June 21, 1966 W. SIEPE ETAL 3,256,993

CENTRIFUGE

Filed Oct. 17, 1963 3 Sheets-Sheet 1

Fig.1

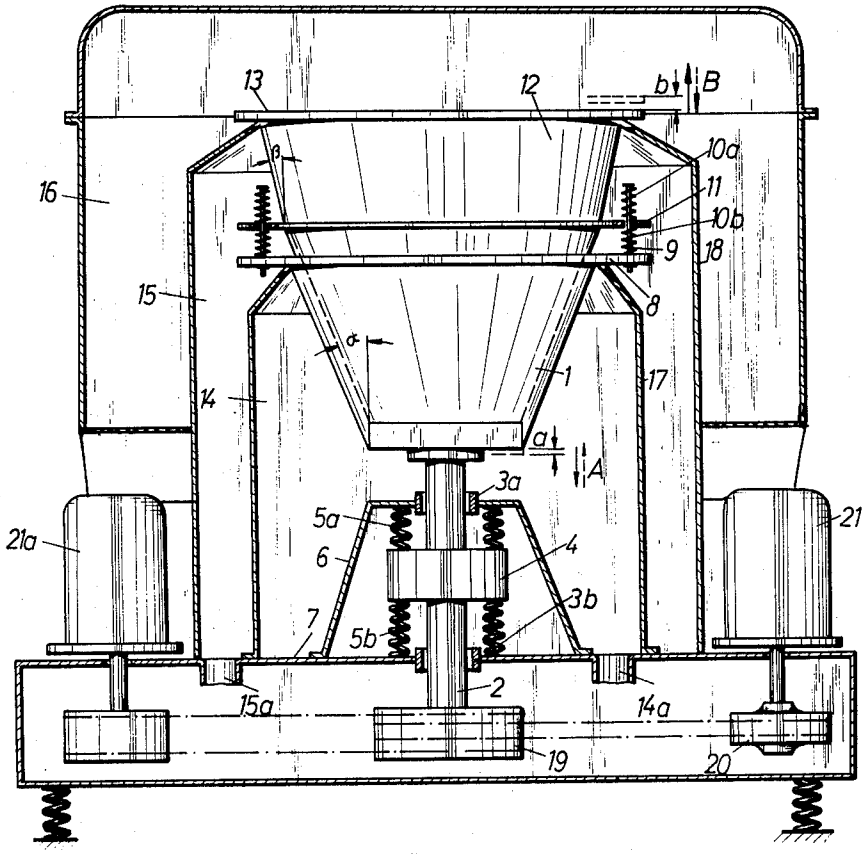
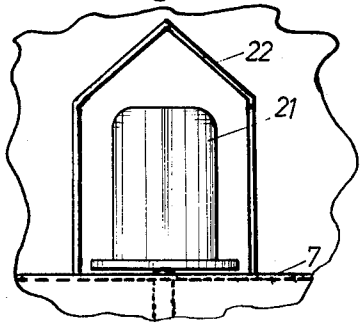


