

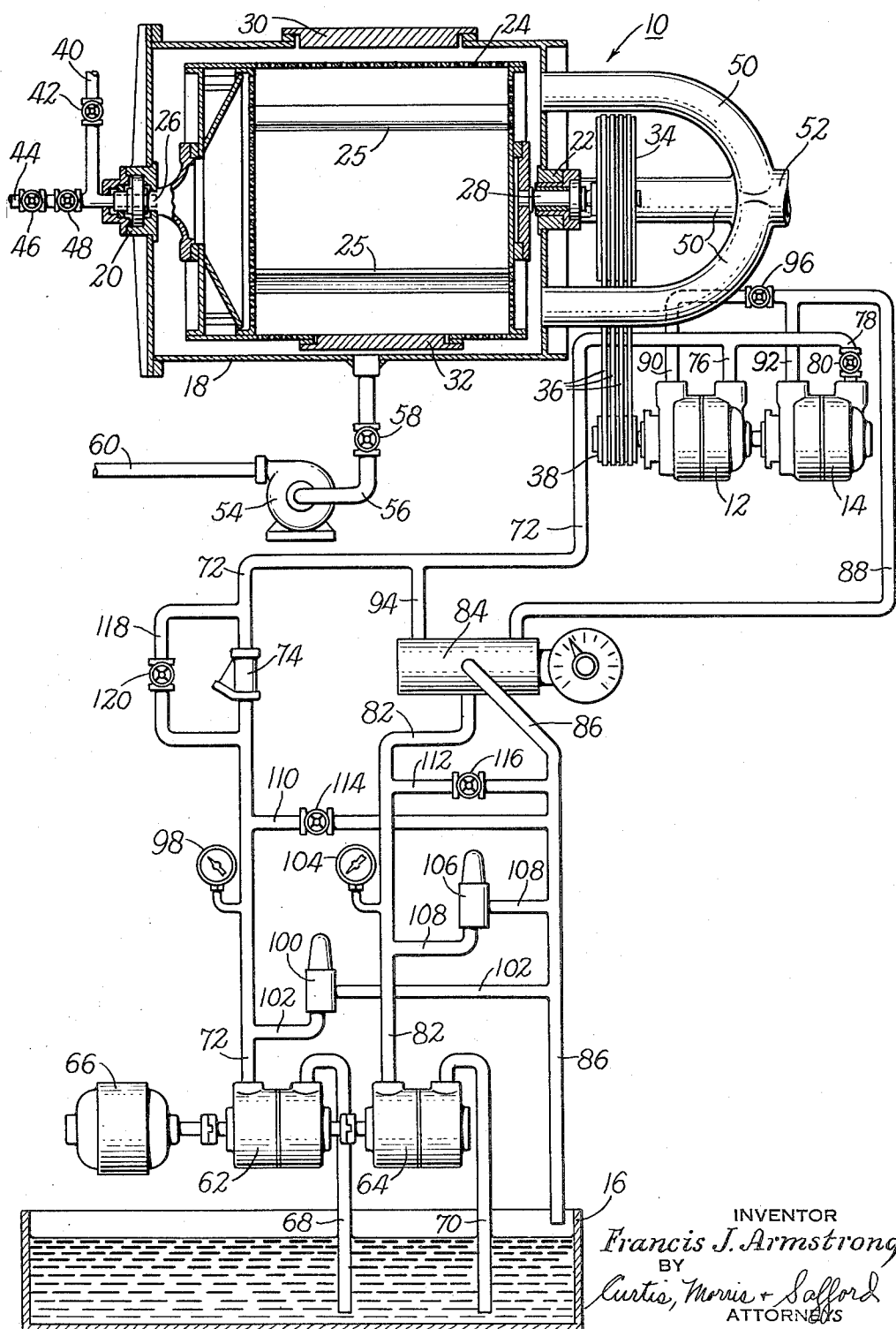
Nov. 23, 1954

F. J. ARMSTRONG

2,695,103

METHOD OF CENTRIFUGAL EXTRACTION

Filed March 8, 1950



INVENTOR
Francis J. Armstrong
BY
Curtis, Morris & Safford
ATTORNEYS

1

2,695,103

METHOD OF CENTRIFUGAL EXTRACTION

Francis J. Armstrong, Fayetteville, N. Y., assignor to U. S. Hoffman Machinery Corp., New York, N. Y., a corporation of Delaware

