

[54] **REMOVAL OF GREEN BOLLS AND HEAVY MATERIALS FROM SEED COTTON BY AIR JETS**

[75] Inventors: **Joseph W. Laird; Roy V. Baker,** both of Lubbock, Tex.

[73] Assignee: **The United States of America as represented by the Secretary of Agriculture,** Washington, D.C.

[22] Filed: **June 4, 1974**

[21] Appl. No.: **476,235**

[52] U.S. Cl. **209/134; 209/474; 209/485; 209/497; 302/31**

[51] Int. Cl.² **B07B 7/01**

[58] Field of Search **209/132-137, 209/147, 151, 474, 475, 497, 154; 239/DIG. 21, 461, 502, 518, 524, 543; 302/31, 45, 47; 34/10**

[56] **References Cited**

UNITED STATES PATENTS

148,099	3/1874	Walker et al.	209/151 X
1,491,433	4/1924	Stebbins.....	209/151 X
2,139,628	12/1938	Terry	239/569
3,555,794	1/1971	Gable et al.	209/136 X
3,680,218	8/1972	Belue et al.	302/31 X

3,738,483	6/1973	MacKenzie	209/12
3,759,579	9/1973	Johnston.....	302/31

FOREIGN PATENTS OR APPLICATIONS

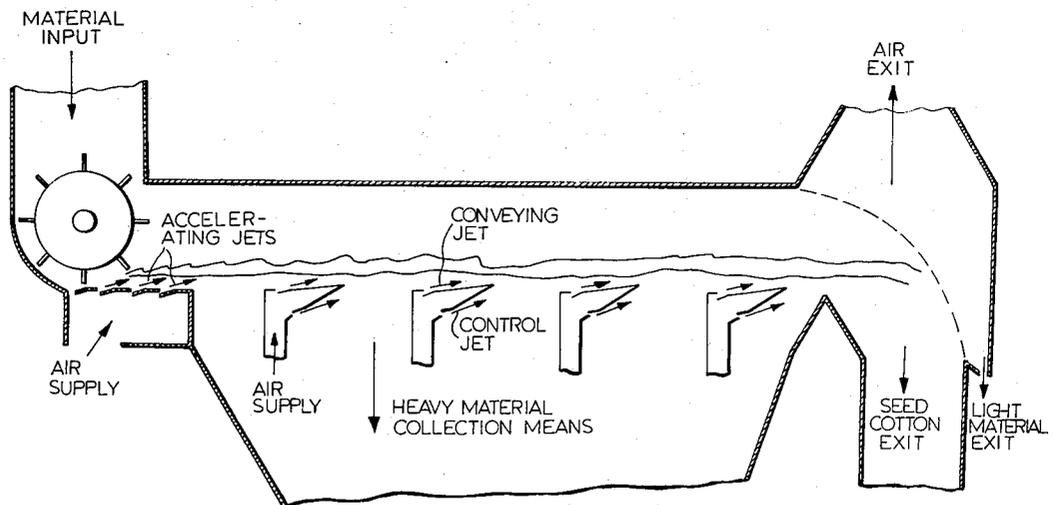
707,763	4/1954	United Kingdom.....	209/155
768,878	2/1957	United Kingdom.....	34/156

Primary Examiner—Frank W. Lutter
Assistant Examiner—Ralph J. Hill
Attorney, Agent, or Firm—M. Howard Silverstein; Max D. Hensley

[57] **ABSTRACT**

Method and apparatus for the classification of materials on the basis of different density and/or aerodynamic transportation properties is disclosed. Material to be separated is introduced onto a short section of air jet conveyor which imparts to it a critical horizontal velocity, whereupon it is passed across a separating mechanism which consists of a series of spaced air jet nozzles ejecting air at an angle through vents. By balancing the variables of air pressure, air velocity, and pivoting the nozzles, light materials are carried over the separating mechanism where the dense materials fall through the nozzle spaces of the separating mechanism and are carried off by a conveying mechanism.