Fig.2



INVENTORS:
W. Siepe and H. Schmidt
BY
Richards & Geier
ATTORNEYS

June 21, 1966 W. SIEPE ETAL 3,256,993

CENTRIFUGE

Filed Oct. 17, 1963 3 Sheets-Sheet 2

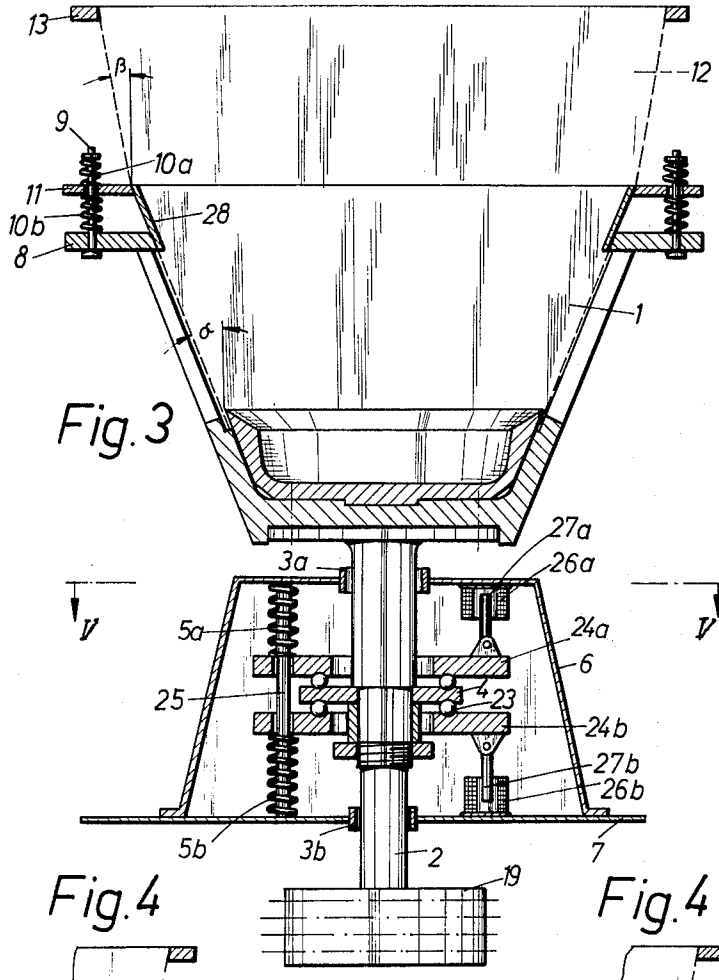


Fig. 3

Fig. 4

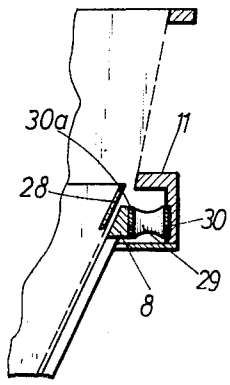
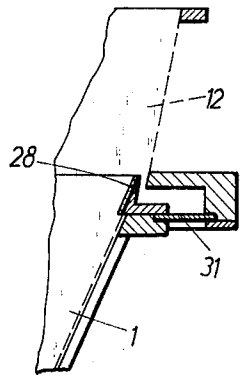


