METHOD AND APPARATUS FOR SEPARATING RIBS FROM TOBACCO LEAVES

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This application is a continuation-in-part of our application Serial Number 102,445, filed April 12, 1961, now abandoned.

The present invention relates to a method of and to an apparatus for separating lighter particles from heavier particles.

More particularly, the invention relates to a method of and to an apparatus for separating heavier particles in the form of tobacco ribs from lighter particles in the form of tobacco leaves.

An important object of the invention is to provide a method of continuously separating lighter particles from heavier particles which form a mixture with the lighter particles so that the heavier and/or the lighter particles may be continuously conveyed to a further processing station and that the separation of lighter particles from the heavier particles is completed within very short periods of time.

Another object of the invention is to provide a method of the just outlined characteristics which is especially suited for separating tobacco ribs from tobacco leaves and which may be carried out at such a speed that the consistency of the processed material remains unchanged or changes very little during the separating operation.

A further object of the invention is to provide a method of the just described character which may be carried out in a fully automatic way and which may be resorted to for separating large quantities of tobacco leaves from tobacco ribs so as to satisfy requirements for mass manufacture of tobacco-containing products.

An additional object of the invention is to provide an apparatus for the practice of the above outlined method which is constructed and assembled in such a way that it may be rapidly and conveniently converted for use with different types of mixtures including lighter and/or heavier particles of different specific weight, moisture contents, configuration, thickness, flexibility or other characteristics, and which requires little attention once it is adjusted and started to carry out the method.

Still another object of the invention is to provide an apparatus of the just outlined characteristics for separating ribs from tobacco leaves with the help of one or more air streams which is constructed and assembled in such a way that the leaves are separated from the ribs within very short periods of time and that the consistency, particularly the moisture content, of the leaves is not appreciably affected during short-lasting contact with the air streams.

A concomitant object of the invention is to provide an apparatus for separating tobacco ribs from tobacco leaves by subjecting a mixture of ribs and leaves to the action of one or more air streams which is constructed in such a way that the mixture is separated into heavier and lighter components in two or more stages to make sure that any heavier particles which might have been entrained by the lighter particles are also separated from the lighter particles, or vice versa.

An additional object of the invention is to provide an improved assembly for separating the mixture of tobacco leaves and ribs immediately after and at the same rate at which the mixture is being formed in a steaming or threshing machine.

With the above objects in view, the invention resides in the provision of a method of separating lighter particles from heavier particles which form a mixture with the lighter particles, particularly for separating tobacco leaves from tobacco ribs. This method comprises the steps of introducing the mixture into an ascending non-vertical first air stream which is strong enough to entrain at least the major part of the leaves but which is too weak to entrain the ribs so that at least the major part of the ribs descends by gravity, directing into the path of descending ribs a second air stream which merges with the first stream and which is strong enough to advance into the first stream any leaves that might have been entrained by the descending ribs but which is too weak to prevent gravitational descent of the ribs, and evacuating the leaves from the merged streams.

In accordance with another feature of our method, the first air stream may produce or it may be modified by one or more cross-currents which prevent gravity-induced deflection of leaves from the ascending first air stream, or the first air stream may be divided into a plurality of partial air streams which are deflected and simultaneously accelerated to permit discharge of ribs during deflection and to pick up enough speed to continuously entrain the leaves. These partial streams are then caused to merge before the leaves are separated therefrom.

The apparatus of the practice of our method comprises a separator assembly which includes an upwardly inclined primary separator chamber and preferably a second separator chamber which latter communicates with the primary separator chamber, pneumatic conveyor means for admitting the mixture of tobacco leaves and tobacco ribs or another mixture which comprises heavier and lighter particles into the lower zone of the primary chamber together with an air stream which flows into the upper zone of the primary separator chamber and which is strong enough to entrain at least the major part of the leaves whereas the ribs are free to drop into the second chamber, means for admitting at least one second stream of air into one of the chambers so that the second stream either rises through the second chamber and towards the upper zone of the primary chamber and carries with it any leaves which might have been entrained by the ribs into the lower zone of the secondary chamber or that the second air stream forms a cross-current and affects the lifting force of the first mentioned air stream, means for evacuating the leaves from the upper zone of the primary separator chamber, and means for evacuating the ribs from the secondary chamber.

The novel features which are considered as characteristic of the invention are set forth in particular in the appended claims. The invention itself, however, belongs to its construction and its method of operation, together with additional objects and advantages thereof, will be best understood from the following detailed description of certain specific embodiments with reference to the accompanying drawings, in which:

FIG. 2 illustrates a vector diagram indicative of the manner in which the movements of lighter particles may be affected by gravity, by an ascending air stream, and by one or more cross-currents;

FIG. 3 illustrates another vector diagram showing the manner in which gravity, an air stream and one or more cross-currents affect the lighter particles in the separator assembly of FIG. 1;
FIG. 4 illustrates a further vector diagram indicating the manner in which gravity, an ascending air stream and one or more cross-currents affect the heavier particles;

FIG. 5 is a partly elevational and partly vertical sectional view of a modified separator assembly;

FIG. 6 is a fragmentary vertical section through the upper portion of a separator assembly which constitutes a slight modification of the assembly shown in FIG. 5;

FIG. 7 is a partly elevational and partly vertical sectional view of a further separator assembly;

FIG. 8 is a somewhat schematic perspective view of the entire apparatus which embodies an assembly of the type shown in FIGS. 1, 5, 6 or 7;

FIG. 9 is a partly elevational and partly vertical sectional view of an apparatus which constitutes a modification of the apparatus shown in FIG. 8; and

FIG. 10 is a fragmentary partly elevational and partly vertical sectional view of a further separator assembly which is somewhat similar to the assembly forming part of the apparatus shown in FIG. 5.