4 Claims, 7 Drawing Figures



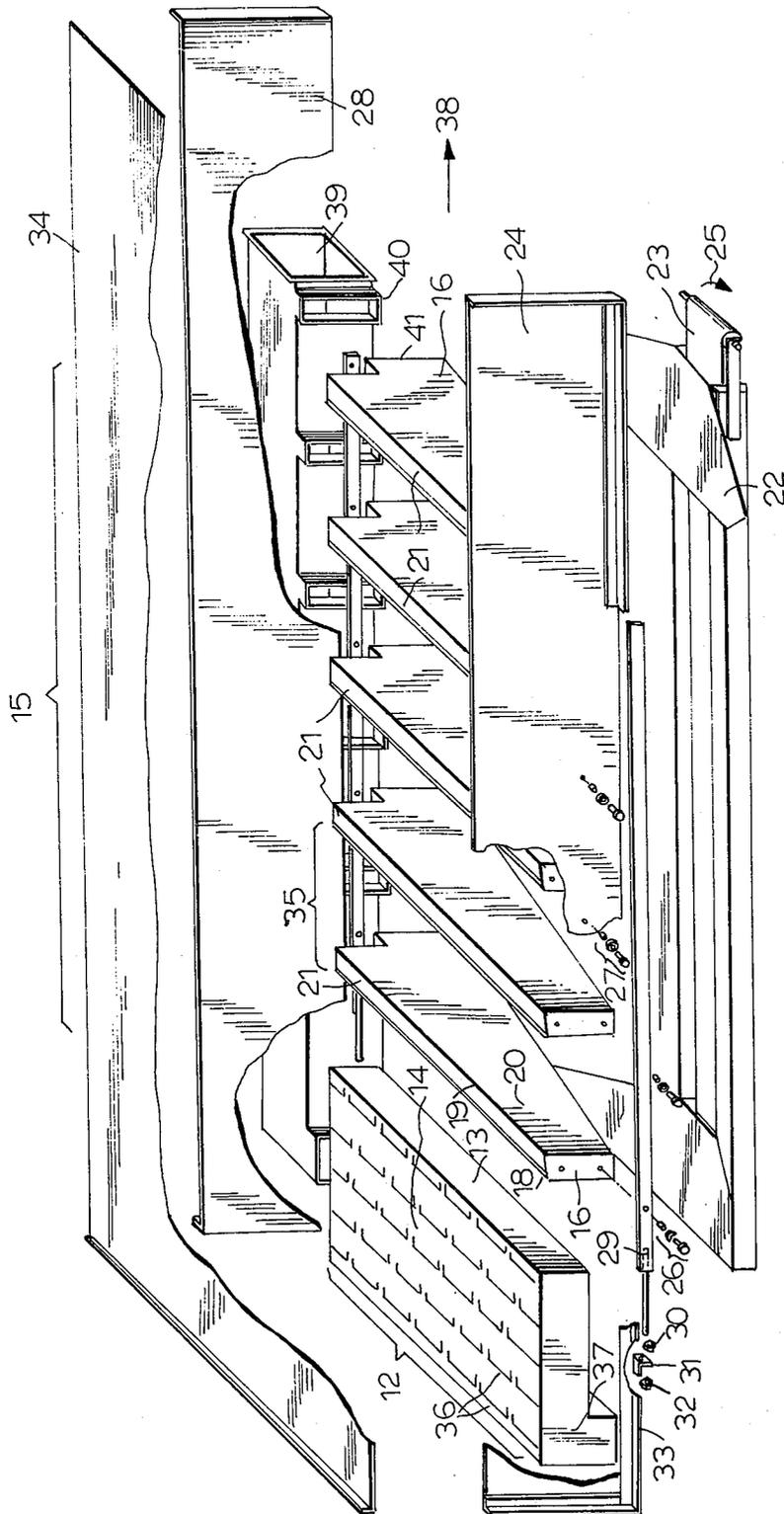


FIG. 1

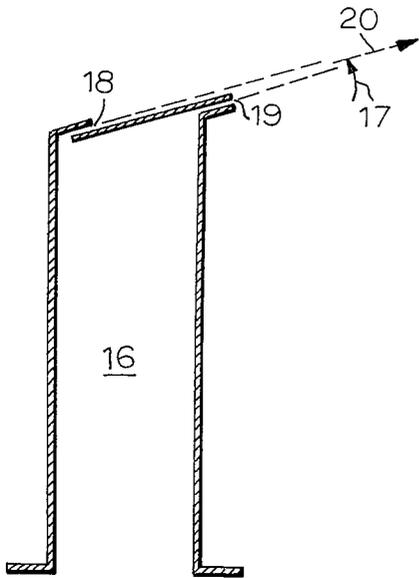


FIG. 2a

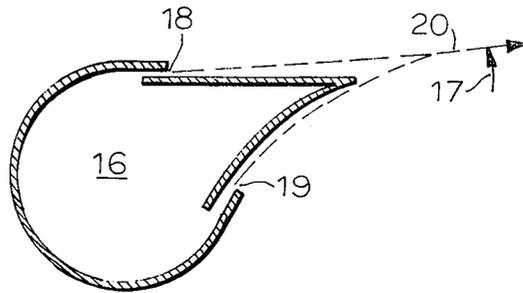


FIG. 2b

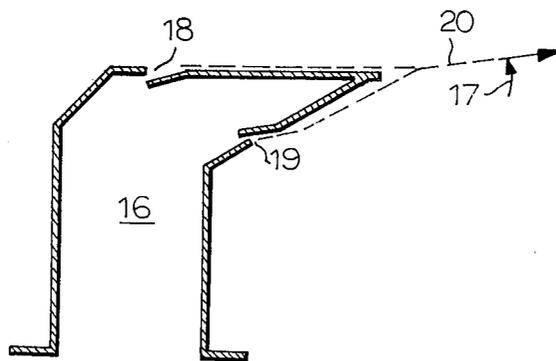


FIG. 2c

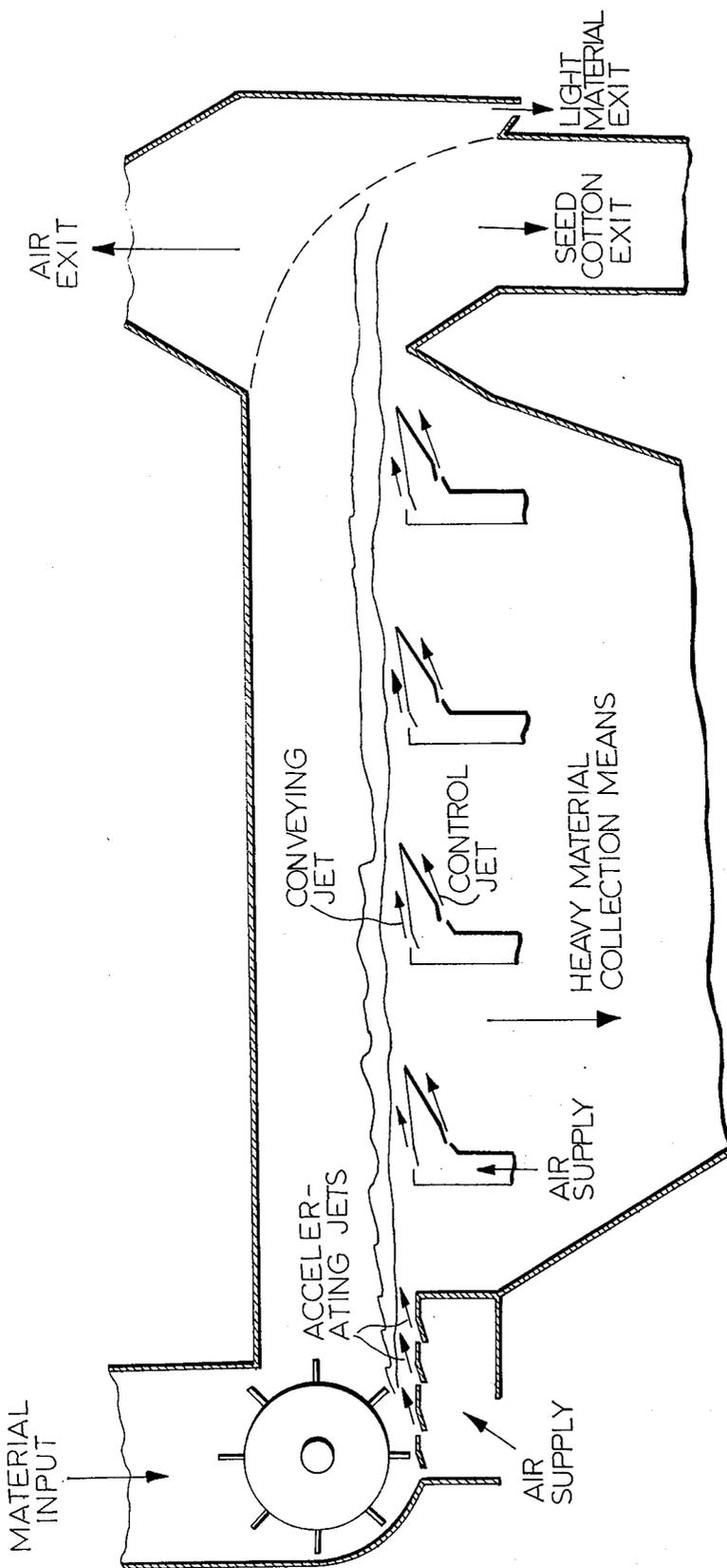


FIG. 3

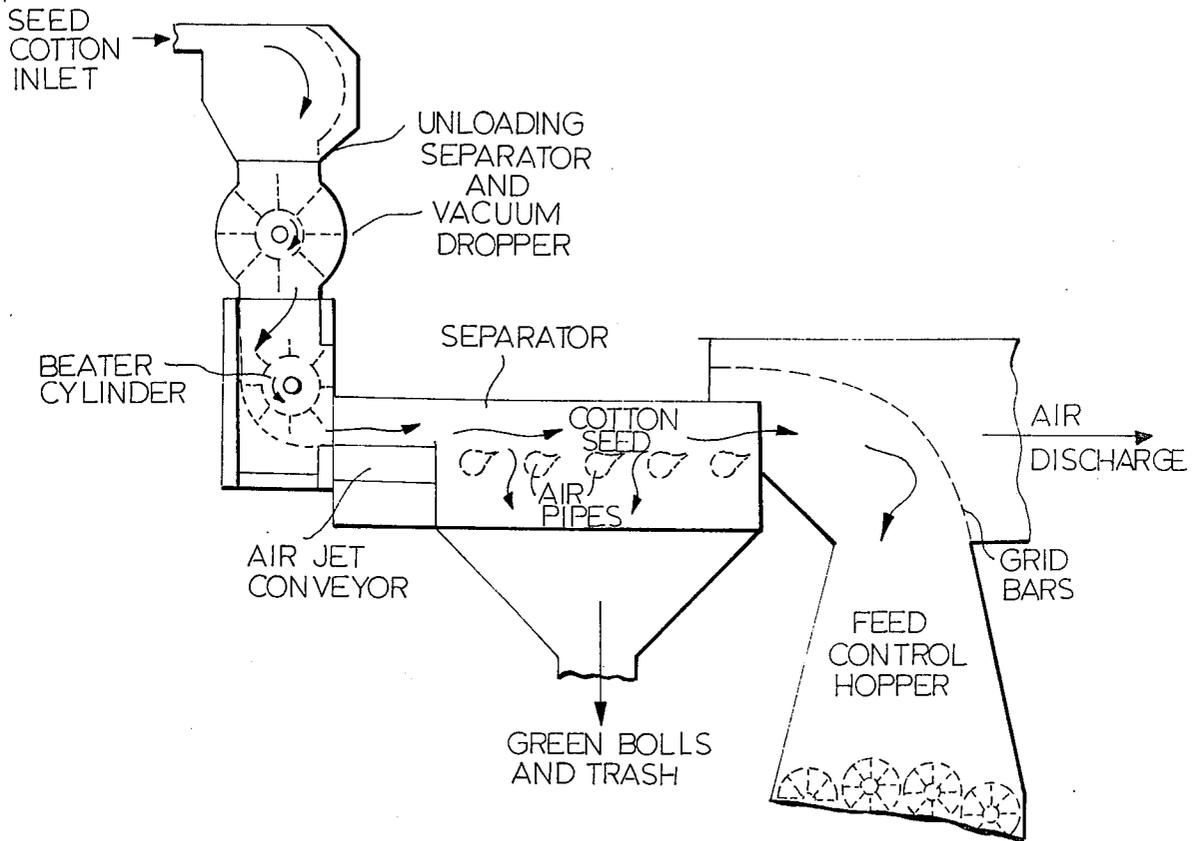
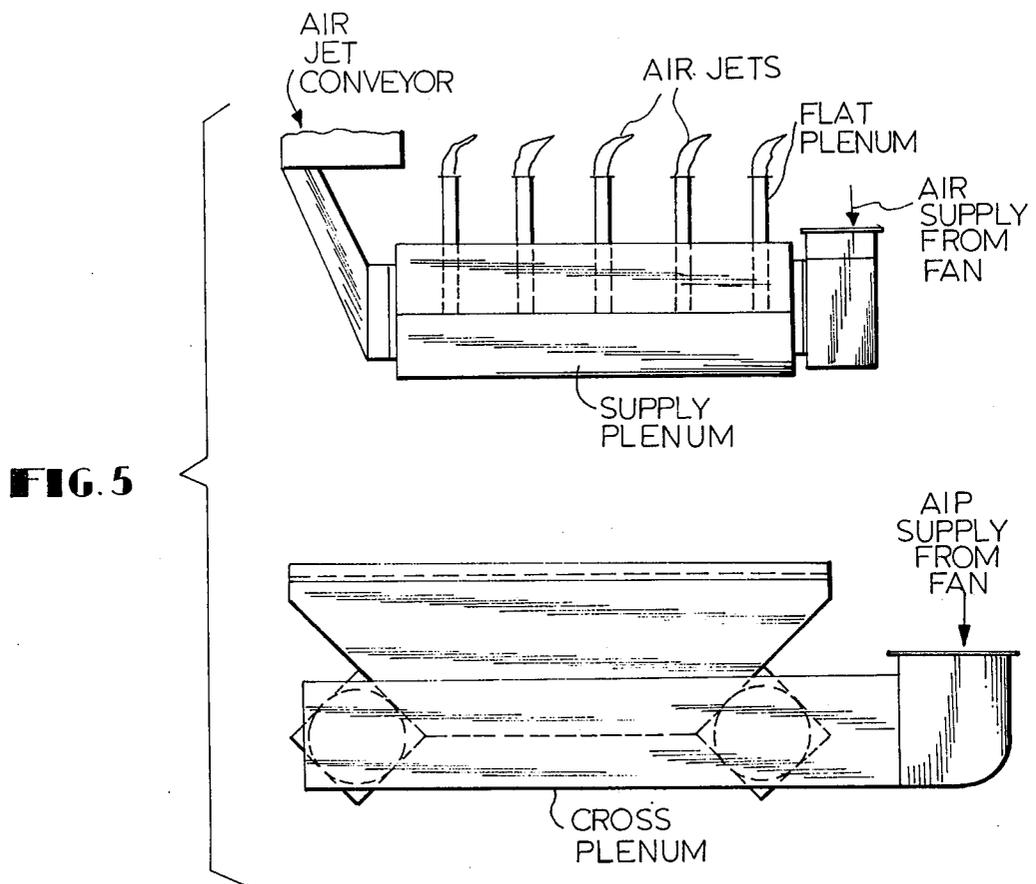


FIG. 4



REMOVAL OF GREEN BOLLS AND HEAVY MATERIALS FROM SEED COTTON BY AIR JETS

PRIOR ART AND BACKGROUND OF THE INVENTION

Machine-stripped cotton harvested early in the season often contains many green bolls which cause problems during ginning. Cleaning machinery in the gin breaks open many of these bolls, which allows the wet lint and soft seed from the green bolls to become mixed with the mature cotton. This wet material is sticky and tends to adhere to various parts of the cleaning and ginning machinery. It is most troublesome at the gin stand because it sticks to the gin saws and clogs the teeth. Wet, sticky material reduces ginning capacity, and in severe cases, completely halts the ginning operation. In these cases, it is necessary to shut down the gin and remove the material from the saw teeth by hand. Cleaning saw teeth is a slow process which results in considerable downtime and increases operational costs. Wet, immature lint can also lower the overall quality of the cotton.

Green boll separators presently used at cotton gins are not efficient enough to control this problem, especially in high capacity gins where green boll separators are heavily loaded. Also, the green boll separators require an air intake at the boll outlet throat in order to reclaim seed cotton that was separated with the bolls. This intake of air causes a reduction in suction at the unloading telescope and lowers its capacity. Approximately 15 hp is required to provide the necessary airflow into the green boll separator for efficient reclaiming.