Application March 8, 1950, Serial No. 148,426

9 Claims. (Cl. 210—63)

This invention relates to the centrifugal extraction of liquids from fabrics in centrifugal extractors that are rotatable about a horizontal axis and more particularly to a method of so driving such a horizontal extractor as to achieve a balanced loading of the goods therein and thereby eliminate vibration of the extractor at centrifuging speed. Centrifugal extractors of the type with which the present invention is concerned are used extensively for removing water or soap solutions from laundry and dry cleaning solvents from goods that have been dry cleaned therewith.

Centrifugal extraction of liquids from fabrics has been carried out in both vertical and horizontal extractors and when considered only from the point of view of ease in achieving a balanced distribution of the goods in the centrifuge rotor and thereby eliminating the vibration due to unbalanced loading, the vertical extractor is generally preferred. However, it is often desirable to carry out washing of the goods, drainage of excess washing liquid therefrom, centrifugal extraction and perhaps drying of the goods as well in a single piece of equipment. In carrying out such a three or four step process, a tumbler, wherein the goods are contained in a perforated drum rotatable about a horizontal axis, is commonly used because of the fact that the washing step, which is normally considered the most important step of the process, can be carried out more effectively in a tumbler. However, although washing can be done more effectively in a horizontal drum, the use of such a horizontal drum gives rise to a problem in the centrifuging step of the process because of the difficulty of securing balanced distribution of the goods around the periphery of the drum; and unless special precautions are taken, the unbalanced condition of the goods causes the rotary drum to vibrate during centrifuging to such an extent that it is impossible to attain a rotational speed high enough to secure adequate centrifugal removal of the liquid from the goods.

It is accordingly an object of the present invention to provide an improved method of achieving a balanced condition of goods within the rotor of a horizontal extractor. It is another object of the invention to provide a method of securing a substantially uniform weight-distribution of goods around the periphery of the rotor of a horizontal extractor and thereby eliminate vibration of the drum. It is still another object of the invention to provide a method of driving a horizontal extractor which automatically produces a balanced condition of the goods within the extractor and thereby eliminates vibration during centrifuging. Other objects of the invention will be in part obvious and in part pointed out hereinafter.

In the copending application of H. F. Hamlin, Serial No. 729,500, filed February 19, 1947, now Pat. No. 2,573,966, it is disclosed that for a horizontal drum of a given diameter containing goods of the type that are laundered or dry cleaned, there is a critical speed at which the goods become distributed throughout the cross-section of the drum. At speeds slightly below this critical speed, the goods at the upturning side of the drum fall away near the top of the drum and leave a portion of the volume of the drum containing no goods. At speeds slightly above this critical speed the radially outward forces on the goods are such that an axial space is formed in the drum, which space contains no goods. Distribution of the goods throughout the drum is achieved in only a very narrow speed range, referred to herein

2

as the critical speed. At this critical speed the goods in effect float within the drum. It has been found that the critical speed is attained when the centrifugal force at the drum periphery is approximately one pound per pound of goods. Stated mathematically, the critical speed is about $54r^{-1/2}$ R. P. M. when r is the radius of the drum in feet.

I have found that if a drum containing the goods is rotated for a period of time at a speed within the critical range, the goods in the course of their random movements within the drum will at irregular intervals momentarily achieve a weight-balanced condition around the periphery of the drum. I have further found that if the drum is accelerated at the instant that this balanced condition is achieved, the balanced condition is then "frozen" or "set," and that when the balanced condition has been set the drum may be accelerated rapidly to and maintained at a desired centrifuging speed without substantial vibration. Hence in one of its broader aspects the method of the invention comprises rotating a drum containing goods at the critical speed to produce distribution of the goods throughout the drum and until a momentary weight-balanced condition of the goods is established and thereafter immediately accelerating the drum to "freeze" or "set" the balanced state of the goods in the drum.

