., assignors to Stephens-Adamson Mfg. Co.,
a corporation of Illinois

Application June 20, 1940, Serial No. 341,424

7 Claims. (Cl. 209—466)

This invention relates to the separation of granular or lump materials of different specific gravities such as, for instance, removing the relatively heavy, stony material from coal and more particularly to cleaning what is called fine coal, although the application to other uses is contemplated and will readily occur to others in various industries.

Generally speaking, the scheme includes feeding the mixture in a thin swift stream down a steep chute into an oscillating trough sloping gently downward and swept by air flowing through its pervious bottom and upwardly through the stream of material and in dividing that stream horizontally to deliver the heavy materials below and the light material above.

Apparatus forming the embodiment of the invention at present preferred is shown in the accompanying drawings in which

Fig. 1 is a side view;

Fig. 2 is a vertical cross section on the line 2—2 of Fig. 1;

Fig. 3 is a longitudinal vertical section on the line 3—3 of Fig. 2;

Fig. 4 is a plan view, parts being broken away;

Fig. 5 is a horizontal section on the line 5—5 of Fig. 1;

Fig. 6 is a vertical section on the line 6—6 of Fig. 1, and Fig. 7 is a diagrammatic layout in vertical section illustrating the general organization of the apparatus.

But these specific drawings and the corresponding description are used for the purpose of illustration only and are not intended to impose unnecessary limitations on the claims.

General description

In Fig. 7, A indicates a steep chute down which the materials to be separated are fed in a thin stream from a feed pan B, receiving a supply from any suitable source from any kind of a spout C.

The chute A and the pan B are shown in one piece with a trough D, having an air pervious bottom E through which air flows upwardly from a pressure chamber F. The bottom E is inclined downwardly at G to a bottom discharge spout H, throttled by pan I and beyond the spout the trough D terminates in a discharge spout J for the lighter materials, in this instance preferably fine coal, to the cleaning of which the scheme is especially suited but not limited.

The unit including the feed pan, the trough, etc., is oscillated by an eccentric on a shaft K, through a rod L, pivoted to the trough at M.

The foregoing comprises a working unit that will perform considerable separation, sometimes sufficient for the purpose in hand, but in many instances it should be used in conjunction with a second similar unit, indicated generally by N, which is fed by the stream of heavier materials from the spout H of the first unit and delivers its separated streams to an elevator O, which returns the lighter part of the materials from the second unit to the feed of the first unit and delivers the final refuse or the cleaned heavier material to a chute P leading to a conveyor Q.

In such a setup the product of the chute J of the first trough will be commercially clean coal, which will be delivered to a suitable conveyor R and the product of the lower spout S of the second unit will be practically all heavier material or stony refuse.

The slopes, the air pressures, the control of the discharge from the lower spouts, etc., will be varied to suit conditions and differences in materials under treatment.

When the apparatus includes a single two-stage unit, as diagrammatically illustrated in Fig. 7, the elevator will preferably be in the form of a circular wheel, but when a battery of such units is assembled together the elevator will more appropriately take the form of a flexible conveyor having an elongated loop and serving the several units in the battery. As here shown, the return to the feed of the first unit is through a spout T delivering to the chute A. This is a concession to compactness of construction. The return would more appropriately be delivered to the feed pan B.

The mode of separation during the operation is not known with certainty and may be the subject of differences of opinion. The following is advanced as a theory based on study and observation.

The feed to the chute A is in a thin stream uniformly spread across its width. The depth little, if any, exceeds the short dimension of the largest lumps. The velocity of the stream accelerates as it flows down the chute and may reach a velocity (for fine coal) of three to five hundred feet per minute at the bottom of the chute.

As the stream flows down the chute it opens up, the several lumps or grains becoming spread apart and more or less segregated and displaced from their fellows lengthwise and crosswise to the stream.

In this open condition and at maximum speed the stream of material strikes the sloping bot-

tom of the trough at an obtuse angle and meets the air flowing through the porous blocks at the upper end of the trough, deflecting the current of air down stream. The lumps bound from the trough bottom—the coal apparently more and further than the refuse—which at once makes a separation with the heavy refuse forming a lower stratum moving down the vibrating trough with the lighter coal laid on above. The smaller particles bound less than the lumps but are entrained by the current of air to a greater extent from which they settle out, the heavier first into or on the forming stratum of heavy refuse, and the lighter being carried further away into or on the stratum of lump coal above.