Referring now in greater detail to the illustrated embodiments, and first to FIG. 1, there is shown a separator assembly which forms part of an apparatus for separating lighter particles from a mixture of lighter and heavier particles and which is especially suited for separating tobacco leaves from tobacco ribs. This assembly comprises a housing 2 which is mounted on a frame 1 having a series of vertical columns and a horizontal support plate or table 8. The lower or intake end of a vertical supply duct 3 is in registry with an aperture provided in the table 8 and the discharge end of this duct communicates with the lower zone of a primary separator chamber which is defined by the walls of the housing 2 and which receives a continuous supply of intermixed tobacco leaves and tobacco ribs delivered to the duct 3 by a pressure conduit 9, the latter connected to a source of compressed air and receiving the mixture from a stemming machine which will be described in connection with FIG. 8. The housing 2 further defines a secondary separator chamber 10 whose lower zone assumes the form of a duct 4 serving as a means for collecting the ribs.

The discharge end of the duct 4 is located above an air lock here shown as a cell wheel 5 whose vanes are driven by an electric motor 6 mounted on the table 8. The wheel 5 drives the ribs into a conduit 7 and this conduit extends through the table 8 to discharge the ribs onto a take-off conveyer or the like, not shown in FIG. 1.

It will be noted that the upper zone of the secondary separator chamber 10 communicates with the primary separator chamber and that the secondary separator chamber is located substantially at a level below the upper zone of the primary separator chamber so that the ribs admitted through the duct 3 and entrained by the stream of compressed air which also enters through the duct 3 may drop into the lower zone 4 of the secondary separator chamber as soon as the stream of compressed air ascending through the primary chamber expands and is slowed down to such an extent that it can still retain and lift the leaves but is too weak to retain the heavier ribs.

The primary separator chamber is inclined with respect to the vertical and its upper (i.e. left-hand) side is bounded by an outer wall 13 which also serves as a stop for the leaves that are being entrained along this wall by the air stream which is continuously admitted through the pressure conduit 9. The right-hand side of the secondary separator chamber 10 is bounded by a similarly inclined right-hand wall 11 of the housing 2.

The upper end portion of the wall 12 is connected with a convex deflecting member in the form of a baffle plate 13 whose purpose is to reduce the cross-sectional area of the upper zone of the inclined primary separator chamber. The right-hand side of the primary separator chamber in the region of its upper zone is bounded by a second deflecting member in the form of a baffle plate 14 which, together with the upper portion of the baffle plate 13, defines the intake end of an evacuating duct 15 extending along the underside of the top wall 16 of the housing 2. The upper end of the baffle plate 14 merges into the top wall 16 and the lower end of this plate is connected to or is integral with a curved guide plate 17 which extends from the right-hand wall 11 of the secondary separator chamber 10. In the duct 15, the velocity of air admitted through the conduit 9 again increases so as to entrain the leaves through this duct and into an extractor 18 which is connected to a vacuum generating device preferably to the suction side of the same fan whose pressure side discharges a stream of compressed air into the conduit 9. The leaves accumulating in the extractor 18 may be withdrawn intermittently or continuously, preferably by means of an air stream which is sucked from the extractor.

The lower portion of the wall 11 is provided with a port 19 which serves as a means for admitting a second air stream into the housing 2, i.e., into the lower zone 4 of the secondary separator chamber 10. This second air stream is actually sucked by the ascending air stream which is part of the first air stream and the purpose of the second air stream is to entrain into the primary separator chamber any leaves which might have descended with the ribs into the lower zone 4 and also to affect the movements of the leaves which ascend in the primary separator chamber.

The inflow of air through the port 19 is controlled by a valve 20. A similar valve 22 controls the second port 21 which is provided in the top wall 16 of the housing 2 and whose purpose is to admit air into the duct 15 in order to prevent accumulation of leaves along the inner side of the top wall.

The lower portion of the wall 12 is perforated to form a screen 23, and a similar screen is provided in the wall 12 just below the lower end portion of the baffle plate 13. A third screen 25 is provided in the wall bounding the discharge end of the duct 15 between the upper end of the wall 12 and the arcuate bottom wall 26 of the extractor 18. A plate-like partition 27 extends downwardly from the junction of the wall 12 and the screen 25 so as to make an acute angle with the left-hand side of the wall 12. The free lower edge portion of the partition 27 constitutes a stop for an auxiliary air valve in the form of a flap 28 which is turnable by a horizontal shaft, the latter rockable by a lever mechanism which is indicated in FIG. 1. In broken lines and which is located externally of the housing 2 so as to be within reach when the operator desires to adjust the flap 28. The purpose of this flap is to control the flow of air from an auxiliary air chamber 30 to the screen 25 and through this screen into the duct 15. The auxiliary air chamber 30 is bounded by the wall 12, by a substantially vertical outer wall 29, by the arcuate bottom wall 26 of the extractor 18, and by the rear walls of the housing 2. If necessary, the flap 28 may be turned into abutment with the partition 27 and with the bottom wall 26 so as to completely seal the auxiliary chamber 30 from the screen 25.