Development of an efficient green boll separator using specially constructed air pipes having a series of air jets to convey seed cotton has been achieved and demonstrated using a pilot model, and then a full scale model.

The development of the green boll separator was accomplished as discussed in the following narration.

The experimental green boll separator uses specially constructed air pipes having a series of air jets to convey seed cotton. Air is injected into the pipes and discharges through narrow slots to form the series of air jets. The air jets are adjusted to have enough force to convey the seed cotton, but not the heavier green bolls, which have about 70 percent moisture content. In this way the bolls separate from the cotton and fall through the spaces between the pipes (FIG. 3).

For a given arrangement of air pipes, the capacity and effectiveness of the green boll separator depends upon the velocity of the air jets. At a critical velocity, lightweight material becomes fluidized and is easily conveyed. Heavier material, because it requires higher velocities, is not conveyed and separation occurs. If the air velocity is increased further, the separating effect diminishes. The separator also accomplishes some separation as a result of heavy materials hitting the air pipes, losing momentum, and falling from the conveying stream.

A 12-inch wide experimental model was used to test this principle. These pipes were 2 inches in diameter and were spaced 5 inches apart. Each pipe had a 1/16-inch slot across its entire length and a row of 1/8-inch holes spaced one-half inch apart. Air entered the ends of the pipes through two plenum chambers, which also

served as sidewalls for the separator and as supports for the pipes. The design of the pipes allowed them to be rotated to change the discharge angle of the air jets.

Preliminary trials were conducted in order to adjust the air jets. In these trials, it was found that cotton would not become airborne when dropped directly onto the air pipes. It was necessary to accelerate the cotton to a linear velocity approaching that of the conveying stream before feeding the cotton onto the air pipes. This was accomplished by using a 3-foot section of conveyor immediately ahead of the air pipes to accelerate the cotton to the required velocity. Air jets discharged from the slots at an angle of 85° above the horizontal, and from the holes at an angle of 30° above the horizontal. Air jet velocities of 5000 to 6000 ft/min were selected for further testing.

Two-pound lots of cotton containing immature dried bolls were placed on the accelerating conveyor and fed onto the air jet pipes. (Dried bolls were used because green bolls were not available at the time of the test.) As a check an identical test was conducted using a conventional green boll separator. The experimental green boll separator removed 83 percent of the dried bolls and 1 percent of the seed cotton. The conventional separator removed 40 percent of the dried bolls and none of the seed cotton. These results indicated that modifications should be made to reduce the amount of seed cotton lost by the experimental green boll separator.

It was observed that seed cotton was being lost between the pipes as a result of eddy currents that formed immediately ahead of each pipe. The currents were circulating in a downward direction and carrying some seed cotton under the pipes and out of the conveying stream. To correct this situation, the air pipes were redesigned with an upper and lower slot so that two air jets were emitted from each pipe (FIG. 2). The two air jets converged at the forward end of the pipe and formed a single, high-velocity air stream. The lower air jet served as a control for the upper jet and prevented downward movement of air currents between the pipes. The pipes were oriented so that the air jets would discharge at an angle of 12.5° above the horizontal.

A test of the new pipe shape was conducted. Air jet velocities of 6900 to 7100 ft/min were selected for this test. Cotton was used that contained very heavy green bolls that had been previously separated from the cotton. The number of green bolls put back into the cotton was such that each 40 pounds of cotton would contain 10 bolls. The new air pipes improved the performance of the pilot model green boll separator. Approximately 98 percent of the green bolls were separated, and there was no loss of seed cotton.

The successful operation of the pilot model prompted the construction of a full-scale, 70-inch-wide green boll separator that incorporated the new air pipe design. Five air pipes spaced 9 inches apart were used to form a separation section 4 feet long. Air was fed into the ends of the pipes by two plenum chambers similar to the ones used in the pilot model. Slots in the air pipes were 5/64-inch wide and were oriented so that the air jets would discharge at an angle of 12° above the horizontal. An accelerating section containing a rotating beater cylinder and a 15-inch long air-jet conveyor was constructed. The cylinder was 12 inches in diameter and operated at a speed of 290 rpm. The air jet conveyor discharged air through 48 slots at velocities of approximately 7900 ft/min. Seed cotton was fed into the accelerating section from a conventional vacuum

dropper on the unloading system's seed cotton separator. After passing over the air-pipe separator, the seed cotton was discharged into the hopper of an automatic feed control unit (FIG. 4). The total air requirement for this green boll separator was 3850 cfm. Seventeen percent of this air was needed in the accelerating section, and the remainder went into the air-pipes, producing air-jet velocities of 6000 ft/min.

Early-season cotton containing 250 pounds of green bolls per bale was used in a test of the full-scale separator. The separator removed 244 pounds of green bolls per bale, for an average efficiency of 98 percent. However, this test on the wider green boll separator revealed a problem that was not encountered in tests on the narrow, pilot model. It was found that the velocity of the air jets near the center of the pipes was adequate, but near the ends of the pipes the velocity was too low to convey the seed cotton properly, and some losses occurred at these points. The cause of this problem was traced to inadequacies in the method used to feed air into the ends of the pipes.

