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A. W. WAHLROOS ET AL  
HYDRAULIC FLOTATION SYSTEM

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2 Sheets-Sheet 1

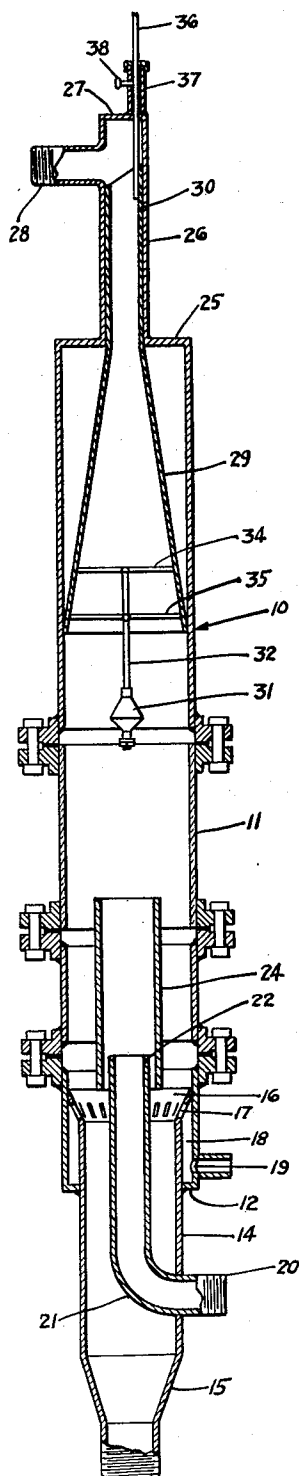


FIG. 1

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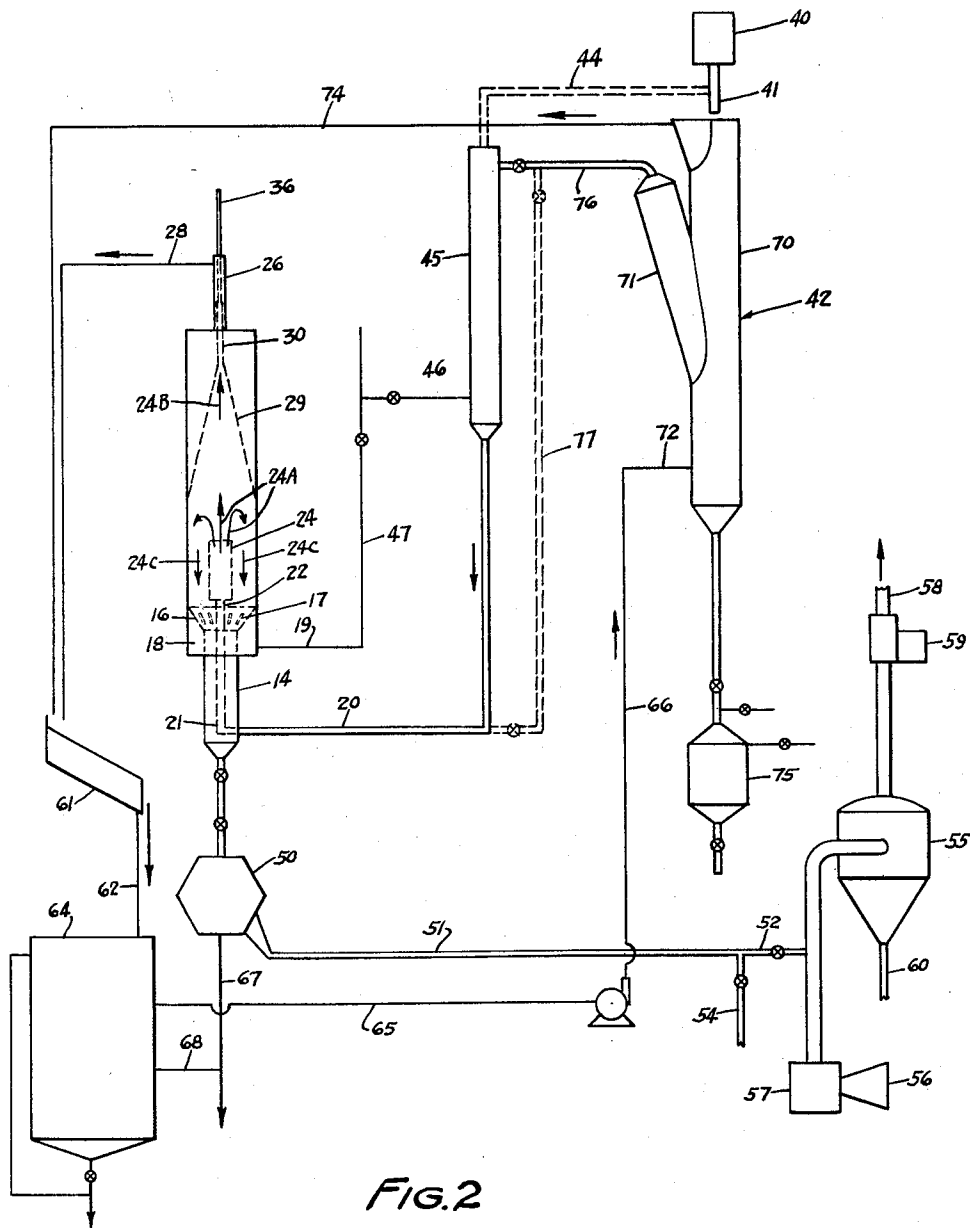


