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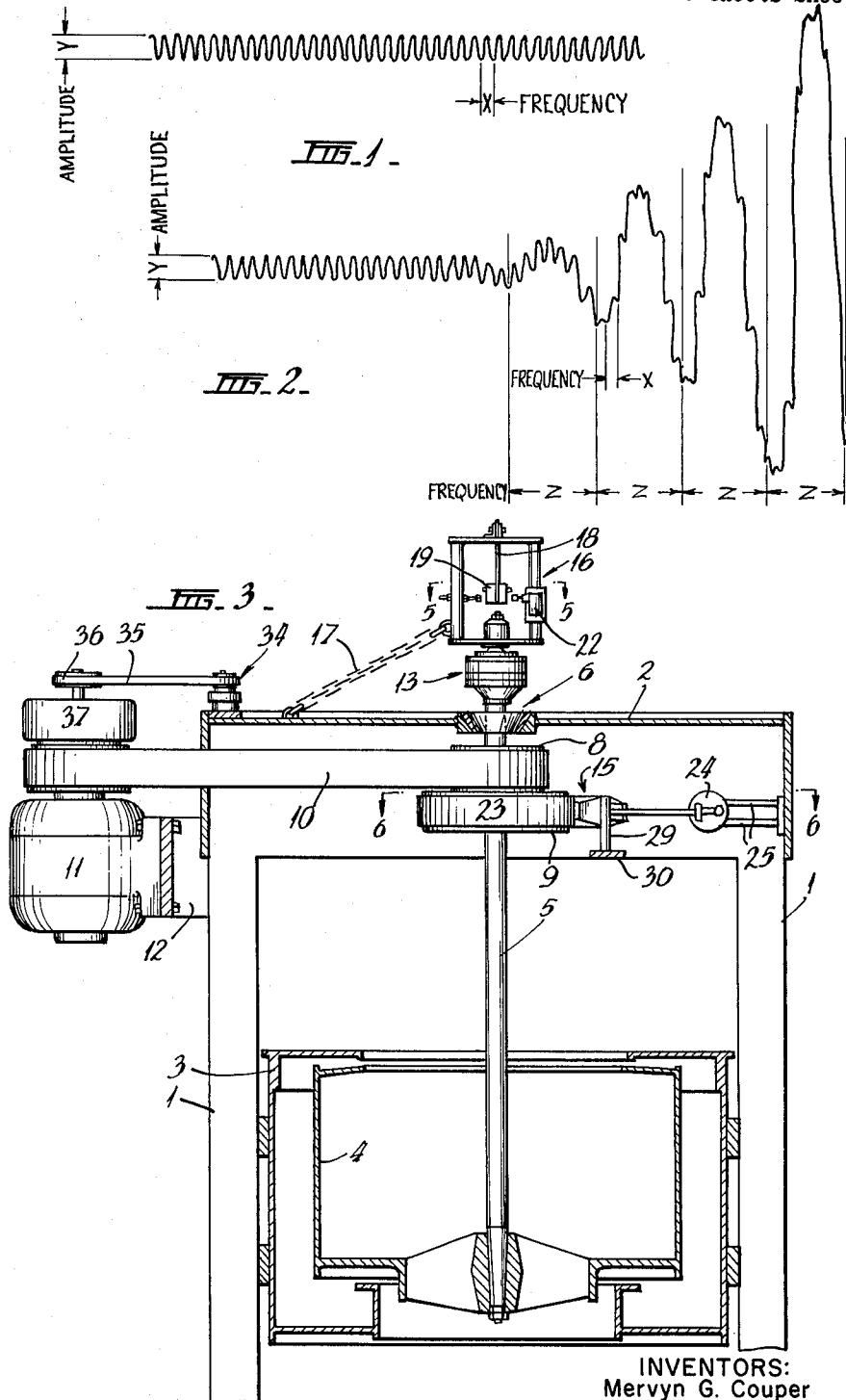
M. G. COUPER ETAL