I have found further that for a given size of drum containing a given load of goods a certain predetermined torque is required to rotate the drum at the critical speed; and that when the momentary balance referred to above is established within the drum, the torque required to rotate the drum at the critical speed drops off very sharply. Hence it is possible to apply continuously to the drum that constant torque which will cause the drum to rotate at its critical speed, and when a balanced condition is momentarily established in the drum, the torque demand will drop and therefore the drum will automatically accelerate. In one of its aspects, the present method comprises applying a constant limited torque to the drum while it is rotating at the critical speed and until a balanced condition is established, whereupon the drum automatically accelerates. This automatic acceleration of the drum when a balanced condition is achieved is an important advantage of the present method.

In carrying out the present method accurate control of speed and power supply is very important. I have found that the desired degree of control can be effectively secured by using a hydraulic drive for the drum. Apparatus incorporating such a hydraulic drive and capable of carrying out the method of the invention is illustrated diagrammatically in the accompanying drawing and a preferred embodiment of the present method will be described in relation to the apparatus shown in the drawing. Although the method claimed herein is particularly addressed to centrifugal extraction, a complete dry cleaning operation will be described to bring out the relationship between the centrifuging step and other steps of the operation.

Referring to the drawing, the apparatus there shown comprises, in general, a conventional tumbler (shown near the top of the drawing) driven by the hydraulic motors 12 and 14 which are connected in tandem and supplied with oil from a reservoir 16 (shown at the bottom of the drawing). The tumbler 10 comprises a horizontally cylindrical casing 18, the opposite ends of which are provided with centrally located bearings 20 and 22. Within the casing 18 there is a conventional perforated drum 24 rotatably mounted by means of the stub shafts 26 and 28 in the bearings 20 and 22 respectively of the casing. The casing 18 and drum 24 are provided respectively with the usual doors 30 and 32 through which goods may be charged into the interior of the drum, and the drum is provided with the usual radial ribs 25 to assist in tumbling the goods within the drum when it is rotated.

The stub shaft 28 extends through the bearing 22 and supports, externally of the casing 18, a relatively large pulley 34 which is connected by the belts 36 to a small

pulley 38 that is in turn connected to the tandem motors 12 and 14 to be driven thereby.

Solvent is admitted to the left-hand end of the tumbler from a pipe 40 having a regulating valve 42 and passes through the bearing 20 to the interior of the casing. Steam is admitted, when required and as described below, from a pipe 44 provided with the valves 46 and 48. Vapors are withdrawn at the right-hand end of the casing through the branch pipes 50 which merge to form a main vapor conduit 52 that conducts the vapors to a condenser (not shown). At the bottom of casing 18, means are provided for removal of solvent from the casing comprising the pump 54, the suction side of which is connected through pipe 56 having shut-off valve 58 to the bottom of casing 18. When valve 58 is open, pump 54 can be used to pump solvent from the casing 18 through a discharge pipe 60 to a suitable point of disposal, or alternatively, the solvent may be pumped continuously through a filter and recirculated to the tumbler.

The apparatus thus far described is adapted to be used in carrying out the washing, centrifuging and drying steps of a dry cleaning process as described in the Hamlin application referred to above. The goods to be dry-cleaned are charged into the interior of drum 24 through the doors 30 and 32 which are then closed. A desired amount of solvent is run into the drum by opening valve 42 in pipe 40 and valve 42 is then closed. The drum 24 is thereafter rotated by the motors 12 and 14 at a relatively slow rate with the direction of rotation being reversed periodically in the usual manner.

At the end of the washing operation, the valve 58 is opened and the solvent pumped from the drum including such portions of solvent as can be drained from the goods. During drainage of the goods rotation of the drum is normally stopped.

When drainage is complete the drum is accelerated in a manner more fully described hereafter to the critical speed whereat the goods are distributed throughout the cross-section of the drum. This critical speed is maintained until a momentary balanced condition of the goods around the periphery of the drum is established therein, at which time the torque demand for rotation of the drum drops sharply and the drum automatically accelerates. The acceleration of the drum beyond the critical speed "freezes" the balanced condition of the goods and thereafter the drum can be accelerated as rapidly as desired to a final centrifuging speed without substantial vibration occurring.