FIG. 2

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## HYDRAULIC FLOTATION SYSTEM

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15 Claims. (Cl. 209—160)

This invention relates to an improved hydraulic system of separating particles of materials of different specific gravities by flotation and to a new and improved apparatus for carrying out that separation. More particularly, the invention relates to an improved hydraulic flotation system of cleaning grain by separating the lighter contaminating materials from the grain and to an improved grain cleaning apparatus.

Depending upon a variety of circumstances, such as its source, method of harvesting, care in shipment, previous treatments and the like, grain may be contaminated by material which is lighter than the grain, such as chaff, bits of husks and straw, weed seeds, insect fragments, rodent pellets and like light weight foreign materials, or by material which is heavier than the grain, such as sand, pebbles, bits of rock, glass, cinders, metal and the like, or by both light and heavy foreign bodies. For convenience, hereinafter these lighter contaminating materials will be referred to collectively as "chaff" and the heavier contaminants will be referred to as "stones," although it is to be understood that other materials are included. Methods are known and apparatus is available for effecting separation of the very lightest and the very heaviest of these contaminating substances. These known means, however, do not serve effectively to remove the contaminants which in their densities more nearly approach the specific gravity of the grain.

The term "lighter" as used in this specification and in the appended claims is meant to refer not only to the lesser weight or weight per unit volume of a contaminating body or particle as compared with the weight or weight per unit volume of the wanted material but also to the lesser velocity it would possess in free fall through a fluid. Similarly, the term "heavier" is meant to include not only the greater weight or weight per unit volume of a contaminating body or particle as compared with that of the wanted material but also the greater velocity of that body or particle freely falling through a fluid. The terms thus encompass substances having approximately the same density as the grain or other wanted material but which have a shape which causes their hydraulic behavior to be different. As a practical matter, the substances which are most difficultly removable from grain are those which, though a little lighter than the grain itself, have very nearly the same density and shapes, such as rodent pellets. It is to the separation and removal of such very slightly lighter foreign bodies that this invention is primarily directed.

While this invention will be described with particular reference to grain, and specifically to wheat, it is to be understood that the applications of the principals of this invention are by no means so limited. In addition to grains, the invention is also applicable to the hydraulic separation and removal by flotation of lighter foreign bodies from such materials as sand, pulverized coal, clays, suspensions of paper-making stock, various ores and minerals and the like. In addition to use in cleaning wheat the method and apparatus of this in-

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vention are likewise applicable to other grains such as barley, soybeans, rye, sorghums, oats, flax, peas, beans, peanuts and the like.

The principal object of this invention is to provide an improved hydraulic flotation system of rapidly separating materials showing different hydraulic behaviors.

Another object of this invention is to provide an improved hydraulic flotation system of removing lighter contaminating materials from other wanted material.

It is another object of this invention to provide an improved hydraulic flotation system of cleaning grain by separating the lighter foreign substances, such as rodent pellets which are especially difficult to remove.

Still another object of this invention is to provide an improved hydraulic flotation system of cleaning wheat by separating the chaff, rodent pellets, insect fragments and the like therefrom, without causing an excessive gain in moisture content of the grain.

A further object of this invention is to provide novel and improved flotation apparatus for separating materials showing different hydraulic behaviors.

It is a further object of this invention to provide for hydraulically removing lighter contaminating material from other wanted material by flotation.

A still further object of this invention is to provide an improved grain cleaning apparatus for hydraulically separating the lighter foreign substances, rapidly from the grain so as to prevent excessive moisture gain in the grain.