As this goes on the velocity of the material is reduced and it builds up, as indicated at U (Fig. 7) to form a thick bed V, pretty well stratified on specific gravity with the finest coal gathered and floating at or near the top.

The air makes the bed or thick stream fluid and accelerates the flow down the inclined trough. The oscillation of the trough helps to move the parts that are in contact with the trough which, for the most part, are heavy lumps on the rough bottom and preferably the motion is designed to give a slight upward or lifting movement at each stroke of the eccentric to throw the lumps forwardly and downwardly along the trough. This combined action of the air and oscillation makes the bed or thick stream flow fast enough to give the apparatus high capacity.

The stream divides horizontally, the lower part passing out the discharge spout H and the upper part out the spout J. The division is determined by the throttling of the spout H. The more material discharged by spout H, the less can pass out spout J, and vice versa.

Specific description

The feed pan B, the chute A and the trough D, are shown made of sheet metal parts welded together into a single unit of U-shape cross section, varying in depth substantially as illustrated, the right end of the feed pan B (Fig. 1) being closed by an inclined plate 10.

The actual bottom of the trough is formed by porous blocks 11 supported by perforated angles 12, welded to the sides of the trough and to partitions 13 by which the space immediately below the pervious bottom is divided into cells 14, here shown as four in number. The common bottom of these cells is formed by a plate 15 welded to the same sheets that form the sides of the trough and the cells 14, and the bottom of each cell is provided with a large airport or passage 16, throttled more or less by a butterfly valve 17, on a shaft 18, journaled in the side walls of the trough and held in adjustment by suitable rack devices 19 (Fig. 6) at corresponding ends of the shafts along one side of the trough.

Air is supplied to the cells from a common header or pressure chamber 20, extending along the lower portion of the trough and having its bottom wall 21 welded to the side portions of the trough, as appears in Fig. 6.

Air is supplied to this chamber through a tapering feeder 22 of U-shape cross section welded to the bottom 21 and communicating with a piece of pipe 23, connected to the main air supply pipe 24 by a flexible hose 25.

Adjacent to the left end in Fig. 3 the porous blocks are inclined downwardly with respect to the main bottom and lead the lower stratum of the stream to a bottom discharge spout H ex-

tending across the trough and equipped with an adjustable gate 27 and throttled by a pan I pivoted to the spout at 29 and adjusted by wing bolts 30 to vary the discharge to suit the conditions. As an alternative the pan I may be pivoted to the main frame and the wing bolts 30 may be connected with brackets on that frame, in which case the motion of the spout 26 would have a different feeding action.

The trough is supported on links or rocker arms 31 pivoted to its sides and to the main frame 32. As here shown, they are inclined towards the upper end of the trough from the vertical and as a rule one end should be adjustable in order to vary that inclination to suit the material to be treated.

The pivot M by which the eccentric rod is connected to the trough is here shown as mounted in a bracket 33 welded to the end wall of the trough at the upper end.

Preferably this bearing and also the bearings for the rocker arms 31, include rubber bushings under compression whereby the bearings are made dustless and frictionless in the ordinary sense of rubbing one part against another in rotation. For detailed description of such bearings, see our copending application, Serial No. 300,814, filed October 23, 1939.

The floor of the trough is flat as distinguished from riffles of prior pneumatic tables and such like, and the trough is inclined lengthwise only.

The other unit N is substantially the same as that just described with the exception that the discharge spout 34 (Fig. 3) is turned downwardly at 35 and equipped with a baffle 36 to insure delivery into the elevator, and the pan 37 delivers into a chute 38 made in one with the trough and leading to a separate section of the elevator. As seen in Fig. 5, this unit converges in width from the width necessary to receive the discharge from pan I to approximately one-third of this width. The full width at the receiving end of this unit is advantageous since the particles are thus already spread out into a thin layer when received and a relatively short chute is sufficient. The narrowing of the unit prior to the discharge therefrom is advantageous since it increases the depth of the stream and thus facilitates a relatively clean separation of the stream into two branches. It will be understood that the volume flowing through unit N is only a small fraction of that flowing through the primary trough D.

The eccentric rod 39 for the lower unit has a bearing similar to that above described mounted in a bracket 40, extending across the top of the trough.

The eccentrics 41 and 42 for the respective troughs are on an eccentric shaft K (Figs. 2 and 4) mounted in roller bearings carried by brackets 44 on the main frame 32.

The main air pipe 24 has its lower end connected by a flexible hose 45 with a pipe 46 leading to the chambers of the lower unit substantially as described in connection with the upper one, and for brevity the details will not be repeated.