3,226,016

INDUSTRIAL CENTRIFUGES

Filed July 9, 1962

3 Sheets-Sheet 1



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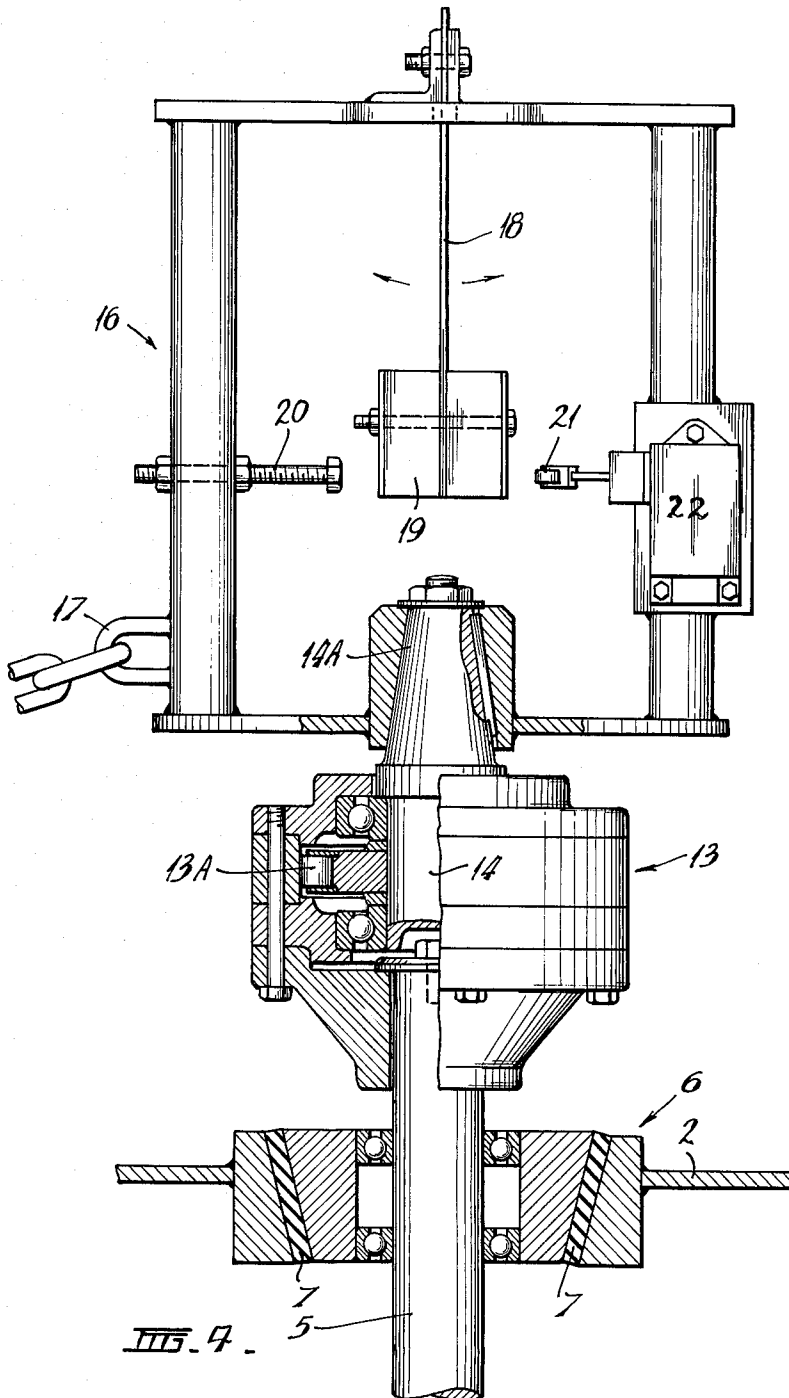
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