Another further object of this invention is to provide improved hydraulic separating apparatus comprising a vertical column having adjustable cone-shape means therein for varying the upward velocities of hydraulic liquids in said column.

Still another object of this invention is to provide an improved rapid method and apparatus for quickly and efficiently separating particulate materials showing different hydraulic behaviors whereby a minimum pickup of the hydraulic fluid by the particulate material occurs.

Other objects of this invention will become apparent as the description proceeds.

To the accomplishment of the foregoing and related ends, this invention then comprises the features hereinafter fully described and particularly pointed out in the claims, the following description setting forth in detail certain illustrative embodiments of the invention, these being indicative, however, of but a few of the various ways in which the principles of the invention may be employed.

This invention is further illustrated by reference to the drawings in which corresponding numerals refer to the same parts and in which:

Figure 1 is a vertical sectional elevational view of the hydraulic flotation separator and cleaner which form part of this invention; and

Figure 2 is a diagrammatic and schematic representation of a cleaning or separating system of which the flotation unit of this invention may form a part.

Broadly stated, this invention comprises a hydraulic flotation system of separating particulate material having different hydraulic behavior characteristics by first forming a slurry of the particulate material in the hydraulic liquid, introducing this slurry upwardly into a liquid column, the upper portion of which is upwardly moving and at least part of the lower portion of which is downwardly moving, adjusting the upward velocity of the upwardly moving portion of the liquid column until the desired critical separation of particulate materials is effected, the lighter chaff-like material floating out through an opening at the top of the liquid column and the heavier wanted material flowing downwardly against the upwardly moving liquid current and out through an opening at the bottom

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of the column, and finally separating the liquid from the solid material. The system which comprises this invention embraces both a method of hydraulic separation and apparatus for carrying out that method. Depending upon the nature of the materials being separated or cleaned and the degree or nature of the foreign bodies, the system of this invention may be used either alone, or in series, or in combination with other separating or cleaning means of a different nature. Thus, in Figure 2 of the drawings the system of this invention is shown in use in combination with an auxiliary and complementary hydraulic separating and cleaning unit of a different type which per se is the subject matter of a copending application Serial No. 383,533 of Arvi W. Wahlroos and Edwin T. Clocker filed of even date herewith. Instead of an auxiliary hydraulic separating unit a dry mechanical separator could obviously also be used.

Referring now to the drawings and particularly to Figure 1 there is here illustrated the hydraulic separating or cleaning flotation apparatus which forms part of the instant invention.

In the form here illustrated the apparatus comprises an elongated upright generally cylindrical standpipe 10 made up of a plurality of flanged sections stacked one upon the other and held by bolts or clamping rings and bolts, one of which sections 11 is preferably made of glass or other transparent material so that the separating action within the standpipe may be observed. Standpipe 10 is closed at both ends. The bottom 12 is intersected by a generally cylindrical outlet conduit 14 concentrically located with respect to the standpipe and having a somewhat smaller diameter. The lower end 15 of the outlet conduit tapers inwardly for union with further conduit means for carrying the discharged slurry of cleaned particulate material to dewatering and drying means. The upper end of the outlet conduit 14 extends for some distance up into the standpipe 10 and terminates in an inverted conical collar section 16 tapering outwardly to the walls of the standpipe. This conical collar is provided with a plurality of radial longitudinal slits 17 around its periphery. The lower end and bottom of the standpipe, the upper end of outlet conduit and the conical slotted collar define an annular chamber 18 through which additional liquid is introduced through an opening 19 for movement upwardly through the slits for imparting some upward movement to the liquid column in the standpipe. A supply line 20 intersects the wall of the outlet conduit 14 and bends in an elbow 21 upwardly as a supply inlet 22 disposed concentrically within the outlet conduit and extending above the top of the conical collar member. Disposed concentrically within the standpipe 10 and around the top of supply inlet 22 and held by brackets (not shown) is a cylindrical supply inlet extension 24 open at both ends and extending upwardly into the standpipe. The top 25 of the standpipe is intersected by an outlet pipe 26 closed at the top 27 but having a discharge pipe 28 in one side for carrying away the lighter particulate material separated within the standpipe 10. Positioned within the upper portion of standpipe 10 is a generally conical velocity regulating means 29, the walls of which converge generally upwardly and terminate in an outlet 30 which extends through the top 25 of the standpipe and into outlet pipe 26. The conical velocity adjusting member is freely slidable within the standpipe and is provided with a float 31 slidably mounted on a rod 32 suspended from the bottom of the center of the conical member by means of brackets 34 and 35. The conical velocity regulating member is adjustable up and down by means of a rod 36 welded to the outlet of the conical member and passing up through an opening in the top 27 of the outlet pipe 26 where it is held in position in tube 37 by a thumb screw 38.