Air is supplied by a blower 47 (Figs. 1 and 4) connected to the main air pipe 24 and provided with a bypass valve by which the delivery of the blower can be varied to suit the conditions.

The machine is driven by a double ended motor 48 (Figs. 1 and 4), one end being connected with the blower by a V-belt drive 49 and the opposite end connected with the eccentric shaft by a V-belt drive 50.

The elevator here shown is a circular wheel having a solid outer wall 51 and side walls 52, the U-shaped inwardly opening space thus formed being divided by vanes 53. The wheel is mounted upon flanged rollers 54 on shafts 55 and 56, the latter of which is driven through a worm-reducing gear 57 (Fig. 4) from a V-belt drive 58, connecting the worm-reducing gear with the eccentric shaft K.

The elevator is divided into a large and small section by an annular partition 59 (Figs. 3 and 7), the larger section receiving the lighter stream delivered by the lower unit and raising it to the chute T (Figs. 1 and 7) by which it is returned to the stream of the first unit, and the smaller section receiving the refuse or final heavy material which it raises and delivers to the chute P, leading to the conveyor Q (Fig. 7).

Should the quantity of material in the system become excessive there would be a tendency to spill over in approaching and leaving the chutes T and P. To take care of this, dribble chutes 60 and 61 (Fig. 2) are provided to return the excess material to the lower portion of the wheel. This is preferable to directing this excess material onto the chute A because to do so would cause an excessive quantity of material at one or both sides of the chute A. It will be observed from Fig. 2 that the inclination of the vanes 53 of the conveyor is such that the material is dumped gradually as the vanes pass over chute A.

Like the other chutes, they are made of sheet metal parts welded together and these two are welded to the opposite sides of the walls forming part of the chutes T and P.

As a specific example the following details are given, but they are not critical and do not indicate the limits of the invention.

The feed chute A is at 45° to the horizontal and the floor of the trough is 8° to the horizontal. The rocker arms 31 are inclined 8° to the vertical on the forward throw of the eccentric, but preferably these last two inclinations are made adjustable between 5° and 8°.

The throw of the eccentrics is $\frac{3}{8}$ " and they are rotated at 400 R. P. M.

The motor 48 is 10 H. P. at 1200 R. P. M., the blower has a capacity of 3000 cu. ft. at 900 R. P. M.

The porous blocks 11 are one foot square and are made of coarse Philtrors furnished by Philtrors, Inc., Rochester, New York. The upper trough contains twelve of these, being approximately three feet wide and four feet long. The lower trough (Fig. 5) tapers from three feet at its upper end to 1 foot at the middle, which width is maintained to the lower end. The side blocks 62, forming the wider portion of the bottom are cut away to form blocks 63 that fit in with a single block 11 in the second section to make up the tapered portion of the trough.

The porosity of all being approximately the same, the volume of air supplied to the two troughs is in the ratio of one to two. The angles 12 are provided with numerous $\frac{5}{8}$ " holes to prevent starving any portion of the porous material.

Other porous blocks are made by the Carborundum Company of Niagara Falls, New York, and will be preferred by some.

The air pressure in the upper cell 14 will be about right when only the impalpable powder goes off with the air. Ordinarily that pressure will be approximately 4" on a water gauge. In getting at the exact adjustment many will find it expedient to increase the pressure until usable

fine coal is being lifted above the stream and then adjust the bypass to reduce the pressure until nothing but dust passes off with the air.

It will be found that about 100 cu. ft. of air per hour per ton of coal will be sufficient. Prior pneumatic tables and similar machines have required about 500 cu. ft. of air per hour per ton.

The air is delivered to the pressure chambers 20 and distributed from there through 5" passages 16, throttled by the valves 17. Whether the valves are all set the same or adjusted to make the pressure difference in the different cells will depend somewhat upon the preference of the operator. Some will reduce the pressure in the second and third cells and have the pressure in the first and fourth substantially equal; others will have the pressure practically uniform in all the cells.

Approximately 3000 cu. ft. per minute is supplied by the blower depending on the adjustment of the bypass. Of this approximately 2000 cu. ft. goes to the cells in the upper trough and the remaining approximately 1000 cu. ft. going to the cells in the lower trough.

The angles 12 supporting the edges of the porous blocks 11 have copious $\frac{5}{8}$ " holes in each flange to pass air freely to the edges of the blocks.