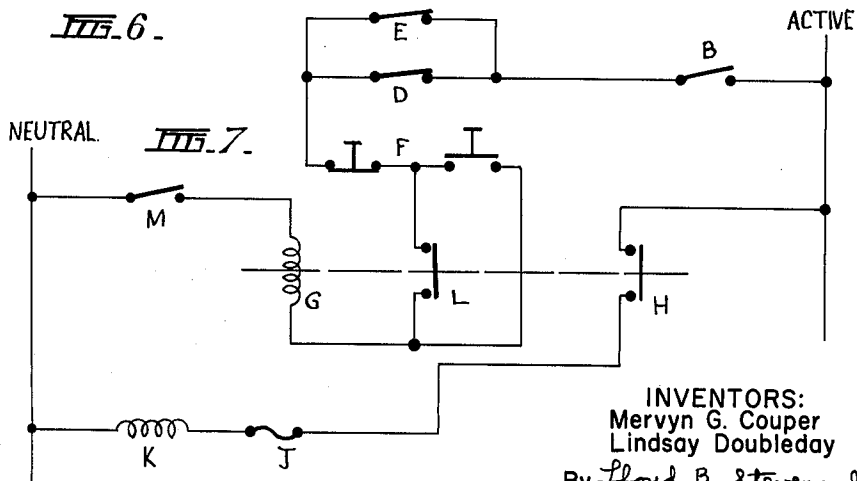
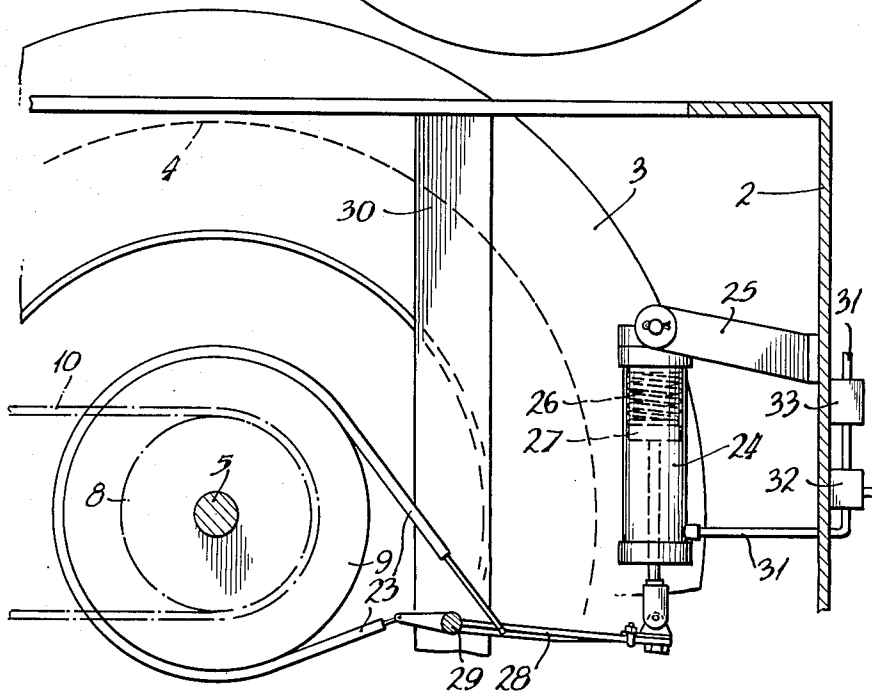
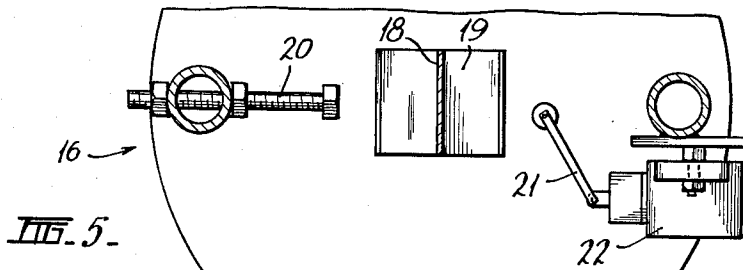
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3 Sheets-Sheet 3