As shown in Figure 2, the grain or other material to be cleaned or separated is fed by means of any conventional conveying means into a feed box 40 from which it flows at a controlled rate either through a spout

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41 into a preliminary hydraulic separator unit indicated generally at 42 or through a preliminary conventional dry mechanical separator and thence to a surge tube or it may be fed directly through line 44 into a surge tube 45 wherein water or other liquid is introduced through line 46 and a slurry of the particulate material and liquid is formed. Liquid is introduced through line 47 and opening 19 into the annular chamber 18 at the bottom of the standpipe 10 and flows upwardly through the slits 17 in conical collar 16. The slurry of solid particulate material is fed through supply line 20 up through elbow 21 and supply inlet 22 and surges up over the top edges of the open ended cylindrical supply inlet extension 24 as shown by arrows 24A. Here the flow of the liquid column is generally upward through the center of the supply inlet and around the edges of the standpipe where the flow of liquid through the slits 17 enters the column. The velocity of this upward flow of liquid is in the range of about 0.1 to 0.4 feed per second and is not of such magnitude as to carry the wheat upward and out through the top of the standpipe to the discharge pipe but is so adjusted by movement of the velocity regulating means as to effect a sharp separation of wheat from chaff. The lighter chaff including rodent pellets, insect fragments and the like is carried by the upward flow of liquid out through the outlet to the discharge pipe as shown by arrow 24B. The velocity of the upwardly moving column of liquid is adjusted by varying the distance between conical member 29 and supply inlet 24. Reducing this distance results in a greater upward velocity in this zone where the critical separation occurs. Increasing the distance reduces the velocity. The upward velocity of the liquid in this zone of separation is adjusted so as to be just insufficient to carry the wheat upward.

The heavier grain passes upwardly through a zone of turbulence indicated by arrows 24A and then falls back downwardly as shown by arrows 24C against the relatively slow countercurrently upwardly moving column of liquid from space 18 where it receives a final wash and passes out through the outlet conduit 14 to conventional dewatering unit 50 and thence on through ducts 51 and 54 when drying is not required or through ducts 51 and 52 to a convention cyclone dryer 55 fed by air from inlet 56 heated at heater 57 and vented out through vent 58 by vent fan 59. The dried wheat is recovered at cyclone discharge 60. The floating chaff and other light contaminants are carried through discharge pipe 28 to screen 61 where the chaff joins that separated by unit 42 and is dewatered and discarded, the liquid being discharged to the sewer or recovered and carried through line 62 to recirculation tank 64 from where it is recirculated through lines 65 and 66 to the preliminary separating unit 42. The liquid from the dewatering unit 50 may also be recirculated through lines 67 and 68 to the recirculation unit or discharged to the sewer, as desired.

It is desired to emphasize that the hydraulic flotation unit which is the subject matter of this invention may be used alone or may be included as part of a more comprehensive hydraulic treating system such as is shown in Figure 2 of the drawings. The choice is dependent entirely upon the condition and relative specific gravities of the materials being treated therein. Where the wanted materials are either heavier or lighter than the contaminating substances, the flotation unit of this invention may be used alone to effect the separation. However, if the wanted material is contaminated with both heavier and lighter foreign substances then some auxiliary means should be employed. The hydraulic separator shown at 42 in Figure 2 of the drawings in per se the subject matter of the above identified copending application filed of even date herewith. The combination system shown in Figure 2 is for purposes of illustration only. The construction and mode of operation of the hydraulic separating unit 42 are disclosed in detail in the aforementioned copending application and are, so far as is necessary to the

understanding of this invention, incorporated by reference into the disclosure of this application.