When the centrifuging of the goods is completed the goods are dried in a manner more fully described in the Hamlin application referred to above. Rotation of the drum is stopped and the casing 10 evacuated through vapor pipe 52 by a vacuum pump (not shown). The drum is then rotated at the critical speed to produce distribution of the goods within the drum and steam is admitted from pipe 44. The steam vaporizes the residual solvent in the goods and a mixture of steam and solvent vapor is withdrawn through pipe 52 to a condenser (not shown) where it is condensed. Upon completion of the drying step the goods are removed through the doors 30 and 32.

As previously indicated the application to the drum 24 of an accurately controlled torque is very important in the carrying out of the present method. The maximum torque demand for the centrifuging step occurs at the beginning of the cycle, that is, a relatively large torque is required to start rotation of the drum 24 from rest. However, if this maximum torque is applied continuously the drum is accelerated through the critical speed range so rapidly that there is little chance of achieving a balanced condition. Hence, in order to achieve the controlled critical speed previously referred to, it is necessary to provide a hydraulic system for supplying motors 12 and 14 that will produce the high initial torque required to start the drum 24 rotating and at the same time reduce and limit the torque at the critical speed. A hydraulic supply system capable of accomplishing this objective is shown in the drawings and will now be described.

The motors 12 and 14 are preferably of the positive displacement, sliding vane type and are reversible by reversal of the direction of fluid flow therethrough. Referring again to the drawing, the motors are supplied with oil from reservoir 16 by a pair of pumps 62 and

64 that are connected in a tandem and driven by an electric motor 66. The pumps may be rotary, positive displacement pumps of the sliding vane type, essentially similar in construction to the motors 12 and 14. They are supplied with oil from reservoir 16 through the pipes 68 and 70 respectively. The discharge of pump 62 is connected by a pipe 72 containing a check valve 74 to the branch pipes 76 and 78 which are connected to one side of the motors 12 and 14 respectively. A shut-off valve 80 is provided in the branch pipe 78. The discharge of pump 64 is connected by a pipe 82 to a conventional reversing valve 84 from which an oil-return pipe 86 extends back to the reservoir 16. The reversing valve 84 may be of conventional construction and includes a pair of reversing ports one of which is connected by pipe 88 to branch pipes 90 and 92 which are in turn connected to the other side of motors 12 and 14. The other reversing port of reversing valve 84 is connected by a branch pipe 94 to the pipe 72. Branch pipe 90 is provided with a shut-off valve 96.

Each of the pump discharge pipes is provided with a pressure gauge and an adjustable pressure relief valve. Thus pipe 72 leading from pump 62 has a pressure gauge 98 connected thereto and there is an adjustable pressure-relief valve 100 located in a pipe 102 interconnecting pipe 72 and the oil-return pipe 86. In like manner, discharge pipe 82 of pump 64 has a pressure gauge 104 and there is an adjustable pressure-relief valve 106 in pipe 108 interconnecting discharge pipe 82 and oil-return pipe 86. Also interconnecting the pump discharge pipes 72 and 82 with the oil-return pipe 86 are the pipes 110 and 112 respectively containing the valves 114 and 116 respectively. Extending around the check valve 74 in pipe 72 there is a by-pass 118 having a shut-off valve 120 therein.

The manner in which the pumps 12 and 14 are supplied with oil to carry out the dry cleaning operation previously described is as follows: The pumps 62 and 64 are driven at constant speed by the electric motor 66. The relief valves 100 and 106 are preset to a relatively low and a relatively high value respectively. The valve 100 is set to a value which will produce a supply pressure that is just sufficient to rotate the drum at the critical speed during the centrifuging step. The valve 106 is set to produce a supply pressure that will start the drum rotating from a rest position. For purposes of illustration, I have found that in the case of a 30" drum containing 4 lbs. of goods per cubic foot of drum volume the valves 100 and 106 may be set at 1000 p. s. i. and 1500 p. s. i. respectively. The proper values for other drum diameters and loadings may be readily determined by experiment.