Fig. 4a



INVENTORS:
W. Siepe and H. Schmidt
BY

ATTORNEYS

June 21, 1966 W. SIEPE ETAL 3,256,993

CENTRIFUGE

Filed Oct. 17, 1963 3 Sheets-Sheet 3

Fig. 5

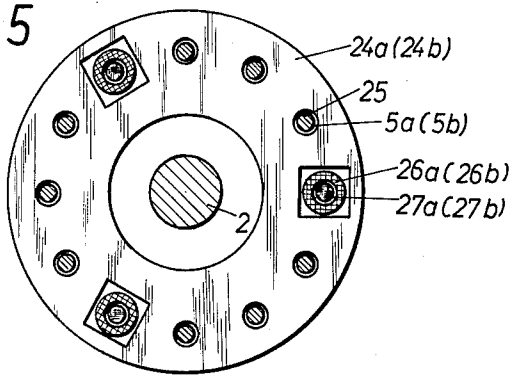


Fig. 6

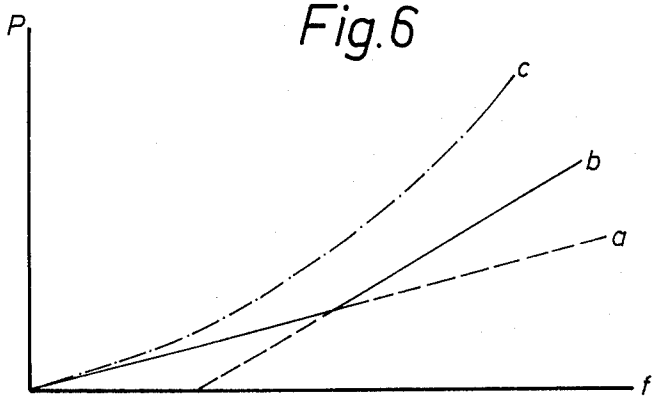
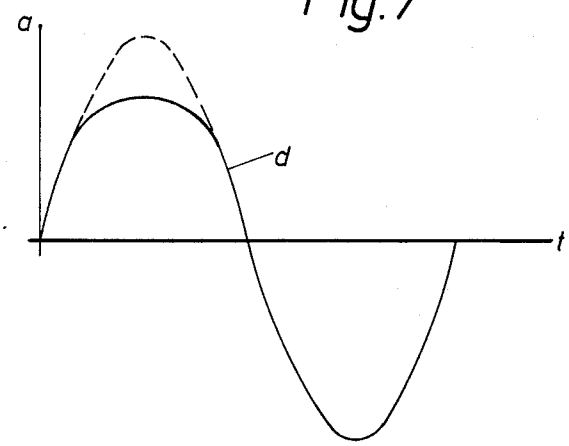


Fig. 7



INVENTORS:
W. Siepe and H. Schmidt
BY
Richards & Geier
ATTORNEYS

United States Patent Office 3,256,993 Patented June 21, 1966

3,256,993

CENTRIFUGE

Werner Siepe, Dusseldorf, and Heinrich Schmidt, Dusseldorf-Oberkassel, Germany, assignors to Hein Lehmann & Co., A.G., Dusseldorf, Germany, a corporation of Germany

Filed Oct. 17, 1963, Ser. No. 316,929
10 Claims. (Cl. 210—370)

This invention relates to a centrifuge and refers more particularly to a centrifuge with counter-oscillating drums.

Recent developments in the construction of centrifugal machines have the tendency to discontinue the application of centrifugal forces upon thick layers of the material to be centrifuged, but on the contrary endeavor to maintain a layer of small thickness. Such constructions, however, have substantial drawbacks, particularly if the material being centrifuged is of a sensitive nature. By way of example, when the so-called thin layer continuously operated centrifuges are used for centrifuging viscous masses, particularly masses of highly viscous sugar, the result is that the outer surfaces of the sugar crystals are detrimentally affected by polishing operations produced by machines which must necessarily operate with highly accelerated parts, or the crystals may be broken altogether. However, only centrifuges of the continuously operated type can be used and only with thin layers in this highly important technical field of treatment of highly viscous sugar masses. So far, despite numerous attempts it was not found possible to eliminate various drawbacks of centrifuges of the so-called thin layer constructions.

On the other hand, the use of constructions of opposite nature, namely, of constructions which operate at least partly with layers of substantial thickness, also has its drawbacks, particularly since such centrifuges either involve high constructional costs or have to operate discontinuously. Discontinuous operation, however, requires substantial constructional problems, particularly as far as the electrical part of the apparatus is concerned.

Attempts to combine the advantages of thin layer and thick layer constructions so far were not successful, despite numerous suggestions involving the use of rings, cascade elements, resilient means and packing locks. All such constructions were found to be impractical.

Prior art constructions are known, wherein centrifugal drums were operated in such manner that an axial oscillating movement was superposed upon the usual rotary movement. In that case the rotary movement takes over to a smaller or larger extent the actual centrifugal operation but contributes only to a smaller extent to the transporting operation, while the superposed axial oscillating movement provides for the transportation of the material being centrifuged to the discharge. In the course of these movements so-called layer-changing processes set in automatically and they are quite advantageous for the centrifuging operations.

Other centrifuges are known in the art which are provided with sieve drums carrying out axial oscillating movements, while the drum shell directly connected with these sieve drums is not movable axially and thus does not participate in the oscillating movements. However, these constructions and their operation have merely the purpose of reducing detrimental oscillations as much as possible.