The separating section of complementary hydraulic cleaning unit 42 is briefly as follows: The grain containing contaminating foreign bodies which are both heavier and lighter than the grain itself is fed into the top of the unit 42 which comprises a generally vertical upright cylindrical standpipe 70 having an angularly upwardly extending conduit 71 branching therefrom. The standpipe 70 and its angularly projecting branch 71 are filled with a swirling upwardly moving column of water or other liquid inert to the material being treated. The swirling motion is imparted to the column by introducing the liquid tangentially at 72 into the lower portion of the standpipe at a rate sufficient to provide the desired rotary movement and upward velocity. As the material from the feeder box falls onto the top of the liquid column the very lightest chaff and like contaminating material is retained on the surface of the liquid and is floated off thru line 74 in the direction of the arrow to the screen 61 for dewatering. The material being treated then falls through a relatively quiescent zone of liquid in the top of the standpipe and the countercurrent flow of solid against liquid serves to separate more of the lighter foreign bodies and float them to the surface. The greater mass of the heaviest contaminants carries the pebbles and stones and the like down to the bottom of the standpipe and into a collecting chamber 75. After falling through the relatively quiescent zone the material being treated enters into a zone in which the liquid is moving upwardly in a swirling circular motion and is being diverted angularly into conduit 71. The material being treated entering into this moving zone is carried off into the angularly disposed conduit. The centrifugal action of the moving liquid serves to throw out the remaining heavier contaminating substances against the walls of the conduit from where they fall to the bottom of the standpipe. Being already in the form of a slurry, the cleaned and separated grain or other material being carried out through the top of conduit 71 need not (unless desired) pass through surge tube 45, but may pass through lines 76 and 77 directly to supply line 20 and into the flotation unit.

Although it is to be understood that the scope of the invention is not limited thereto, the hydraulic flotation unit comprising this invention will now be further described with reference to its use in cleaning grain and particularly wheat, with water being used as the hydraulic fluid. A hydraulic flotation unit was designed to have a capacity of about 5 to 40 bushels of wheat per hour and comprises generally an upright vertical standpipe approximately 8 inches in diameter and about 4½ feet high made up of a stack of a plurality of flanged sections. A transparent section about one foot high is positioned about two feet from the top of the standpipe. The bottom outlet pipe has a diameter of about 6 inches and extends for about 4 inches into the bottom of the standpipe. The supply inlet for the slurry of wheat has a diameter of about 2 inches and extends about 4 inches above the bottom outlet pipe and about 2 inches into the supply inlet extension which is about a foot high and 3½ inches in diameter. The conical velocity regulating member is about a foot and a half high and ranges from about an 8 inch diameter at its base to about 2 inches at its outlet. The maximum length of the zone between the wheat supply inlet 24 and the inlet to the conical section is thus about 16 to 18 inches and this may be reduced down to about 8 to 12 inches by adjusting the conical member.

The wheat is fed into the surge tube 45 at the rate of about 5 to 40 bushels per hour, preferably at about 20 to 30 bushels per hour. Sufficient water is introduced into the surge tube and into the bottom of the standpipe to maintain a ratio of from about 7 to 10 parts by weight of water for each part of wheat and preferably from about 8.1 to 8.7 parts by weight of water to each part of

wheat while in the standpipe. Of this water, about 80 to 90 percent is added in the surge tube and about 10 to 20 percent in the bottom of the standpipe. If the wheat is already in the form of a slurry as it enters the surge tube only enough water need be added to establish the desired ratios. The make-up water and slurry of water and wheat are fed into the vertical standpipe and the conical section is so adjusted as to maintain an upward velocity of water through the intermediate zone between the top of the supply inlet and the bottom of the conical member of from about 0.1 to 0.4 feet per second and preferably for cleaning of wheat about 0.12 to 0.2 feet per second. As the upwardly moving slurry of wheat enters this relatively rapid moving portion of the column of water the critical separation of wheat from chaff occurs. The upward velocity is sufficient to transport the chaff and like light foreign substances upwardly and out through the discharge pipe but is just insufficient to transport the wheat. The wheat then falls into the relatively slow moving column around the supply inlet extension, receiving a final separating action from the countercurrently moving stream of makeup water in which contaminants not theretofore removed, return and are directed into the lower open end of the inlet extension 24, as described, and the clean grain is discharged down through the bottom outlet pipe and passed to the dewatering and drying units.

As herein described, the feed extension 24 is in spaced relationship to the feed inlet 22 and the perforated collar 16, from which an upwardly directed flow of fluid is obtained as a relatively spaced separate moving column relative to the inlet feed mixture moving upwardly through the inlet extension 24, from the feed supply inlet 22. As indicated, the material to be separated flows upwardly through extension 24 in a velocity relative to the force of feed flow therethrough. Due to the enlarged column area immediately above the outlet of extension 24, the velocity of the feed flow is reduced and becomes more closely related to the upward flow velocity of the liquid column about the outer periphery of extension 24. As explained, the material desired to be separated then falls back in a counter flow relationship about the extension 24. In this fall back, there is retained contaminating material which has somewhat related properties as to size and specific gravity, but different configuration or hydraulic properties. These materials fall, adjacent to and into the fluid streams flowing upwardly from perforations 17. At this stage, materials of different configuration, lighter weight or specific gravity, and different hydraulic properties, are suspended or floated in the relatively independently spaced fluid column extending about the inlet column, as described. In conjunction with the separation effected by the action of the fluid streams flowing from perforations 17, a spaced relationship of extension 24, relative to feed inlet 22, causes an aspirating effect. This aspirating effect serves to drag and pull into the inlet feed column materials having their hydraulic behavior effected in the upwardly moving liquid column, supplied from perforations 17, adjacent the base of the inlet feed extension 24.