One leg of an inverted V-shaped guide plate 32 is adjustably fastened to a wall 31 which is adjacent to the lower zone of the primary separator chamber just above the discharge end of the duct 3. The other leg of the guide plate 32 is attached to a horizontal shaft 33 which is supported by the front and rear walls of the housing 2. The two legs of the guide plate 32 are articulately connected to each other by a hinge 34. The guide plate 32 is fastened to that leg of the plate 32 which is mounted on the shaft 33.

A second V-shaped guide plate 36 is secured to the lower portion of the outer wall 29 just above the duct 3, and its lower leg constitutes the upper wall of the lower zone of the primary separator chamber.

Before proceeding with the description of the manner in which the assembly of FIG. 1 separates tobacco leaves...
from tobacco ribs, reference will be had to the vector diagram of FIG. 2 which represents an ideal mode of operation and wherein the vector $g$ represents the action of gravity, the vector $a$ represents the forces operative upon the mixture by the stream of air admitted through the conduit 9, and the vector $b$ represents the force operative upon the material by the cross-current or currents flowing through the screen 23 and/or 24.

The vectors $a$ and $g$ give a resultant vector $c$ which is indicative of a force that acts upon the leaves and whose magnitude and direction are different from the force represented by the vector $a$. The force represented by the vector $b$ is selected in such a way that the resultant vector $d$ is always the force representing the forces operative upon the leaves by the cross-current or currents flowing through the screen 23 and/or 24.

The cross-current (vector $b$) flowing through the screen 23 and/or 24 may affect the force of the air stream (vector $a$) admitted through the conduit 9 in order to make sure that the leaves are entrained upwardly and in a direction toward the intake end of the duct 15, as well as that the force of the air stream admitted through the conduit 9 is reduced in order to make sure that only the leaves can be entrained into the duct 15. The cross-current also prevents the force of gravity from deflecting the leaves from the air stream.

The vector diagram of FIG. 3 illustrates the manner in which the air streams in the separator chambers of the assembly shown in FIG. 1 act upon the tobacco leaves. The force represented by the vector $b'$ and produced by the cross-current or cross-currents is somewhat greater than the force represented by the vector $b$ so that the resultant $e$ of the vectors $b'$ and $c$ makes a small angle with the vector $a$. Also, the force represented by the vector $e$ is smaller than the force which is represented by the vector $d$. It will be readily understood that the force represented by the vector $b'$ deflects the leaves against the inner side of the wall 12 so that the leaves slide along this wall while advancing toward and into the duct 15.

The various forces which act upon the ribs will be explained in connection with the vector diagram of FIG. 4. Because the ribs are heavier, the vector $g'$ representing the action of gravity is longer. Furthermore, since the surface area of a rib is smaller than the surface area of leaf, the lifting force of the air stream admitted through the conduit 9 (represented by the vector $a'$) and acting on the ribs is smaller than the force $a$. Consequently, the resultant $c'$ of the forces represented by the vectors $a'$, $g'$ is directed downwardly. The vector $b''$ which indicates the direction of the cross-current is smaller than the vector $b'$ for the reasons explained above, i.e. because the overall surface area of a rib is comparatively small so that the cross-current cannot fully counteract the resultant force represented by the vector $c'$ and the resultant $f$ of the vectors $c'$, $b''$ again points downwardly.

By studying FIG. 3 and FIG. 4, it will be noted that the vector $e$ points substantially vertically upwardly and the vector $f$ points downwardly, i.e. that the leaves are deflected anticlockwise with respect to the direction of the air stream entering through the conduit 9, and that the ribs are deflected clockwise, as viewed in FIG. 1, so as to enter the lower zone 4 of the secondary separator chamber 10.

In carrying out the method of our invention, the separator assembly of FIG. 1 is operated as follows:

The mixture of tobacco leaves and ribs is fed into the conduit 9 and is entrained into and through the duct 3 in a direction determined by the positioning of the guide plates 33, 36, i.e. the air stream passing through the duct 3 ascends but is not vertical. Some air is permitted to flow through the screen 23, i.e. a cross-current is produced in the primary separator chamber, and this cross-current which traverses the ascending air stream causes the leaves to adhere to the inner side of the wall 12 so as to prevent the force of gravity from deflecting the leaves out of their path in the ascending air stream. The ribs descend by gravity and drop into the lower zone 4 of the secondary separator chamber 10. The major percentage of ribs is normally separated from the leaves before the leaves reach the second screen 24. The second air stream drawn through the port 19 by the first air stream admitted through the conduit 9 ascends through the secondary chamber 10 but is too weak to prevent gravitational descent of the ribs. Its purpose is to lift from the lower zone 4 any leaves which might have been entrained by the ribs and to exert a certain deflecting force on the leaves ascending through the primary separator chamber so that the leaves are forced to travel along the inner side of the wall 12.