Another prior art centrifuge uses a non-perforated drum as a counter oscillating mass relatively to the actual sieve drum; however, this non-perforated drum has no technical function besides guiding the flow of the liquid phase. The shaft of these drums is axially fixed in its bearing casing and the casing itself is oscillatably supported. Axial oscillatory movements are possible only by this special arrangement.

An object of the persent invention is the provision of a centrifuge which will eliminate the drawbacks of prior art constructions.

Another object is the provision of a centrifuge which actually combines the advantages of both the thin-layer and thick layer constructions without having the disadvantages of these constructions.

A further object is to provide a centrifuge which will operate continuously, so that it will be considerably simpler in construction and less expensive in operation than discontinuous as well as automatically discontinuous centrifuges, and which at the same time can be used with thick layers of material being centrifuged, such as highly viscous sugar masses.

Other objects of the present invention will become apparent in the course of the following specification.

The present invention is based in part on the realization that the time period during which the material remains in the centrifugal field is of great importance. A time period which is too long cannot be used, unless the constructor is prepared to accept all the drawbacks of a discontinuous operation; thus the problem of the time element is always related to the problem of transporting the material being centrifuged over the centrifuge drum.

The objects of the present invention are realized, according to one embodiment thereof, through the provision of an oscillating centrifuge having a sieve drum device having surfaces extending outwardly in the direction of the discharge and consisting of two sieve drums which are mounted one behind the other in the axial direction and which have different angles of inclination to the drum axis, the two drums being connected by resilient or elastic members so that they can oscillate relatively to each other.

The invention will appear more clearly from the following detailed description when taken in connection with the accompanying drawings showing by way of example only, preferred embodiments of the inventive idea.

In the drawings:

FIGURE 1 is a vertical section through a centrifuge constructed in accordance with the present invention and provided with coaxially disposed frusto-conical centrifugal drums.

FIGURE 2 is a detail side view, illustrating a driving motor.

FIGURE 3 is a different longitudinal section showing on a larger scale the centrifugal drums, their supports and their drive.

FIGURE 4 is a detail sectional view, partly in side elevation, and shows a different construction of the elastic coupling members.

FIGURE 4*a* is similar to FIG. 4 but shows yet another construction of the coupling members.

FIGURE 5 is a transverse section along the line V—V of FIG. 3.

FIGURE 6 is a diagram showing characteristic spring curves.

FIGURE 7 is a diagram showing the oscillation of the centrifugal drum as a time-distance curve.

The general structure of a centrifuge constituting one embodiment of the present invention is shown, by way of example, in FIG. 1. The centrifuge comprises a sieve drum device consisting of two frusto-conical drums **1** and **12** which extend outwardly in the direction of the discharge passage. The lower centrifugal drum **1** is flanged upon a shaft **2**. The shaft **2** is supported in bearings **3***a* and **3***b* and carries a rotary flange **4**. The flange **4** is indicated diagrammatically in FIG. 1 and is shown in detail in section in FIG. 3.

As illustrated in FIG. 3, the flange **4** is connected by axial bearings **23** and clamping rings **24***a* and **24***b* with a series of springs **5***a* and **5***b* which are mounted on pins **25** and which serve as a support for the flange **4** relatively to the base plate **7** and to the casing **6** enclosing this part of the drive. The centrally guided coiled springs **5***a* and **5***b* maintain the entire sieve drum device consisting of the drums **1** and **12**, at a predetermined height and they make possible the oscillating movements of the sieve drums which constitute an important feature of the present invention.

The sieve drum **1** has the conically enlarged end carrying a flange **8**. The flange **8** carries guiding pins **9** extending through a flange **11** and enclosed by series of springs **10***a* and **10***b*. A transfer ring **28** is provided between the flanges **8** and **11**. The flange **11** is carried by the second sieve drum **12** so that said pins and springs provide an elastic connection between the first sieve drum **1** and the second sieve drum **12**, namely, the two drums rotate jointly through the provision of pins **9** while they can oscillate axially relatively to each other through the provision of the springs **10***a* and **10***b*. This coupling device is of great importance for the proper operation of the centrifuge since its elements are doubly strained, first by the centrifugal force and then by the force of vertical oscillations which is superposed thereon. The second sieve drum **12** also has an upper flange, namely, the flange **13**.