The invention is further described by means of the following examples, these being illustrative only and not to be construed as a limitation upon the scope of the invention.

#### Example 1

Wheat fed to a flotation unit constructed according to this invention was previously purposely contaminated with rodent pellets having a range in apparent specific gravity such that about 50 percent were lighter than water, about 35 percent had specific gravities between about 1.00 and 1.10 and about 15 percent had specific gravities between about 1.10 and 1.15. (The specific gravity of wheat ranges between about 1.2 to 1.35.) The rodent pellets used were identified by marking them with a spot of bright colored lacquer. One bushel of

wheat was contaminated with 20 marked pellets selected as described above. This represents quite heavy contamination. This wheat containing the marked pellets was passed through the flotation unit. In this run the water to wheat ratio was 8.7 to 1 and the upward velocity of the water through the separation zone was 0.15 feet per second. Nineteen of the marked pellets were separated from the wheat in the flotation unit along with an additional 19 unmarked pellets which had been present in the wheat as normally occurring contamination. With the pellets 0.515 percent of the wheat stream was collected, and consisted of chaff, unsound wheat, and approximately 50% sound wheat which could subsequently be recovered.

#### Example II

Another sample of wheat was contaminated with marked rodent pellets selected to have a range of specific gravities as described in Example I. One bushel of this wheat containing 20 marked pellets was passed once through the flotation unit. The water to wheat ratio was 8.1 to 1. The upward velocity of the water through the separating zone was 0.14 feet per second. Fourteen marked and 3 unmarked pellets were removed in the flotation unit. However, the total amount of wheat which was removed with the pellets and other chaff was only 0.231 percent and this contained only an insignificant amount of good quality wheat.

In both of the above examples the rodent pellets which were used were obtained from wheat which had been subject to normal contamination by rodents. Other tests made with relatively lighter rodent pellets obtained from animals fed a restricted diet resulted in separations of 100 percent with very little entrainment.

In the normal operation of this hydraulic flotation unit, the actual contact time of the wheat with the water will be only from about 15 to 60 seconds. By making this contact time between wheat and water at a minimum very little water is absorbed and the wheat may be freed of that by dewatering and drying without damage to its physical or chemical properties. The wheat if dewatered immediately will retain only from about 2 to 3 percent water as surface moisture and that can be removed by drying resulting in an overall moisture gain in the wheat of only a few tenths of a percent. The use of a flash dryer employing high initial air temperatures (550° F.) is possible since drying occurs by free evaporation.

This ease of drying illustrated by the following: Durum wheat from the flotation unit was dewatered in a pilot scale commercial dewatering unit and discharged directly to a countercurrent cascade type of dryer. The initial moisture content of the dry wheat before feeding to the flotation unit was 14.1 percent. As it left the dewatering unit the moisture content of the wheat was 17.1 percent and immediately after it left the dryer the moisture content was 15.0 percent. After being cooled in an air stream the final moisture content of the wheat was 14.2 percent, an increase of 0.1 percent over the feed. The wheat was in the dryer for 15 seconds. Temperature of the air into the dryer was 198° F. and the temperature of the air out of the dryer was 84° F. The temperature of the wheat out of the dryer was 108° F. Tests showed no damage had occurred to the wheat. Durum wheat was selected for use in the experiment because it is considered to be the most sensitive of the wheats to damage by heat.

Spring wheat having a moisture content of 8.8 percent was wet to 12.5 percent moisture content after being exposed to contact with the water for 45 seconds and was introduced into a conventional flash dryer. With an air inlet temperature into the dryer of 400° F. the wheat was dried to within 0.7 percent of its original moisture content. The temperature of the wheat being discharged from the dryer was 80° F. The wheat showed no damage due to treatment at these temperatures.

It will be understood that the dimensions and conditions recited above are given for a particular material (wheat) and for operation at a particular capacity. Obviously, variations which will readily suggest themselves to persons skilled in this art may be made to adapt this invention to the treatment of different materials and at different rates.

As many apparently widely different embodiments of this invention may be made without departing from the spirit and scope thereof, it is to be understood that we do not limit ourselves to the specific embodiments herein.