At the time the first air stream reaches the second screen 24, it is slowed down considerably but is still strong enough to advance the leaves toward the channel defined by the baffle plates 13, 14, particularly since it is assisted by the second cross-current which flows through the screen 24 and into the auxiliary air chamber 30. Any ribs which might have risen to the level of the baffle plates 13, 14 are slowed down by impact against these plates and descend into the secondary chamber 10 to accumulate in the lower zone 4. Thus the air stream ascending from the channel defined by the plates 13, 14 pass through the second air stream which is admitted through the port 19 and which flows mainly along the inner side of the wall 11 so as to merge with the first air stream and to introduce into the first air stream any leaves which might have entered the secondary separator chamber 10.

The leaves entering the evacuating duct 15 are sucked into the extractor 18 and, if necessary, additional air may be admitted through the port 21 for providing the air current required for the evacuation of leaves. In addition, the valve 22 may adjust the strength of the air current flowing through the duct 15. The strength of the suction which is operative through the screens 23, 24 and the quantity of air flowing from the auxiliary chamber 30 through the screen 25 may be adjusted by the flap 28. The suction at the screens 23, 24 is selected in such a way that the leaves ascending through the primary separator chamber are held close to the inner side of the wall 12 with the maximum possible retention of leaves.

FIG. 5 illustrates a modified separator assembly wherein the port 21 provided in the top wall 16 of the housing 2 is controlled by a slightly different valve in the form of a flap 123. The arcuate wall 26 bounding the lower portion of the extractor 18 is formed in such a way that this wall 26 constitutes a fourth screen which extends from the screen 25 all the way to the outer wall 29. The partition 27 of FIG. 1 is replaced by two spaced stops 127 which determine the extent to which the valve 28 may be rocked by its shaft. These stops are engaged by the valve 28 when the latter seals the chamber 30 from the screens 25, 26.

The guide plate 32 of the assembly shown in FIG. 5 is mounted in a slightly different way. One leg of this plate is again secured to the wall 31 bounding the lower zone of the primary separator chamber, and the other leg of this plate is secured to a plate-like carrier 40 which is pivotable about the horizontal shaft 33. The hinge 34 is connected to the carrier 40 by a web 135. The upper leg of the guide plate 32 cooperates with the carrier 40 to separate the lower zone of the primary separator chamber from the lower zone 4 of the secondary separator chamber 10. The lower leg of the other guide plate 36 is again inclined in such a way that this plate cooperates with the lower leg of the plate 32 in order to direct the air stream admitted through the conduit 9 in upward direction so that the air stream is inclined to the vertical.

An important advantage of the assembly shown in FIG. 5 is that suction operating through the screens 23, 24 may
be varied within wide limits because the screens 25, 26 extend all the way between the upper ends of the walls 12, 29. Moreover, the suction operating through the screens 23, 24 may be regulated by slidable valves or flaps 41, 42 which are respectively associated with the screens 24, 23 and serve as a means for facilitating initiation and adjustment of suction in order to enable the apparatus of which the assembly shown in FIG. 5 forms a component part to be utilized in connection with different types of mixtures. In other words, the valves 41, 42 are adjusted prior to adjustment of the valve 28. The guide plates 52, 56 serve as a means for adjusting the inclination of the air stream which is admitted through the conduit 9, i.e. to change the forces represented in FIGS. 3 and 4 by the vectors e and f. Otherwise, the operation of the assembly shown in FIG. 5 is the same as that of the assembly shown in FIG. 2.

FIG. 6 illustrates the upper part of a separator assembly wherein the arcuate wall 26 bounding the lower part of the extractor 18 is without perforations. The screen 25 of FIG. 5 is replaced by a flap 43 which is hinged to the upper end portion of the wall 12 and which is pivotable into a position with and away from the wall 26 so as to regulate the flow of air from the auxiliary air chamber 30 into the duct 15. The cross-current or currents entering the auxiliary air chamber flow in the direction indicated by the arrow 44 as soon as the flap 43 is pivoted away from the wall 26. The arrangement is such that the flap 43 may reduce the cross-sectional area of the duct 15 if it is pivoted in a direction to permit the air to flow from the auxiliary air chamber 30.

It will be readily understood that the separator assembly of FIGS. 1, 5 or 6 may operate with compressed air streams which are forced into or with air streams which are sucked through the duct 3.

Referring now to FIG. 7, there is shown a different separator assembly wherein the wall 12 is replaced by a series of specially configured walls or baffles which define a plurality of passages 53, 54, 55 constituting the upper zone of the primary separator chamber. The intake ends 50, 51, 52 of the passages 53–55 receive leaves which are entrained by the ascending air stream admitted through the conduit 9. It will be noted that the lower portions 56, 57, 58 of the walls 59, 60, 61 respectively bounding the left-hand sides of the passages 53, 54, 55 are inclined in the same direction as the wall 12 of FIGS. 1 or 5. The lower portions 57, 58 of the walls 60, 61 are formed with wedge-shaped guide surfaces 64, 65 for the leaves which ascend toward the duct 15 and/or into the extractor 18. The right-hand sides of the passages 53, 54 are respectively bounded by walls 62, 63. As shown, the discharge ends 66, 67, 68 of the passages 53, 54, 55 and the discharge end of the duct 15 communicate with the extractor 18. The wall 59 makes an acute angle with the outer wall 29, and the wall 69 bounding the right-hand side of the duct 53 makes an acute angle with the left-hand wall 60 of the median passage 53. Furthermore, the right-hand wall 70 of the median passage 54 makes an acute angle with the left-hand wall 61 of the third passage 55. The other wall 71 of the passage 55 makes an acute angle with the lower wall 72 of the duct 15.