During the washing step, the pump 64 is used alone to supply oil to motors 12 and 14 in parallel. Valves 80, 96 and 114 are opened and valves 116 and 120 closed. Oil from pump 62 merely circulates through pipes 72, 110 and 86 back to the reservoir. Oil from pump 64 passes through pipe 82 to the reversing valve 84 and then through either pipe 88 or through pipes 94 and 72 to the motors 12 and 14. As previously indicated, the reversing valve 84 periodically reverses the flow of oil to the motors 12 and 14 to reverse the direction of rotation of the drum 24. Oil passing through the motors flows back to reversing valve 84 through either pipe 88 or pipes 72 and 94, and then through pipe 86 to the reservoir 18.

Upon completion of the washing step, valve 116 is opened to by-pass oil from pump 64 back to the reservoir and the drum stops rotating. Solvent is removed from the drum 24 and casing 18 through pipes 56 and 60. When drainage is complete valves 80 and 116 are closed and the reversing valve 84 adjusted to supply oil to pipes 94 and 72. Thereupon oil is supplied from pump 64 to motor 12 only. Since the pressure relief valve 106 has been set to the relatively high pressure of 1500 lbs. per square inch, the available torque is sufficient to start rotation of the drum 24 and the drum starts to rotate. The capacity of the pump 64 is so selected that the volume of oil pumped thereby is just sufficient to rotate drum 24 at the critical speed and thus the drum will be accelerated to and maintained at the critical speed until some further adjustment is made.

When the drum attains the critical speed, the valve 114 is closed and valve 120 opened. Thereupon the pressure of the oil supply to the motor 12 is determined by the

5

setting of pressure relief valve 100 which as previously described is set at a value lower than that of pressure relief valve 106 namely, about 1000 lbs. per square inch. This latter pressure is selected as the pressure that is just sufficient to supply the torque necessary to rotate drum 24 at its critical speed. However, since both pumps are now connected to the motor 12, the volume of oil available is considerably more than enough to rotate the drum at the critical speed if the torque demand decreases.

It has been previously pointed out that when a momentary balanced condition occurs within drum 24, the torque demand drops rapidly and hence when this balanced condition occurs, the drum automatically accelerates beyond the critical speed and "freezes" the goods in their balanced condition within the drum. The drum will then continue accelerating until the volumetric capacity of both pumps 62 and 64 is attained.

Once the drum has accelerated past the critical speed and the balanced condition of the goods is "frozen" the drum may be accelerated as rapidly as desired to centrifuging speed. In order to increase the rate of acceleration during this period and thus save time, the setting of pressure relief valve 100 may be increased, if desired, to increase the torque available for accelerating drum 24.

Upon completion of the centrifuging step, valves 114 and 116 are opened and valve 96 gradually closed to decelerate the drum to a rest position. Valve 96 is then opened again and the casing 18 evacuated in preparation for the drying step. When the casing has been evacuated to the desired extent, valve 116 is closed to cause the pump 64 to supply oil to motor 12 and as before the drum 24 is accelerated to and maintained at the critical speed. This critical speed is maintained throughout the drying operation in order to secure distribution of the goods through the cross-section of the drum and thereby provide effective contact between the steam and goods for evaporation of the solvent therefrom.

It has been found that by carrying out the centrifuging step as described above, vibration of the drum 24, due to unbalance, is substantially eliminated. The described method of operation presents the very important advantage that the balanced condition of the goods is automatically achieved within drum 24. The driving conditions established are such that the drum 24 cannot accelerate until this balanced condition is achieved and therefore there is complete certainty that the balanced condition will be achieved within the drum.

It is of course to be understood that the foregoing description is illustrative and that numerous modifications may be made within the scope of the invention. The hydraulic system described above has been found to be a particularly convenient way of securing the torque limitation required to maintain the drum rotating at its critical speed until the desired balanced condition has been achieved therein. However, other methods of torque limitations might be used. Also, although the present method has been described in connection with a dry cleaning operation, it is apparent that the method may be used equally well for centrifugal removal of liquids from goods in laundering and other like operations.