What we claim is:

1. A hydraulic flotation unit comprising in combination an elongated vertical tube having a top and a bottom, a vertical outlet tube disposed within said elongated vertical tube at the bottom end thereof, a vertical feed inlet tube disposed within said outlet tube and extending up into said elongated vertical tube, liquid and feed flow guides adjacent the outlet of said inlet tube an outlet tube at the top of said elongated vertical tube and a movable conical member within said elongated vertical tube between the outlet at the top thereof and the feed inlet tube.

2. A hydraulic flotation unit comprising in combination an elongated vertical tube having a top and a bottom, a vertical outlet tube disposed within said elongated vertical tube at the bottom end thereof, means for introducing liquid into the bottom of said elongated vertical tube and around the outlet tube, a vertical feed inlet tube disposed within said outlet tube and extending up into said elongated vertical tube, a feed guide extending upwardly from said inlet tube, an outlet tube at the top of said elongated vertical tube and a movable conical member within said elongated vertical tube between the outlet at the top thereof and the feed inlet tube.

3. A hydraulic flotation unit comprising in combination an elongated vertical tubular standpipe having a top and a bottom, a vertical outlet tube disposed within said standpipe at the bottom thereof and terminating in an outwardly and upwardly extending perforated conical collar section, means for introducing liquid into the bottom of the standpipe and around the outlet tube beneath said perforated collar section, a vertical feed inlet tube disposed within said outlet tube and extending up into the standpipe, a collective flowguide adjacent the outlet end of said feed inlet tube an outlet tube at the top of the standpipe and a movable conical member within the standpipe between the outlet at the top thereof and the feed inlet tube.

4. A hydraulic flotation unit comprising a generally cylindrical vertical tubular standpipe having a top and a bottom, a vertical outlet tube of lesser diameter disposed within said standpipe at the bottom thereof and terminating in an outwardly and upwardly extending perforated conical collar section, means for introducing liquid into the bottom of the standpipe through the space around the outlet tube, a vertical feed inlet tube of lesser diameter disposed within said outlet tube and extending up into the standpipe, a vertical feed inlet tube extension of greater diameter than the feed inlet tube, open at both ends, disposed about and above the end of the feed inlet tube, an outlet tube at the top of the standpipe and a movable conical member within the standpipe between the outlet at the top thereof and the feed inlet tube extension, the walls of said conical member converging upwardly and terminating in an outlet tube disposed within the outlet tube of said standpipe.

5. A hydraulic flotation unit comprising a generally cylindrical vertical tubular standpipe having a top and a bottom, a vertical outlet tube of lesser diameter disposed axially within said standpipe at the bottom thereof and terminating in an outwardly and upwardly extending perforated conical collar section, means for introducing liquid into the bottom of the standpipe through the space around the outlet tube and the perforations in the conical

cal collar section, a vertical feed inlet tube of lesser diameter disposed axially within said outlet tube and extending up into the standpipe, a generally cylindrical vertical feed inlet tube extension of greater diameter than the feed inlet tube, open at both ends, disposed axially about and above the upper end of the feed inlet tube, an outlet tube at the top of the standpipe, a movable conical velocity regulating member within the standpipe between the outlet tube at the top thereof and the feed inlet extension, said conical member being open at both ends, the walls of said conical member converging upwardly and terminating in an outlet tube disposed within the outlet tube of the standpipe and means for adjusting the height of the conical member.

6. The hydraulic flotation unit of claim 5 further characterized in that at least part of the walls of the standpipe in the zone between the top of the inlet tube extension and the bottom of the conical member is transparent.

7. A hydraulic flotation system for separating particles of materials of different specific gravities comprising an elongated substantially cylindrical tubular standpipe having a top and a bottom and adapted to contain a generally upwardly moving column of liquid, a vertical outlet tube of lesser diameter disposed axially within standpipe at the bottom thereof adapted to receive the downwardly moving portion of said generally upwardly moving column of liquid carrying the heavier particulate material, said outlet tube terminating in an outwardly and upwardly extending perforated conical collar section, means for introducing liquid into the bottom of the standpipe through the space around the outlet tube and up through the perforations in the conical collar section, a vertical feed inlet tube of lesser diameter disposed axially within said outlet tube and extending up into the standpipe for introducing a supply of a slurry of solid particulate material entrained in a liquid into said generally upwardly moving liquid column, a generally cylindrical vertical feed inlet tube extension of greater diameter than the feed inlet tube, open at both ends, disposed axially about and above the upper end of the feed inlet tube, an outlet tube at the top of the standpipe adapted to receive the lighter of the solid particulate material and deliver it to a discharge pipe, a movable conical liquid velocity regulating member within the standpipe between the outlet tube at the top thereof and the feed inlet extension, said conical member being open at both ends, the walls of said conical member converging upwardly and terminating in an outlet disposed within the outlet tube of the standpipe, means for adjusting the height of the conical member whereby the velocity of the generally upwardly moving column may be regulated and the lighter and heavier solid particulate material separated thereby, and means for removing the liquid from said separated solid particulate materials.