The adjustment of the throttling pans I controls the discharge of middlings or heavy material forming the lower portion of the stream, and in doing so controls the height of the stream above the chute H. The gates 27 of course, take part in controlling the discharge, but as a rule when they are once adjusted they remain fixed.

In such a machine as here illustrated the pans I should be so adjusted that the chute J of the upper trough delivers merchantable coal only and the chute 38 of the bottom trough delivers heavy material only, the intermediate material being returned to the stream of the first trough.

It will be found that separation will be enhanced when a relatively large percentage of heavy refuse is present.

The apparatus here disclosed has a capacity of 30 to 50 tons per hour, depending on the coal. It appears to work best when the coal is screened to include sizes from $\frac{1}{8}$ " to $\frac{3}{8}$ " or from $\frac{1}{8}$ " to zero. Roughly speaking, with coal in either of these brackets the capacity would approach 50 tons per hour, but with coal from $\frac{3}{8}$ " to zero the capacity would drop towards 30 tons per hour. Of course, coal in large lumps can be treated in the apparatus, but the superiority of the separation is most marked in the fine coal brackets.

The walls of the chutes H are here shown at right angles to the main body of the floor of the troughs. They may, with advantage, be inclined in the direction of the travel in the respective troughs and the corner between the chute and the inclined porous blocks 11 may be rounded to advantage.

The chute P and the conveyor Q are included because the design allows little clearance at the bottom for a conveyor to take away the heavy material. In another design more clearance could be afforded in which case the chute P and associated parts could be omitted and the conveyor Q placed directly under the chute 38.

The elevator O would then be changed and the chute T made to deliver into the pan B.

The swift open stream formed in the chute A and impinging at an obtuse angle on the bottom of the trough swept by the relatively light air

current appears to be the key to the separation which is effected quickly and the stratified stream is ready for division as the relatively light and heavy materials move downward together but in different layers. Pneumatic tables and such like of the past have had nothing to produce the swift open stream, have required up to five times as much air per ton per hour and most of them have included some sort of riffles to work a counter-flow of the heavy material with respect to the light material. They separate the material more or less gradually whereas in our scheme the swift run down the chute is followed by quick separation and stratification ready for division along lines of specific gravity. Apparatus like that shown here has been found satisfactory when shortened by removing the intermediate two feet of the trough and bringing the two end portions together—in other words, the trough was shortened by omitting the two intermediate lengths of porous blocks and the corresponding air cells, etc.

We cannot give critical angles or lengths for the chutes or the troughs because a little cut and try may be necessary under any particular set of conditions and even then some will prefer one thing and some another.

It has not been found possible to show the material in the chutes and troughs as it appears in practice. The stream in the chute A opens up as it gathers speed and this is fostered by the rapid oscillation. The upper part of the block II that receives the stream appears to be relatively clear.

As the bed builds up in the trough it offers more resistance to the flow of air, but the air and the rapid oscillation keeps the stream fluid enough for the necessary movement to produce high capacity.

The chute A and the feed pan B are made in one with the trough D to simplify the apparatus. Oscillating the feed pan makes it deliver the wide stream needed for the swift open stream in the chute A. The feed pan B and the chute A may be made separate from the trough D and also separate from each other. But this separate construction would require an oscillating mechanism for the feed pan or some sort of feeder and a separate support for the chute A. The arrangement shown is simpler.

We claim:

1. The process of separating relatively light and heavy material in granular form, which includes feeding the mixture in a thin flat stream down an incline so steep that the particles speed up and separate as they approach the bottom thereof, into a reciprocating trough having an air pervious bottom inclined substantially less than the stream but in the same direction, and sufficiently inclined so that the particles of the stream will impinge against a relatively clean surface of the bottom of the trough and move away from the point of impingement rapidly enough to maintain said point relatively clean, passing air continuously through the air pervious bottom and through the stream and severing the stream horizontally in the trough and delivering the upper and lower branches of the stream separately.

2. The process of separating relatively light and heavy material in granular form, which includes feeding the mixture in a thin flat stream down an incline so steep and of sufficient length that the particles speed up and separate into a

scattered state of substantially not more than one particle depth at each point as they approach the bottom thereof, into a reciprocating trough having an air pervious bottom inclined substantially less than the incline but in the same direction, and sufficiently inclined so that the piled up particles of the stream will move along the trough rapidly enough to maintain the upper end thereof relatively clean so that the stream may pass rapidly thereover, passing air continuously through the air pervious bottom and through the stream including a part of the stream where the particles are still separated as a result of their speeding up down the incline, and horizontally severing the stream in the trough and delivering the upper and lower branches of the stream separately.