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INDUSTRIAL CENTRIFUGES

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19 Claims. (Cl. 233—23)

This invention relates to industrial centrifuges and provides means for effectively arresting rotation of the centrifuge basket when so-called "out-of-balance" vibration or centrifuge basket imbalance-of-rotation frequency of vibration occurs in the course of loading the centrifuge basket with a slurry of solids. More particularly, the invention relates to centrifuges known as industrial suspended-basket type or batch centrifuges, utilized mainly in the chemical industry for the recovery of solids from aqueous slurries.

Conventional basket or batch centrifuges are invariably mounted with the axis of the centrifuge basket disposed in the vertical plane, and, because of the possibility of uneven loading of the machine, the basket is normally supported by bearings, either above or below the basket, in a frame, so that a certain degree of flexibility in loading of the basket is provided. Centrifuges with the support-bearing above the basket are usually called either "suspended" or "overhung" type centrifuges, and it is to this type of centrifuge, that is to say, industrial suspended-basket type centrifuges, that the present invention applies in particular. Centrifuges of this particular type are constructed in such a way as to remain balanced when they are loaded unevenly with solids. The centrifuge basket is supported by an overhung bearing mounted in rubber to provide flexibility, the basket being free to oscillate about the support bearing, which is a fulcrum. The amount of oscillation is governed by the amount of flexibility in the rubber mounting of the support bearing, the basket rotating about its centre of gravity.

In the operation of centrifuges, particularly the suspended-basket type, vibrations can occur when the centrifuge basket is being loaded with a slurry of solids. These vibrations are of two kinds. The first is when there is an uneven loading of the slurry of solids, in this case the solids in the slurry distributing unevenly around the centrifuge basket with the result that the centrifuge rotates about the centre of gravity of the mass of the centrifuge basket and solids. With this kind of vibration, the frequency corresponds to the centrifuge basket speed of rotation. The amplitude of vibration will depend on the distance the original centre of gravity has been displaced. The displacement of the centre of gravity depends on the mass of solids loaded unevenly. With this type of vibration the amplitude of vibration is constant, and the centrifuge remains stable and balanced. This is shown in FIG. 1 of the accompanying drawings, which graphically illustrates vibration amplitude Y and vibration frequency X as being constant, the frequency X being the natural frequency of vibration of the centrifuge basket and corresponding to the speed of rotation, said natural frequency being measured by manually displacing the centrifuge basket sideways, allowing the basket to oscillate freely, and measuring the frequency of oscillation.

The second kind of vibration, which is essentially one of increasing intensity of amplitude, usually occurs when the centrifuge is being initially charged with a slurry or during washing processes when liquids are being charged on top of a layer of solid particles on so-called "cake." They only occur when the slurries or liquids are charged too quickly or in long bursts. The liquids do not filter out quickly and a layer of liquid is formed

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on top of the cake. This vibration is a secondary vibration and is shown in FIG. 2 of the accompanying drawings, which graphically illustrates the increase in amplitude of vibration amplitude Y, a vibration frequency Z being superimposed on vibration frequency X. The amplitude of vibration is of increasing intensity and violent centrifuge basket imbalance-of-rotation occurs. The supposition is that the second kind of vibration is caused by the layer of liquid on top of the cake in the basket "slipping" and rotating around the basket at a speed slower than the speed of the basket, a series of "waves" being set up which rotate around the basket thereby causing the centre of gravity to shift continually. The centrifuge basket is assumed to endeavour to rotate around the shifting centre of gravity and becomes unbalanced. From measurements made with a suspended-basket type centrifuge, the frequency of the second kind of vibration was found to correspond to the natural frequency of the centrifuge basket and is encountered when the centrifuge basket is rotating up to or down from maximum speed and when the centrifuge basket is in imbalance.

In order effectively to arrest said second kind of vibration, the centrifuge drive motor must be de-energized and the centrifuge brake applied within a second or two of the imbalance-of-rotation vibrations occurring. In examining the problem of effectively arresting such imbalance-of-rotation vibrations it was found by us that vibrational amplitude was ineffective as a sensing medium because the amplitude at which a sensing device based thereon might operate was too great to ensue effective arresting of the imbalance-of-rotation vibrations. An amplitude sensing device set to operate at small enough amplitudes to ensue effective control was found to operate when the centrifuge encountered the first occurrence of vibration.