The method of feeding air into the pipes was changed to overcome this problem. The entire green boll separator was redesigned so that air was supplied through an opening in the bottom of each pipe along its entire length (FIG. 5). This change produced uniform air jets the full length of the pipes. In addition to these changes, the green boll separator was also equipped with a recirculating air system. The intake of a 7.5 hp fan was connected to the discharge hood of a seed cotton collecting chamber. Seed cotton leaving the air pipe separator entered the collecting chamber and was separated from the conveying air by closely spaced grid bars. The air passed through the grid bars into the discharge hood and was recirculated to the fan. The fan discharged the air through a filter into supply plenums that fed the air pipes. The complete separation system is shown in FIGS. 1 and 4.

Machine-stripped cotton containing partially dried green bolls was used to test this unit. The bolls had moisture content ranging from 35-50 percent, instead of the normal 70 percent. Thus the green bolls used in this test were lighter in weight and more difficult to separate. Average green boll removal efficiencies ranged from 53 to 61 percent, depending upon jet velocity. Higher efficiencies were obtained with the lower jet velocities. As a result of using the lightweight green bolls, the efficiencies obtained in this test were not as high as those of previous tests, and the data showed greater variation. The amount of seed cotton lost was not measured, but visual observation of the material being removed by the air pipe separator indicated that the amount being lost was negligible. In addition to removing green bolls, the separator removed some wet, immature locks of cotton. This removal was considered beneficial since the locks were too wet to be ginned.

Additional tests were conducted to determine the capacity of the air pipe separator. Capacity is a function of the spacing, velocity, and discharge angle of the air jets. An analysis of the data from these tests provided an indication that the air pipes should be spaced 9 to 11 inches apart, center to center. A smaller spacing decreases green boll removal, and a larger spacing increases the loss of seed cotton. Air pipes spaced within the optimum range required air jet discharge angles of 12° to 20° above the horizontal to insure satisfactory conveying without excessive seed cotton loss. With this arrangement, the air jet velocity required for dry seed

cotton was 6500 to 7000 fpm; and for wet seed cotton, approximately 7500 fpm. Under these conditions the 70-inch-wide separator has satisfactorily conveyed up to 27,800 pounds of machine stripped cotton per hour. This quantity was the maximum that the Laboratory's unloading system could deliver to the green boll separator. In this test the separator was not fully loaded, and it appeared that it could have satisfactorily handled a larger quantity of cotton.

The 5 to 7 hp required for operation of the air pipe green boll separator represents a sizable reduction (one-third) when compared with that required by the conventional separators (about 15 hp).

Also, conventional green boll separators reduce the unloading capacity of suction unloading systems. The air pipe green boll separator is installed following the suction unloading system and has no effect upon its air flow characteristics.

The air pipe green boll separator removed the more dense materials from machine-stripped seed cotton and also removed many small particles. Because of its unique air separating characteristics, this separator offers possibilities for use in making separations of other agricultural products that can be classified on the basis of density or size.

OBJECTIVES

The main objective of this machine is in the use of separation or classification of materials on the basis of different density and/or aerodynamic transportation properties. A more particular application for this machine is the separation of green bolls and other foreign material from dry open cotton. Another object of this invention is to subject the materials which are to be separated for an extended period of time to allow more complete separation. It is another object of this invention to provide a machine which is independent of, and compatible with, the types of material handling systems which precede or follow it in the system, allowing more flexibility in system design. Another object of this invention is to reduce the energy required for accomplishing the desired separation of materials. Other objects and advantages of this invention will become apparent in the detailed descriptions and drawings.

GENERAL DESCRIPTION OF THE INVENTION

This invention relates to a new type of machine for separation or classification of materials on the basis of different density and/or aerodynamic transportation properties. More specifically, the machine was developed for the separation of green bolls and other foreign materials from dry open cotton. The green boll separator is typically installed into the existing cotton gin process and is operated in harmony with existing ginning equipment (FIG. 4).

In describing the preferred embodiment of the invention, reference is made to illustrated drawing FIGS. 1 and 2. The materials to be separated are introduced into region 12 onto a short section of air jet conveyor 14 which is used to assure that the materials are accelerated to the proper velocity for air conveying horizontally across the air jet section 15 in the region above nozzles 21 bounded by the side 24 and 28 and top cover 34.

Compressed air from the plenum 16 within each nozzle exits through jet slots 18 and 19, converging into a thin horizontal curtain of high velocity air 20 which is directed to convey the less dense materials to the re-

5

gion above the next nozzle 21 in series. The air pressure inside plenum 16 is maintained at the appropriate pressure to form jets at slots 18 and 19 which will provide an air stream 20 at the appropriate velocity to convey the less dense materials into the region above the next nozzle 21 in series but allow more dense materials to settle below the level necessary to enter the region above the next nozzle. The more dense materials usually impact on the back of the next nozzle 21 losing their horizontal velocity, then fall vertically into a suitable collection means 22. Then the dense materials are gathered into a conveying means 23 by the collection means 22 and are conveyed to the disposal point 25. Subsequent treatment of the dense materials after separation and collection is not an intended function of this invention.

Each succeeding stage of separation, nozzle, performs identically as described except for a buildup in volume of air flow in the region above the nozzles. Because of random position within the mass of material and interparticle drag, separation is not complete at any stage but the cumulative amount of separation increases at each stage. Five stages were found adequate to initiate 96-97 percent efficiency in separation of green bolls from seed cotton of approximately 70 percent moisture.