As shown in FIG. 1, a suitably shaped inner wall **17** separates a chamber **14** adapted to be filled with a liquid containing mass from a chamber **15** which is also to be filled with a liquid-containing mass. A similar wall **18** separates the chamber **15** from a chamber **16** for solid particles. The base plate **7** is connected with outflow pipes **14***a* and **15***a* for withdrawing the ejected liquids from the chambers **14** and **15**, respectively.

The shaft **2** is rotated along with a pulley **19** which is driven by a belt drive actuated by pulleys **20** which are driven by motors **21**, **21***a*. As best shown in FIG. 2, the motor **21** may be located in a protective casing **22** constituting a niche-like structure forming a break in the wall enclosing the chamber **16**.

As illustrated in FIG. 3, the axial swinging movements of the drums take place by magnetic means comprising electromagnets **26***a* carried by the casing **6** and electromagnets **26***b* carried by the base plate **7**. The armatures **27***a* of the electromagnets **26***a* are carried by the ring **24***a* while the armatures **27***b* of electromagnets **26***b* are carried by the ring **24***b*. FIGURE 5 illustrates the symmetrical radial arrangement of electromagnets and springs **5***a* and **5***b*, with their guiding pins **25**. Current is supplied to the electromagnets by any suitable means which are not illustrated.

Obviously, this electromagnetic drive can be conveniently replaced by other suitable means, such as a purely mechanical drive, an electromechanical drive, a purely electrical drive or by pneumatic or hydraulic means.

As a rule, the angle of inclination α of the drum **1** is greater than the angle of inclination β of the drum **12**.

However, if the drums are subjected to a non-sinusoidal vertical oscillation, the angle of inclination β of the drum **12** may be reduced and can be even made equal to zero, so that then the drum **12** will have a cylindrical shape.

In operation, the rotary movement is provided by the motors **21**, **21***a* through the drive **20**, **19** while the oscillating movement is imparted by the electromagnets **26***a*, **26***b*. The supply of current to the windings of the electromagnets is so regulated that the drums carry out oscillations of a predetermined type, usually sinus-shaped oscillations.

The oscillatory system of the two drums is so set that their axial natural frequency is close to the excitation frequency supplied to the drum **1** or the shaft **2**.

Oscillation amplitudes of drums **1** and **12** are indicated as *a* and *b* in FIG. 1 and according to the laws of oscillation mechanics their ratio to each other in the first approximation is inversely proportional to the weight of the drums. Therefore, by suitably selecting the weight ratio it is possible to provide the desired ratio *a*:*b* of the amplitudes of the drums **1** and **12**. Arrows A and B show by full and broken lines the opposite directions of the oscillatory movement.

The amount of the amplitudes is determined by the strength of the oscillatory excitation, syntonization between excitation frequency and location of the natural frequency point of the system, as well as damping properties of the elastic coupling.

The speed with which a predetermined material to be centrifuged is transported is determined by the amplitude, the oscillation frequency, the angles of inclinations of the outer surfaces of the drums and their roughness. The two drums always have the same frequency of oscillation. By suitably selecting the amplitudes and the angles of inclination it is possible to provide different speeds of transportation and thus to predetermine the time periods during which the material to be centrifuged remains in the two drums. By varying the excitation frequency and the strength of excitation it is possible, during operation, to adapt the time periods during which the material remains in the drums to the specific composition of the material.

In accordance with the present invention, the different oscillation properties of the two elastically interconnected drums having different angles of inclination are utilized to produce the desired transportation and centrifuging effects.