A valve in the form of a flap 73 is articulately connected to the upper end portion of the wall 71 by a hinge 74 so that it may regulate the cross-sectional area of the duct 15. A similar valve or flap 75 is secured to the upper end portions of the walls 61, 70 by a hinge 76, and a third hinge 78 connects a valve or flap 77 to the upper end portions of the walls 60, 69. It will be readily understood that the flaps 73, 75, 77 are adjustable by suitable linkages which are not shown in FIG. 7. The uppermost flap 73 extends upward beyond the flaps 75, 77 and its purpose is to change the quantity of air drawn through the duct 15 with respect to the quantity of air that is being drawn through the passages 53–55. The distribution of the partial air streams flowing through the passages 53–55 may be varied by adjustment of the flaps 75 and 77.

When practiced with the apparatus of FIG. 7, the method of our invention is carried out as follows:

The mixture of leaves and ribs is admitted into the ascending vertical air stream which enters the lower zone of the primary separator chamber through the duct 9, and the ribs are permitted to descend by gravity into the lower zone of the secondary separator chamber 10 in the same way as described in connection with FIG. 1. The strength of the cross-currents or partial air flows 53–55 is selected in such a way that they entrain a substantial part of the leaves from the ascending air stream and advance the leaves directly into the extractor 18. The leaves remaining in the ascending air stream pass along the baffle plate 13 and are lifted into the intake end of the duct 15 to advance along the lower wall 72 of this duct toward and into the extractor 18. The air stream drawn or blown into the secondary separator chamber 10 merges with the first air stream and lifts any leaves which might have been entrained by the descending ribs. The ribs are evacuated through the cell wheel 5 and the leaves are withdrawn from the extractor 18. Any ribs which might have been lifted to the intake ends 50–52 of the respective passages 53–55 are slowed down by the walls which define these passages and descend into the secondary separator chamber 10.

FIG. 8 illustrates a separating apparatus which, in addition to the housing 2 of the separator assembly shown in FIG. 1 or 5, comprises a stemming or threshing machine 202 whose hopper 203 is provided with an outlet 204 through which the mixture of leaves and ribs formed in thestemming machine 202 is admitted into the air stream flowing through the conduit 9. Unstemmed tobacco leaves are delivered by a conveyor 210 which discharges leaves into a chute 201 provided on the machine 202. The extractor 18 conveys an air and tobacco leaves into a box 207 which is provided with an air lock 208 adapted to discharge the leaves onto the upper run of a take-off conveyor 209.

The source of compressed air comprises a fan 206 whose pressure side is connected to a conduit 205 leading to the conduit 9. The suction side of this fan is connected with a conduit 210 which draws air from the extractor 18. A branch conduit 211 connects the pressure side of the fan 206 with the part 19 of the lower zone of the secondary separator chamber in the housing 2. Referring to FIG. 9, there is shown a different apparatus for separating tobacco leaves from tobacco ribs or stems. This modified apparatus comprises a deating or rib removing assembly 301, including a stemming or threshing machine 301' which is mounted on legs 301a and which receives unstemmed tobacco from a chute 319. The mixture 347 consisting of tobacco ribs and tobacco leaves which is formed in the machine 301' is then discharged into a hopper 302 which is located beneath the machine 301' and which is provided at its lower end with an outlet 303 through which the mixture enters into a supply duct 304 leading to a separator assembly 305. The intake end of the supply duct 304 is connected to a pressure conduit 310 leading to the pressure side of a source of compressed air here shown in the form of a fan 309. The suction side of this fan is connected with a suction conduit 308 leading to an air extractor 307, and the latter communicates with the upper end of the separator assembly 305 through an air passage duct 306 which discharges the leaves through an air lock here shown in the form of a cell wheel 310 and onto the upper run of a take-off conveyor 318.

The fan 309 discharges excess air through a nozzle 311 which is controlled by a valve 312, the latter having a manually actuable handgrip member 312a. At the
juncture of the conduit 310 with the duct 384, there is provided a regulating device in the form of a rotary throttle valve 313 which may be turned by means of a handle 315a so as to adjust the stream of compressed air which passes from the pressure side of the fan 309 and through the wind box 304 and which entrains the mixture 347 into the separator assembly 365.

At the upstream side of the regulating device 313, the pressure conduit 310 communicates with the intake end of a pressure line 314 which conveys a second stream of compressed air to a pair of upwardly extending branch lines 315, 315 leading into the separators 338.