DETAILED DESCRIPTION OF INVENTION:

In describing the preferred embodiment of the invention illustrated in the drawings, specific terminology will be resorted to for the sake of clarity. However, it is not intended to be limited to the specific terms so selected, and it is to be understood that each specific term includes all technical equivalents which operate in a similar manner to accomplish a similar purpose. Machine dimensions, materials of construction, control devices, operating configurations and applications illustrated are typical only and all other more sophisticated equivalents are also intended.

FIG. 1 is an expanded view in perspective showing the various parts of the machine in relation to each other as typically assembled, with parts broken away to illustrate important details.

FIGS. 2a, 2b and 2c are side views of cross sections of the optional forms in which the air jet nozzles may be constructed.

FIG. 3 is a schematic diagram of the air separator indicating direction of flow and illustrating how seed cotton flows over air pipes and green bolls and trash falls between.

FIG. 4 is a schematic diagram of a typical air pipe separator installation illustrating separator in relation to the overall gin operation.

FIG. 5 is a front and side view of the details of the improved method of feeding air into air pipes.

In the specific embodiment of the invention selected for illustration in the referenced drawing, FIG. 1 designates generally a machine for separating green bolls and other heavy, dense materials from dry open cotton. The materials to be separated are introduced into region 12 onto a short section of air jet conveyor 14 which is used to assure that the materials are accelerated to the proper velocity for air conveying horizontally across the air jet section 15 in the region above nozzles 21 bounded by the sides 24 and 28 and top plate 34. The accelerating section 14 must discharge the cotton into the region above the first nozzle 21 at velocities between 1000 and 1400 feet per minute. A

6

15-inch section of air jet conveyor 14 with five rows of slots 36 punched louver fashion in the substantially horizontal, flat top surface with 5/64-inch openings in slots 36 is sufficient to accomplish this acceleration when air is supplied inside the plenum 37 sufficient to produce 3.0 to 3.5 inches of water gauge pressure, resulting in a velocity of 7500 to 8000 feet per minute in the jets emitting from slots 36.

Compressed air from the plenum 16 within each nozzle 21 exits through jet slots 18 and 19 in the same direction as that in which the materials from the accelerating section are being conveyed, converging into a thin horizontal curtain of high velocity air 20 which is directed to convey the less dense materials to the region above the next nozzle 21 in series. The air pressure inside plenum 16 is maintained at the appropriate pressure to form jets at slots 18 and 19 which will provide an air stream 20 at the appropriate velocity to convey the less dense materials into the region above the next nozzle 21 in series but allow more dense materials to settle below the level necessary to enter the region above the next nozzle. The more dense materials usually impact on the back of the next nozzle 21 losing their horizontal velocity, then fall vertically into a suitable collection means 22. Then the dense materials are gathered into a conveying means 23 by the collection means 22 and are conveyed to the disposal point 25. The conveyor system for removal of waste material located below the collecting system and substantially paralleling the space opening the full length of the collecting system comprises a plurality of end supported, uniform regularly shaped, essentially parallel, equally spaced, rubber surfaced rollers, the location of the end rollers being defined by the ends of the collecting means and a continuous belt apparatus, formed around the end rollers and passing over and under the plurality of rollers, the belt having its width defined by the length of the rollers and the belt length defined by the location of the end rollers. A drive means imparts circumrotation to the plurality of rollers. Subsequent treatment of the dense materials after separation and collection is not an intended function in this invention.

Each succeeding stage of separation, nozzle to nozzle, performs identically as described except for a buildup in volume of air flow in the region above the nozzles. Because of random position within the mass of material and interparticle drag, separation is not complete at any stage but the cumulative amount of separation increases at each stage until the less dense material (dry open cotton) is discharged from the machine at 38 in an airborne condition with velocity sufficient to carry it into the next unit of the system where it can be disposed of in any manner desired. Five stages are shown in FIG. 1 for illustrative purposes. The number of stages which can be utilized is indefinite. However, empirical development data indicated that five stages produced approximately 96 to 98 percent efficiency in green boll and trash removal. Limitations would result from the physical space available for the machine to occupy, the number of stages required for cumulative separation to reach the desired efficiency level, and cost. These would represent the controlling factors in determining the number of stages that could be utilized.

Air is supplied in this machine through connection to duct 39 which in turn is connected to plenums 16 and 37 by flexible connections between ports 40 and plenum openings 41. The air supply is regulated by con-

trols external to this machine to provide the required pressure and volume at the inlet connection of duct 39. Balancing of the air supply within the machine is accomplished by adjustable baffles inserted in ports 40 of duct 39.

Variables which can be manipulated for control of the performance of the machine are: (1) spacing between nozzles 35, FIG. 1. (2) The velocity of the air stream 20, FIG. 2. (3) The direction of stream 20 with respect to the horizontal direction 17, FIG. 2. (4) The configuration of nozzles 21, FIG. 2. (5) The size of the jets 18 and 19, FIG. 2.

The velocity of jets 18 and 19 and the angle 17 of air stream 20 are the controlled variables. This is important in that without proper balancing of the variables the machine will not operate properly. The velocity of jets 18 and 19 is controlled by regulation of the air which is supplied to plenum 16. As previously stated this air supply is from an external source capable of either automatic or manual control.