Since many embodiments might be made of the present invention and since many changes might be made in the embodiment disclosed herein, it is to be understood that the foregoing description is to be interpreted as illustrative only and not in a limiting sense.

What is claimed is:

1. The method of distributing goods substantially uniformly around the inner surface of the rotating drum of a horizontal extractor to produce a weight-balanced loading of said drum and thereby eliminate vibration of said extractor at high speed which comprises applying to said drum a constant rotating torque to rotate said drum at a critical speed whereat the goods in said drum are distributed throughout the cross-section of said drum, the magnitude of said constant torque being just sufficient to maintain said drum at said critical speed while said goods are in a weight-unbalanced condition, whereby when a momentary weight-balanced condition is established within said drum, the drum automatically accelerates to "freeze" the balanced state of the goods, and thereafter increasing the rotating torque applied to said drum to accelerate said drum rapidly to a centrifuging speed.

2. The method of distributing goods substantially uniformly around the inner surface of the rotating drum of a horizontal extractor driven by a hydraulic-fluid-operated

6

positive displacement motor to produce a weight-balanced loading of said drum and thereby eliminate vibration of said extractor at high speed, which comprises supplying hydraulic fluid to said motor to accelerate said drum from rest to a critical speed whereat the goods in said drum are distributed throughout the cross-section of said drum, and limiting the pressure of the supply of hydraulic fluid to the minimum value necessary to maintain said drum at said critical speed for a period of time sufficient to cause said goods to become substantially uniformly distributed, in terms of weight, around said drum, whereby when said goods become uniformly distributed around said drum, said drum will automatically accelerate to an extracting speed.

3. The method of distributing goods substantially uniformly around the inner surface of the rotating drum of a horizontal extractor driven by a hydraulic-fluid-operated, positive displacement motor to produce a weight-balanced loading of said drum and thereby eliminate vibration of said extractor at high speed, which comprises supplying hydraulic fluid to said motor to accelerate said drum from rest to a critical speed whereat said goods are distributed throughout the cross-section of said drum, limiting the pressure of said hydraulic fluid to the minimum value necessary to maintain said drum at said critical speed for a period of time sufficient to cause said goods to become substantially uniformly distributed, in terms of weight, around said drum, and thereafter increasing pressure of said hydraulic fluid supplied to said motor to accelerate said drum rapidly to an extracting speed.

4. The method of distributing goods substantially uniformly around the inner surface of the rotating drum of a horizontal extractor driven by a hydraulic-fluid-operated, positive displacement motor to eliminate vibration of said extractor at high speed, which comprises supplying hydraulic fluid to said motor to accelerate said drum from rest to a critical speed of about $54R^{-1/2}$ revolutions per minute, where R equals the radius of the drum in feet, until the drum has attained said critical speed; and thereafter limiting the pressure of said hydraulic fluid supply to the minimum value necessary to maintain said critical speed for a period of time sufficient to cause said goods to become substantially uniformly distributed, in terms of weight, around said drum, whereby when said goods become uniformly distributed said drum will automatically accelerate to an extracting speed.

5. The method of distributing goods substantially uniformly around the inner surface of the rotating drum of a horizontal extractor driven by a hydraulic-fluid-operated, positive displacement motor to eliminate vibration of said extractor at high speed, which comprises supplying hydraulic fluid to said motor at a pressure which would be sufficient to drive said rotating drum at high speed, while at the same time limiting the flow of hydraulic fluid to a maximum volume rate that will cause the drum to attain a relatively low critical speed whereat said goods are distributed throughout the cross-section of said drum, until the drum has attained said critical speed; and thereafter substantially increasing the available supply of hydraulic fluid to said motor while at the same time limiting the pressure of said fluid supply to the minimum value necessary to maintain said critical speed, for a period of time sufficient to cause said goods to become substantially uniformly distributed, in terms of weight, around said drum, whereby when said goods become uniformly distributed, said drum will automatically accelerate to an extracting speed.