8. In the process of hydraulically cleaning and separating a selective material from contaminant material mixed therewith and having different hydraulic behavior in a liquid system, the steps comprising continuously mixing and introducing a feed stream of the mixture of materials into a liquid stream, maintaining a concurrently flowing liquid stream adjacent said first mixed flowing streams, joining all of said liquid streams at an outflow end of said first mentioned mixed flowing streams, initially separating a portion of the contaminant material by its hydraulic behavior in the said juncture area of said liquid streams, discharging the liquid of said joined streams with said separated portion of contaminant material, returning the selective portion of the material and retained contaminant material therewith in countercurrent flow relationship in said adjacent concurrent flowing liquid stream, effecting a further separation of the selective material from retained contaminant material of different hydraulic behavior than said selective material, separating and recirculating retained contaminant material into and with said feed stream slurry, and continu-

ously withdrawing a slurry of the countercurrent flowing selective material from the cleaning process.

9. In the process of claim 8, the selective material being a grain material, contaminant material comprising rodent pellets and the liquid being water.

10. In a fluid unit for cleaning grain of contaminant material, the structure comprising a material feed means for a continuous flow of a mixture of grain material and contaminant material, a fluid flow guide means for said mixture in spaced relationship to said material feed means and for recirculation therein of a portion of said contaminant material, a further fluid guide means about said feed means and said flow guide means and in spaced circumferential relationship thereto, a fluid inlet means for supplying concurrent fluid flows to each of said flow guide means, control means for affecting the hydraulic behavior of said grain and contaminant materials, and discharge outlet means for continuously carrying cleaned grain from said unit.

11. A hydraulic flotation system of separating lighter and heavier particles of materials of different hydraulic behaviors which comprises forming a slurry of said particles, introducing said slurry upwardly into a generally upwardly relatively rapidly moving liquid column, maintaining a spaced upwardly moving liquid column in adjacent relationship to the said upwardly relatively rapidly moving liquid column, joining the said spaced upwardly moving liquid columns, effecting a primary separation of the lighter and heavier particles in said slurry at the juncture of said columns, the upward velocity of said first column adjacent the point of introduction of the slurry being sufficient to transport and to create an aspiration effect relative to said adjacent liquid column, the upward velocity of said adjacent liquid column being sufficient to transport the lighter of said particles upwardly but insufficient to transport the heavier of said particles, effecting a separation and recirculation of the entrapped lighter particles from the heavier particles by said aspiration effect, withdrawing lighter particles from the top of said liquid column, and withdrawing heavier particles from the bottom of said liquid column.

12. A hydraulic flotation system of cleaning grain of contaminant material which comprises forming a slurry of grain and its contaminant material, introducing said slurry upwardly into a generally upwardly moving liquid column, maintaining a second liquid column in adjacent concurrent flow relationship with said first slurry column, adjusting the upward flow velocity of said slurry column such that it is sufficient to support said slurry of grain and create an aspiration effect relative to said second liquid column and simultaneously produce separation and recirculation of foreign material from said second column back into said slurry column, adjusting the relative flow of said second column such that it is sufficient to collect and transport the lighter contaminant material upwardly but is insufficient to transport the grain, effecting a juncture of said liquid columns and separation of grain into said second column, withdrawing contaminant material from the top of the said columns, withdrawing grain cleaned of contaminant material from the bottom of said columns, and removing the liquid from the grain.

13. The system of claim 12 further characterized in that the ratio of liquid to grain is in the range of about 7 to 10 parts by weight of liquid to each part of grain.

14. The system of claim 12 further characterized in that upward velocity of said generally upwardly moving liquid column adjacent the point of introduction of the slurry is in the range of about 0.1 to about 0.4 ft. per second.

15. The system of claim 12 further characterized in that the liquid is water, the grain is wheat and the ratio of water to wheat by weight is from about 8.1 to about 8.7 to 1 and the upward velocity of the said generally upwardly moving liquid column of water adjacent to

point of introduction of the wheat slurry is in the range  
of about 0.12 to about 0.2 ft. per second.

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