The assembly 365 comprises a housing 321, which is mounted on a frame 320 and which includes an inclined upwardly and outwardly diverging funnel-shaped mixture-receiving channel or diffuser 332 which is bounded at its underside by a substantially convex lower wall 325 and at its upper side by a substantially convex upper wall 324. The channel 322 constitutes the lower zone of a primary separator chamber 323 whose upper zone accommodates three profiled baffles 339, 330, 331. These baffles define between themselves a pair of arcuate passages 327, 333 communicating with the evacuating duct 306. In addition, the baffles 329 and the upper zone 336 define between themselves a third passage 326, and a fourth passage 346 is provided between the baffle 331 and the top wall 321c of the housing 321, the passages 326 and 346 also communicating with the duct 306. At the trailing or upper ends of the baffles 325–329, these are provided with respective apertures 333, 334 which are pivotable about horizontal shafts 332a, 333a, 334a, and each of these shafts may be rocked by non-illustrated handgrip means located externally of the housing 321. The shafts 332a–334a enable an operator to adjust the respective flaps to any desired position of inclination and to thereafter retain the flaps in such adjusted positions so as to determine the flow of air and of separated lighter particles through the passages 326–328 and 346.

The fan 309, the conduit 310, the duct 304 and the line 314 together constitute a pneumatic conveyor whose function is to advance the mixture 347 into the separator chamber 322 and to convey blasts of compressed air into a secondary separator chamber 335.

The upper zone of the primary separator chamber 323 communicates with the upper zone 336 of the secondary separator 335 and the upper zone 336 leads into the passage 346. The lower zone of the secondary separator chamber 335 is bounded by a funnel-shaped upwardly and outwardly diverging wall 337 which includes two mutually inclined perforated or apertured sections or screens 338, 336. These apertured sections converge toward an air lock in the form of a cell wheel 366 which serves as a means for evacuating the ribs from the secondary separator chamber. The wall section 333 separates the chamber 335 from a plenum chamber 342 which communicates with the branch line 315 and which is also bounded by the lower wall 325 of the channel 322, by the bottom wall 341 of the housing 321 and by the front and rear end walls 321a, 321b of the housing. It will be readily understood that the walls 321a, 321b also bound the separator chambers 323, 335 and the evacuating duct 306, but the front end wall 321a is largely broken away in FIG. 9 in order to expose the interior of the separator assembly 365.

The right-hand wall 343 of the housing 321, the apertured wall section 339, the walls 321a, 321b and the bottom wall 341 define between themselves a second plenum chamber 344 which communicates with the branch line 315. The flow of air through the branch lines 316, 315 is respectively controlled by valves 340, 349 which may be regulated by hand. The air lock 349 evacuates tobacco ribs onto the upper run of a second take-off conveyor 345 which is mounted below the bottom wall 341 and which is provided with inclined side walls 345a, 345b forming a trough and serving as a means for guiding the ribs onto the upper run of this conveyor.

The apparatus of FIG. 9 operates as follows:

Unstemmed tobacco leaves are admitted through the chute 319 and enter the machine 301 of the assembly 365 in which the ribs R are separated from the waste material and from which the resulting mixture 347 is discharged into the hopper 302 to pass preferentially continuously through the outlet 303 and into the supply duct 304. The stream of air passing through the duct 304 entrains the mixture into and through the channel 322. While advancing through the duct 304 and through the separator chamber 322, certain heavier components of this mixture (almost exclusively ribs) descend toward and advance along the lower wall 325 to be discharged into the secondary separator chamber 335. This is due to the fact that the ribs are heavier than the leaves. Of course, some ribs might remain entangled between the leaves as the mixture passes through the duct 304 and through the channel 322, and such ribs are then advanced into the primary separator chamber 323. It will be noted that the right-hand end portion of the conveyer lower wall 325 is nearly horizontal so as to offer little resistance to forward movement of the ribs in the secondary separator chamber 335. These ribs drop onto the apertured wall section 338 and advance toward the air lock 340 through which they are evacuated onto the take-off conveyer 345. Any leaves which might have been entrained with the ribs are separated therefrom by the blast Y of air streaming from the plenum chamber 342 through the apertures of the wall section 338 so that these leaves rise through the secondary separator chamber 335 and into the latter's upper zone 336 to be drawn into the passage 346 and thence into the evacuating duct 306. Thrus, a preliminary separation of the ribs from the leaves takes place right in the lower zone or channel 322, and this separation is thereupon continued in the upper zone of the primary separator chamber 323. The inertia of the heavier components which have entered the chamber 323 (mainly ribs which remain in the partly sorted mixture) causes these heavier components to advance into the secondary separator chamber 335 where they drop by gravity onto the apertured wall sections 338, 339 and descend along these sections toward and into the air lock 340 to be evacuated onto the conveyer 345. Any ribs which are entrained with the lighter leaves into the passages 326, 327, 328 and 346 are slowed down by impact against the inclined surfaces of the baffles 329–331 and by the top wall 321c so that they begin to move countercurrently to the movement of leaves and descend into the lower zone of the secondary separator chamber 335. The leaves L advance with the air streams moving through the passages 326–328 and 346 and accumulate in the extractor 307. It was observed that the major percentage of ribs is separated from the mixture 347 while this mixture moves with the ascending non-vertical air stream advancing toward and into the passages 326–328 and 346 so that the secondary separator chamber 335 is mainly a settling compartment for the ribs R. In FIG. 9, the stream of air discharged by the pneumatic conveyer and the branches of this stream travelling through the passages 326–328 and 346 are identified by the reference numerals X. The blasts Y of air admitted from the plenum chambers 342, 344 through the apertured wall sections 338, 339 form a second stream YY which ascends through the secondary chamber 335 and which thereupon merges with the streams X to form a stream Z moving into the evacuation duct 306 and to the extractor 307. Any leaves L which enter the secondary separator chamber 335 are lifted by the stream X passing to the passage 346 and by the second stream YY so that the particles descending by gravity onto the wall 337 consist exclusively or nearly entirely of ribs R. The separating action in the chamber 335 is surprisingly effective which is attributed to the fact that the space of the chamber is comparatively large and because this chamber receives a smaller percentage of the original mixture.
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347. Therefore, the material entering the chamber 335 is free to expand so that the lighter leaves are fully expanded and may be subjected individually to the lifting action of the stream YY. Hardly any leaves will descend into the air locks 340.