3. Apparatus for separating relatively light and heavy material in granular form, including a chute so steep and of such length that particles fed at the upper part thereof speed up and separate as they approach the bottom thereof, means for feeding a mixture of particles of the light and heavy material in a thin flat stream at the upper part of the chute; a reciprocating trough having an air pervious bottom inclined substantially less than the chute, but in the same direction, positioned to receive the particles from the chute and so inclined and unobstructed that the particles falling down the chute will impinge against a relatively clean surface of the bottom of the trough and move away from the point of impingement rapidly enough to maintain said point relatively clean, means for passing air continuously through the air pervious bottom and through the stream of particles passing thereover, and means for severing the stream horizontally in the trough and delivering the upper and lower branches of the stream separately.

4. Apparatus for separating relatively light and heavy material in granular form, including a chute, at least a part of which is so steep and of such length that particles fed at the upper part thereof speed up and separate into a scattered state of substantially not more than one particle depth at each point as they approach the bottom thereof, means for feeding a mixture of particles of the light and heavy material in a thin flat stream at the upper part of the chute, a reciprocating trough having an air pervious bottom inclined substantially less than the chute, but in the same direction, positioned to receive the particles from the chute and so inclined and unobstructed that the piled up particles of the stream will move along the trough rapidly enough to maintain the upper end thereof relatively clean so that the separated particles can stay separated as they pass rapidly over said upper end, means for passing air continuously through the air pervious bottom and through the stream of particles passing thereover, and means for severing the stream horizontally in the trough and delivering the upper and lower branches of the stream separately.

5. Compact two-stage apparatus for separating relatively light and heavy particles including primary and secondary separating units sloping longitudinally in opposite directions with the primary unit located approximately directly above the secondary unit, each unit being adapted to separate a mixture of light and heavy particles fed to its upper portion into light and heavy branches, the secondary unit being disposed to receive at its upper end the heavy branch from the primary unit, and a circular wheel type ele-

vator disposed to receive the lighter branch from the secondary unit and to deliver it to the upper portion of the primary unit, said primary unit being of a nature which works best with the material spread fairly uniformly across its width and said circular elevator including partitions disposed of such angle that the material raised above each partition is dumped gradually as the partition moves across the second unit, and means adapted to conduct back to the elevator any material which does not fall directly from the elevator to the primary unit.

6. Apparatus for separating relatively light and heavy material in granular form, including a chute, at least a part of which is so steep and of such length that particles fed by the upper part thereof speed up and separate into a scattered state of substantially not more than one particle depth at each point as they approach the bottom thereof, means for feeding a mixture of particles of the light and heavy material in a thin flat stream at the upper part of the chute, a reciprocating trough having an air pervious bottom inclined substantially less than the chute, but in the same direction, positioned to receive the particles from the chute and so inclined and unobstructed that the piled up particles of the stream will move along the trough rapidly enough to maintain the upper end thereof relatively clean so that the separated particles can stay separated as they pass rapidly over said upper end, means for passing air continuously through the air pervious bottom and through the stream of particles passing thereover, and means for severing the stream horizontally in the trough and deliv-

5 ering the upper and lower branches of the stream separately, said trough converging in width downwardly between the upper end thereof and the means for severing the stream whereby the depth of the stream is increased to facilitate horizontal division thereof.

7. Compact two-stage apparatus for separating relatively light and heavy particles including primary and secondary vibratory-trough separating units sloping longitudinally in opposite directions with the primary unit located approximately directly above the secondary unit, each unit being adapted to separate a mixture of light and heavy particles fed to its upper portion in a thin stream into light and heavy branches, the secondary unit being disposed to receive at its upper end the heavy branch from the primary unit, means for horizontally dividing the stream in the secondary unit and a circular wheel type elevator rotating in planes generally transverse to the units and disposed to receive the lighter branch from the secondary unit and to deliver it to the upper portion of the primary unit, said secondary unit being substantially as wide at its receiving end and at the position of initial separation as the primary unit; and said secondary unit at its lower portion in the vicinity of said elevator and in the vicinity of the means for horizontally dividing the stream, being substantially narrower than the upper unit, whereby the depth of the smaller amount of material therein is increased and the size of the circular elevator required to encompass both units is reduced.

MYRON A. KENDALL.
CHESTER C. MOORE.