The material to be centrifuged is supplied to the lower drum **1**, so that in operation the lower drum always contains a substantial amount of material which should pass through the sieve openings of the drum. This material is usually a mixture of solid particles and a liquid and, as a rule, it slides better and can be more easily transported than a centrifuged material which has been separated from the liquid phase to a very great extent.

After the completion of the first centrifuging step in the sieve drum **1**, the material being centrifuged travels via the transfer ring **28** into the second drum **12** wherein it finds other conditions suitable for the desired centrifugal operations, as far as the oscillations and the angle of inclination β are concerned, whereby the angle of inclination has a permanent effect upon the transportation of the material. By suitably selecting the angle of inclination β and by suitably selecting a different oscillation for the drum **12**, according to the present invention, the speed of transportation of the material and thus the time period during which it remains in the second drum **12**, can be varied within wide limits. It should be noted that this is the part of the operation which determines the quality of the material which has been centrifuged.

An important feature of the centrifuging of the present invention is that it can operate continuously and with a thick layer of material, preferably in the drum **12**.

While the centrifuge can be used with a very large variety of different materials, it is particularly suitable for the treatment of highly viscous sugar masses.

The diagram of FIG. 6 shows characteristic spring curves of the elastic elements interconnecting the two drums, whereby curves *a* and *b* have straight line characterisitcs. Curves *a* and *b* have full line portions representing a progressive characteristic which makes possible a particularly advantageous operation of the sieve drum device, since it makes it possible to attain non-sinuous oscillations of the sieve drums. The curve *c* also has a continuous progression which provides a distortion of the purely sinus-shaped oscillations. Thus pointed acceleration ends are produced which are particularly advantageous for the transportation of the material being centrifuged. In FIG. 7 the full line *d* illustrates in a simplified form the shape of a typical course of oscillations of this nature, small frequency changes having been omitted.

When these oscillations are used, particularly for the upper drum **12**, the second centrifuging step results in secure transportation, without any flaws, of the centrifuged material which in the meantime, has become substantially heavier, toward the outflow.

In accordance with the present invention this flawless transportation of the material is obtained even when the angle β approaches zero.

It is apparent from the above description that the selection of means elastically connecting the two drums is of paramount importance. While the connection consisting of pins **9** and springs **10***a* and **10***b* shown in FIGS. 1 and 2, was found to be satisfactory, it can be replaced by other suitable means.

For example, plate spring posts are also suitable due to their compact construction and sturdiness.

In accordance with the embodiment shown in FIG. 4, connection between the two drums is provided by combined rubber-metal means comprising a closed elastic ring **29** consisting of a resilient material, such as rubber. The ring **29** is firmly connected with metal rings **30** and **30***a* which provide a connection between the ring **29** and the flanges **8** and **11** of the drums **1** and **12**. The ring **29** also provides a completely tight connection between the two drums.

These rings, instead of being closed annular bodies, may consist of separate parts which are symmetrically mounted around the drum circumference.

In accordance with the embodiment shown in FIG. 4*a*, the rubber ring is replaced by a resilient metal ring **31** which is firmly fixed at one end to the upper flange **8** of the drum **1** and at the other end to the lower flange **11** of the drum **12**. The metal ring **31** also provides a completely tight connection between the two drums.

The centrifuge of the present invention has the advantage that it can operate continuously with thick layers of the material to be centrifuged, such as highly viscous sugar masses. It delivers an end product of the finest quality; furthermore, the amount of material processed by the centrifuge is greater than could be obtained heretofore, even by the use of discontinuously operating machines. This large output is the direct result of the construction of the present invention which makes it possible to carry out a completely satisfactory centrifuging operation with thick layers of the material to be centrifuged.

It is apparent that the examples shown above have been given solely by way of illustration and not by way of limitation and that they are capable of many variations and modifications within the scope of the present invention. All such variations and modifications are to be included within the scope of the present invention.