The leaves accumulating in the extractor 307 are separated from the air stream which is evacuated through the conduit 308 and the condensed leaves are thereupon evacuated through the air lock 317 and onto the conveyer 318. 3 to be moved to a further processing station, not shown. The air stream in the fan 309 through the conduit 308 is therupon recirculated through the conduit 310 and enters the duct 304 as well as the line 314 to bring about separation of a next batch.

It will be understood that, while the operation of the apparatus shown in FIG. 9 has been described in connection with separation of tobacco leaves from tobacco stems, this apparatus is equally useful for processing many other types of mixtures which contain heavier and lighter particles.

The stream X is strong enough to move the leaves L through the lower zone 322 and into the upper zones of the chambers 323, 335 but is weak enough to permit gravitational descent of ribs R into the lower zone of the chamber 335. On the other hand, the stream YY is just strong enough to counteract the gravity of the leaves L which might have entered the lower zone of the chamber 335 and to entrap these leaves into the passage 346. The descent of ribs R is hardly affected by the second stream YY.

FIG. 10 illustrates a portion of a modified separating apparatus which differentiates from the apparatus of FIG. 9 mainly in the construction of the separator assembly. The modified separator assembly 305 of FIG. 10 comprises several component parts which are identical or analogous to those described in connection with FIG. 9 and which are identified by the same reference numerals as used in FIG. 9, each followed by a prime.

The baffles 329–331 of FIG. 9 are omitted and the convex upper wall 325 is replaced by an inclined but substantially flat upper wall 350 which is formed with a lower apertured portion or screen 353 and with an upper apertured portion or screen 354. The flow of air through these screens is respectively controllable by valves or flaps 362, 363 which are provided at the outer side of the wall 350 by which they may be shifted along this wall by manually or otherwise actuable means not shown. The upper wall 350, the outer wall 358 of the housing 321, the front and rear walls 321a, 321b and the aperture bottom wall or screen 355 of the passage 346 define between themselves an auxiliary air chamber 351 which communicates with the primary separator chamber 323 through the screens 353, 354 and which may also communicate with the passage 346 through the screen 355. The upper end of the wall 350 is connected to or is integral with a convex deflecting member or baffle plate 352 which extends into the primary separator chamber 323 and which has a smooth transition into the apertured screen 355. The passage 346 discharges into an evacuating duct 356 whose apertured arcuate bottom wall 357 forms a fourth screen and extends to the screen 355.

The auxiliary air chamber 351 accommodates a pair of spaced stops 359, 360 which are respectively secured to the walls 358, 350 and which serve as abutmen means for the ends of a valve or flap 361, the latter turnably mounted in the chamber 351 on a horizontal shaft 361a and adjustable by a linkage 361b of any known design.

The extent to which the cross-currents escaping through the screens 353, 354 may penetrate through the composite screens 353, 357 depends on the angular position of the flap 361. The apparatus of FIG. 10 is started as follows:

In the first step, the number of exposed apertures in the screens 353, 354 is selected in such a way that the leaves L entering the primary separator chamber 323 are caused to move toward the inner side of the wall 350 and advance therealong toward the baffle plate 352. Once the valves 362, 363 are properly adjusted, the originally closed flap 361 is turned to such an extent that the leaves L strike against the inner side of the screens 353, 354 and may even tend to adhere to these screens. The leaves are then assumed that the flow of air through the gap between the stops 359, 360 is excessive so that the operator then turns the flap in clockwise direction, as viewed in FIG. 10, in order to reduce the strength of cross-currents flowing through the screens 353, 354 and to permit upward movement of the leaves along the inner side of the wall 350. Thus, by short and very simple experimentation, the operator can adjust the position of the valves 362, 363 and of the flap 361 in such a way that the leaves move at the desired rate of speed toward the passage 346 and into the evacuating duct 356. The operation is then continued in a fully automatic way and any ribs which might have advanced to the baffle plate 352 are slowed down to the extent necessary to descend by gravity into the secondary separator chamber 335' whence they are evacuated onto the takeoff conveyer 345' in the same manner as described in connection with FIG. 9. The interior of the secondary separator chamber 335' is identical to that shown in FIG. 9, and the duct 394' forms part of a pneumatic conveyer and receives a mixture of leaves and ribs from an assembly analogous to that which was described in connection with FIG. 9.