The angle 17 of air stream 20 is controlled by moving the lower part of the nozzles 21 at pivot 26. The entire nozzle assembly rotates about pivots 27 which extend through housings 24 and 28 located on each side of the machine. There is a bar 29 located on each side of housings 24 and 28. The nozzles 21 are moved by adjustment of bar 29. How is this accomplished? The forward end of bar 29 is rounded and threaded. Bar 29, consists of pivot 26 which extends through bar 29 which screws into bracket 31 at the round threaded end of bar 29 by nuts 30 and 32. Bar 29 is moved by adjusting nuts 30 and 32 which cause the bar to move in relation to bracket 31 which is affixed to frame 33 which is affixed to housings 24 and 28. This results in a change of the verticle axis of the nozzle assembly, and the desired resultant angle is achieved by this adjustment on each side of the machine.

The spacing 35 between the nozzles 21 is also adjustable. Proper settings for this spacing can be determined by the characteristics of the materials to be separated and by the velocity of the air in the jets and the angle at which the jets are operated. Optimum settings were determined empirically by trial and error methods. For typical early season cotton as harvested containing green bolls with moisture contents ranging between 50 and 80 percent wet basis, the spacing 35 of 9 to 12 inches is considered optimum between nozzles 21.

The velocity of the air jets 18 and 19 is considered optimum between 6500 and 7000 feet per minute. The width of the opening in jets 18 and 19 is 1/16 to 5/64-inch. The air stream from the converged jets discharges at an angle of 15° to 20° above the horizontal. Air must be supplied into plenum 16 in sufficient quantity to maintain a gauge pressure inside the plenum of 2.5 to 2.8 inches of water.

There are many configurations which the nozzles 21 can take. However, for purposes of illustration of the preferred embodiments of this invention, attention is directed to FIG. 2 which is a cross sectional view of three typical shapes which the jet head of the air nozzles (21 in FIG. 1 at AA) can take on.

In FIG. 2, *a* and *c*, the head portion only of the nozzles is shown with the remaining portions forming air plenum 16 detached. The nozzle shape in FIG. 2 *b* used only a small round air plenum 16 which was attached to air supply ducts 39 on each end. Round slip connectors were used for attaching this nozzle to ducts 39 rather than the square ports 40, illustrated in FIG. 1, to allow

rotation of the whole nozzle for adjusting discharge angle 17 of air stream 20. Nozzle *b*, FIG. 2 is suitable for use in machines of limited width because the small size of plenum 16 restricts the amount of air that can be supplied for forming jets 18 and 19. Nozzles shaped like FIG. 2 *c* are suitable for use where it is desired to reduce the open space between nozzles to help prevent loss of the light materials with the dense materials being separated. Nozzle shape FIG. 2 *a* is suitable for use where maximum open space between nozzles is desired to achieve maximum separation. Nozzle shape *a*, FIG. 2, is currently in use in the air jet seed cotton cleaner as illustrated in FIG. 1.

The invention consisting of the air jet conveyor/accelerator, separator, air jet nozzles, air plenums, sides, cover, bottom, and collector bin, can be fabricated from sheet metal, plastic, or any other material which would be compatible with the design characteristics sufficiently to sustain the velocities, pressures, and volumes described above. Attachments can be made in any manner feasible with the material selected. The nuts, bolts, washers, baffles, gaskets, and flexible connections can be of standard construction or vendor purchased, and need only be compatible with the materials used in the major assembly portions of the invention. The conveyor can be purchased or fabricated to use with compatible materials standard to the construction of conveyors.

We claim:

1. An air jet apparatus for classifying materials said apparatus comprising:

- a. an accelerating means for horizontally accelerating and conveying the materials which comprises a substantially horizontal, flat surface having a series of rows of louvered openings;
- b. a separating means oriented in the same plane as the accelerating means comprising a plurality of air jet nozzles having spaces therebetween, each nozzle comprising an air plenum having ends and both upper and lower longitudinal sections, as well as means for securing said sections together and means for attaching said secured sections to said ends, means comprising two parallel slots in the upper section which communicate with the interior of said nozzle for producing converging air jets; said air jets converging in the direction at which said materials are conveyed by the accelerating means; and means connecting said nozzles for simultaneously pivoting said nozzles about an axis parallel to the slot; and
- c. a collecting system located below the separating means and formed into the configuration of a trough having an open top communicating with the open spaces between the nozzles and a bottom sloped at an acute angle towards a bottom opening communicating with a conveyor means for removal of waste material.

2. The apparatus of claim 1 wherein the accelerating means comprises five rows of 5/64 inch-wide, louvered openings and the spaces between the nozzles are 12 inches wide.

3. The apparatus of claim 1 wherein the conveyor means comprises a continuous belt.

4. A method for separating green bolls from open cotton comprising:

- a. providing a horizontally directed air jet by blowing air at 7500 to 8000 ft./min. through louvered openings in a substantially flat surface;

9

- b. introducing green boll-contaminated cotton into the air jet of step (a), thereby accelerating the cotton;
- c. providing a thin horizontal curtain of high velocity air by blowing air through a plurality of air jets, said air jets discharging at an angle of from 12° to 20° above the horizontal in the same direction as that

5

10

- in which the cotton from the accelerating means is being conveyed;
- d. passing the accelerated cotton of step (b) into the horizontal air curtain of step (c); and
- e. allowing the green bolls to fall out of the curtain while recovering the cotton carried by the curtain.

* * * * *

10

15

20

25

30

35

40

45

50

55

60

65