What is claimed is:

1. A centrifuge, comprising a casing, said casing comprising means constituting a discharge passage; a first sieve drum, a second sieve drum, means supporting said drums axially one behind the other, at least said first sieve drum being frustoconical in shape and extending outwardly in the direction of said discharge passage, means elastically interconnecting said drums, means oscillating said drums substantially axially relatively to each other, and means rotating said drums jointly.

2. A centrifuge, comprising a casing, said casing comprising means constituing a discharge passage; a first sieve drum, a second sieve drum, means supporting said drums axially one behind the other, said drums being frustoconical in shape and having different angles of inclination to the central axis, the surfaces of said drums extending outwardly in the direction of said discharge passage, means elastically interconnecting said drums, means oscillating said drums substantially axially relatively to each other, and means rotating said drums jointly.

3. A centrifuge in accordance with claim **2**, wherein the angle of inclination of the first drum is greater than the angle of inclination of the second drum.

4. A centrifuge in accordance with claim **2**, wherein the means oscillating the drums impart sinus-shaped oscillations to at least one of said drums.

5. A centrifuge in accordance with claim **2**, wherein the means oscillating the drums impart distorted sinus-shaped oscillations to at least one of said drums.

6. A centrifuge in accordance with claim **2**, wherein the means rotating said drums jointly comprise a plurality of similar motors disposed symmetrically relatively to said casing.

7. A centrifuge, comprising a vertical shaft, a frusto-conical upwardly outwardly extending first drum coaxially carried by the upper end of the said shaft, a pulley carried by the lower end of said shaft, a flange carried by said shaft intermediate said drum and said pulley, a first ring located above said flange, a second ring located below said flange, bearings connecting said flange with said first ring and said second ring, a base plate, a casing carried by said base plate, said shaft extending through said base plate and said casing, first springs engaging the first ring and said casing, second springs engaging the second ring and said base plate, means connected with said rings for imparting oscillatory movements to said rings, whereby said oscillatory movements are transmitted to said first drum through said flange and said shaft, a frusto-conical upwardly outwardly extending second drum located above the first drum and coaxial therewith, the angle of inclination of the first drum being greater than the angle of inclination of the second drum, a flange carried by the upper end of the first drum, a flange carried by the second drum adjacent the lower end thereof, means elastically interconnecting the two last-mentioned flanges, a transfer ring between the two last-mentioned flanges, a second casing enclosing the first drum and carried by said base plate, said base plate having an outlet communicating with the space between the two casings, a third casing enclosing the second drum, said transfer ring and said flange-interconnecting means, said third casing being carried by said base plate, said base plate having an outlet communicating with the space between the second and third casings, a fourth casing enclosing the third casing, a plurality of motors symmetrically disposed in recesses formed in said fourth casing, and a drive operatively connecting said motors with said pulley.

8. A centrifuge according to claim **7**, wherein said means elastically interconnecting the two flanges comprise pins carried by one of the flanges and extending through and beyond openings formed in the other flange, and third springs enclosing said pins, some of the third springs being located between the two flanges, other of said third springs having one of their ends engaging one of the flanges and the other of their ends connected with the pins.

9. A centrifuge according to claim **7**, wherein said means elastically interconnecting the two flanges comprise a rubber ring and two metal rings connected with the rubber ring, one of the metal rings being connected to one flange while the other metal ring is connected to the other flange.

10. A centrifuge according to claim **7**, wherein said means elastically interconnecting the two flanges comprise a resilient metal ring having one end connected to one flange and another end connected to the other flange.

References Cited by the Examiner

UNITED STATES PATENTS

1,057,856	4/1913	Le Blanc et al.	210—380 X
1,963,476	6/1934	Smith	210—380 X
2,312,829	3/1943	Bird et al.	210—380 X
2,883,054	4/1959	Sanchez	210—380 X
2,964,193	12/1960	Heckmann	210—370
3,133,879	5/1964	Becker et al.	210—380 X

RUEBEN FRIEDMAN, *Primary Examiner.*

J. DE CESARE, *Assistant Examiner.*