The cross-currents penetrating through the screens 353, 354 and into the auxiliary air chamber 351 are permitted to enter the passage 346' and the duct 356' through the screens 355, 357 and are then evacuated from the assembly 355' in the same manner as in the apparatus of FIG. 9.

Without further analysis, the foregoing will so fully reveal the gist of the present invention that others can, by applying current knowledge, readily adapt it for various applications without omitting features that, from the standpoint of prior art, fairly constitute essential characteristics of the generic and specific aspects of this invention and, therefore, such adaptations should and are intended to be comprehended within the meaning and range of equivalence of the following claims.

What is claimed as new and desired to be secured by Letters Patent is:

1. In a method of separating lighter particles from heavier ones, which form a mixture with said lighter particles, the steps of introducing into an air stream passing through the housing forming an inclined ascending path an air stream containing said mixture of lighter and heavier particles at such a high speed that said air stream containing the entire mixture of lighter and heavier particles ascends in an intermediate point of said housing located along said inclined ascending path spaced from said lower part of said housing and spaced also from the upper part of said housing; deflecting at said intermediate point of said inclined ascending path part of said air stream without permitting any lighter or heavier particles to be carried along with said deflected part of said air stream so as to reduce at said intermediate point of said inclined ascending path the air pressure in said ascending air stream, thereby creating at said intermediate point a separation zone in which the air pressure in said undeflected part of said air stream is reduced so as to lose its capacity to carry away said heavier particles which then descend from said separation zone remaining at a point located under said separation zone the thus descending heavier particles; and withdrawing from said upper part of said housing said lighter particles further ascending along said inclined ascending path with said undeflected part of said air stream into said upper part of said housing.

2. In a method as set forth in claim 1, the additional step of conveying a second air stream countercurrently to the direction of movement of descending heavier par-
articles and merging said second air stream with the first named air stream in said separation zone so that at least some lighter particles which might have been entrained by descending heavier particles are returned into the undeflected part of said first named air stream.

3. In a method as set forth in claim 1, the additional step of expanding the air stream between the lower part of said housing and said separation zone so that, upon deflection of said first named part of the air stream, the remaining part of the air stream is just strong enough to entrain lighter particles into the upper part of said housing.

4. In a method as set forth in claim 1, wherein the lighter and heavier particles are separated from air prior to removal from the respective parts of said housing.

5. In a method as set forth in claim 1, wherein the lighter particles are tobacco leaves and the heavier particles are composed mainly of tobacco ribs.

6. In an apparatus for separating lighter particles from heavier particles which form a mixture with said lighter particles, in combination, a housing forming an inclined ascending path for an air stream and having a lower part at the bottom of said path and an upper part at the top of said path and an intermediate portion spaced from said lower part and said upper part; means for introducing into said lower part of said housing an air stream containing said mixture of lighter and heavier particles at such a high speed that said air stream containing the entire mixture of said lighter and heavier particles ascends to said intermediate portion of said housing spaced from said lower and upper part thereof; means for deflecting at said intermediate portion of said housing portion of said air stream without permitting any lighter or heavier particles to be carried along with said deflected part of said air stream so as to reduce at said intermediate portion of said housing the air pressure in said ascending air stream, thereby creating at said intermediate portion of said housing a separation zone in which the air pressure in said undeflected part of said stream is reduced so as to lose its capacity to carry along said heavier particles which then descend from said separation zone; means associated with said housing for removing at a point located under said separation zone the thus descending heavier particles; and means for withdrawing from said upper part of said housing said lighter particles further ascending along said inclined ascending path with said undeflected part of said air stream into said upper part of said housing.

7. A structure as set forth in claim 6, wherein the means for deflecting part of said air stream comprises an apertured wall forming part of said housing and bounding a portion of said separation zone.

8. A structure as set forth in claim 7, wherein said wall comprises a sieve and further comprising means for regulating the flow of air through said sieve.

9. A structure as set forth in claim 6, wherein said housing is provided with means for admitting at said point below said separation zone additional air counter-currently to the direction of movement of descending heavier particles.

10. A structure as set forth in claim 6, wherein the means for introducing into said lower part of the housing an air stream containing a mixture of lighter and heavier particles comprises a pneumatic conveyor including a suction fan having an intake end connected with said upper part and a discharge end connected with the lower part of said housing.

11. A structure as set forth in claim 6, wherein said means for removing descending heavier particles and said means for withdrawing lighter particles comprise air locks arranged to separate the respective particles from said air stream.

12. A structure as set forth in claim 6, wherein said housing is provided with an auxiliary air chamber adjacent to said separation zone and wherein said deflecting means comprises an apertured wall located between said auxiliary chamber and said separation zone, and a device for withdrawing air from said auxiliary air chamber to thereby induce the flow of said first named part of the air stream from said separation zone into said auxiliary air chamber.

13. A structure as set forth in claim 6, wherein said housing defines a separator chamber having an upper zone communicating with said separation zone to receive descending heavier particles and a lower zone accommodating said removing means.

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