6. The method of distributing goods substantially uniformly around the inner surface of the rotating drum of a horizontal extractor driven by a hydraulic-fluid-operated, positive displacement motor to eliminate vibration of said extractor at high speed, which comprises supplying hydraulic fluid to said motor at a pressure which would be sufficient to drive said rotating drum at high speed, while at the same time limiting the flow of hydraulic fluid to a maximum volume rate that will cause the drum to attain a relatively low critical speed whereat said goods are distributed throughout the cross-section of said drum, until the drum has attained said critical speed; then substantially increasing the available supply of hydraulic fluid to said motor, while at the same time limiting the pressure of said fluid supply to the minimum value necessary to maintain said critical speed, for a period of time sufficient to cause said goods to become substantially uniformly distributed, in terms of weight, around said drum; and

7

thereafter substantially increasing the pressure of said hydraulic fluid supply to cause said drum to accelerate rapidly to an extracting speed.

7. The method of distributing goods substantially uniformly around the inner surface of the rotating drum of a horizontal extractor driven by a hydraulic-fluid-operated, positive displacement motor to eliminate vibration of said extractor at high speed, which comprises supplying hydraulic fluid to said motor at a pressure which would be sufficient to drive said rotating drum at high speed, while at the same time limiting the flow of hydraulic fluid to a maximum volume rate that will cause the drum to attain a relatively low critical speed of about $54R^{-1/2}$ revolutions per minute, where R equals the radius of the drum in feet, until the drum has attained said critical speed; and thereafter substantially increasing the available supply of hydraulic fluid to said motor while at the same time limiting the pressure of said fluid supply to the minimum value necessary to maintain said critical speed, for a period of time sufficient to cause said goods to become substantially uniformly distributed, in terms of weight, around said drum, whereby when said goods become uniformly distributed, said drum will automatically accelerate to an extracting speed.

8. The method of distributing goods substantially uniformly around the inner surface of the rotating drum of a horizontal extractor driven by a hydraulic-fluid-operated, positive displacement motor to eliminate vibration of said extractor at high speed, which comprises supplying hydraulic fluid to said motor at a pressure which would be sufficient to drive said rotating drum at high speed while at the same time limiting the flow of hydraulic fluid to a maximum volume rate that will cause the drum to attain a critical speed of about $54R^{-1/2}$ revolutions per minute, where R equals the radius of the drum in feet, until the drum has attained said critical speed; then substantially increasing the available supply of hydraulic fluid to said motor while at the same time limiting

8

the pressure of said fluid supply to the minimum value necessary to maintain said critical speed, for a period of time sufficient to cause said goods to become substantially uniformly distributed, in terms of weight, around said drum; and thereafter substantially increasing the pressure of said hydraulic fluid supply to cause said drum to accelerate rapidly to an extracting speed.

9. The method of distributing goods substantially uniformly around the inner surface of a rotating drum of a horizontal extractor to produce a weight-balanced loading of said drum and thereby eliminate vibration of said extractor at high speed which comprises applying to said drum a constant rotating torque to rotate said drum at a critical speed whereas the goods in said drum are distributed throughout the cross-section of said drum, the magnitude of said constant torque being just sufficient to maintain said drum at said critical speed while said goods are in a weight-unbalanced condition, whereby when a momentary weight-balanced condition is established within said drum the drum automatically accelerates to "freeze" the balanced state of the goods.

References Cited in the file of this patent

UNITED STATES PATENTS

Number	Name	Date
1,902,972	Ronse	Mar. 28, 1933
2,296,258	Breckenridge	Sept. 22, 1942
2,311,545	Hurley et al.	Feb. 16, 1943
2,311,924	Bassett	Feb. 23, 1943
2,380,595	Hertrich	July 31, 1945
2,513,844	Castner	July 4, 1950
2,513,845	Castner	July 4, 1950
2,517,452	Stindt	Aug. 1, 1950
2,528,594	Kahn	Nov. 7, 1950
2,530,822	Kahn	Nov. 21, 1950
2,540,168	Kahn	Feb. 6, 1951
2,582,810	Wilcox	Jan. 15, 1952