We have now developed centrifuge basket imbalance-of-rotation arresting or control means for industrial centrifuges, in which a resonant reed device resonant-responsive to centrifuge basket imbalance-of-rotation frequency of vibration is arranged to de-energize the centrifuge electric-drive motor and actuate the centrifuge basket braking mechanism when imbalance-of-rotation vibration is encountered and bring the centrifuge basket to rest. The arrangement conveniently comprises a resonant reed and weight device tuned to the natural frequency of the centrifuge basket and resonant-responsive to centrifuge basket imbalance-of-rotation vibration, said reed and weight device being located to strike and actuate an electrical microswitch in the centrifuge drive motor electrical circuit for de-energizing said motor and actuating the centrifuge basket brake mechanism. When the frequency of vibration of the centrifuge basket corresponding to the natural frequency of vibration of said resonant reed and weight device is encountered in reaching the maximum speed or rotation of said basket, causing incidental resonance of the resonant reed and weight device and which would result in accidental de-energization of the drive motor and actuation of the centrifuge basket brake mechanism, an electrical switch is included in said circuit to restrain de-energization of said motor and allow the centrifuge basket to reach maximum speed. By the application of this invention, centrifuge basket imbalance-of-rotation can be arrested automatically before it becomes dangerous.

Thus, in accordance with this invention, centrifuge basket imbalance-of-rotation arresting means is provided in an industrial centrifuge equipped with an electrical drive motor and a brake for the centrifuge basket, said arresting means comprising a resonant reed device resonant-responsive to centrifuge basket imbalance-of-rotation fre-

quency of vibration, means for de-energizing said electrical drive motor and actuated when said resonant reed device resonates responsive to said centrifuge basket imbalance-of-rotation frequency of vibration, means for actuating said centrifuge basket brake when said resonant reed device resonates responsive to said centrifuge basket imbalance-of-rotation frequency of vibration, and means restraining de-energization of said electrical drive motor and actuation of said centrifuge basket brake when the frequency of vibration of the centrifuge basket corresponding to the natural frequency of vibration of said resonant reed device is encountered in reaching the maximum speed of rotation of said centrifuge basket.

More particularly, the invention provides centrifuge basket imbalance-of-rotation arresting means in an industrial suspended-basket type centrifuge equipped with an electrical drive motor and a brake for the centrifuge basket, said arresting means comprising a resonant reed and weight device resonant-responsive to centrifuge basket imbalance-of-rotation frequency of vibration, drive motor de-energizing means comprising a primary electrical switch in said drive motor electrical circuit and switch actuating mechanism located to be struck by said resonant reed and weight device when said resonant reed and weight device resonates responsive to said centrifuge basket imbalance-of-rotation frequency of vibration, a secondary electrical switch in said electrical circuit for actuating mechanism connected to apply said centrifuge basket brake when said drive motor is de-energized, and an electrical short-circuiting switch in said electrical circuit connected to short-circuit said primary electrical switch means and maintain operative said drive motor until the centrifuge basket passes a speed of rotation corresponding to the natural frequency of vibration of said resonant reed and weight device in reaching the maximum speed of rotation of said centrifuge basket.

Said drive motor de-energizing means preferably comprises a switch actuating member located to be struck by said resonant reed and weight device when said resonant reed and weight device resonates responsive to said centrifuge basket imbalance-of-rotation frequency of vibration, and a primary electrical switch in said drive motor electrical circuit connected for actuation by said switch actuating member; whilst the centrifuge basket brake actuating means preferably comprises a spring-loaded ram urging operation of the brake and fluid pressure constrained from said operation, a solenoid valve operative to admit fluid under pressure from a source of supply to said ram or vent fluid from said ram, and a secondary electrical switch in said drive motor electrical circuit connected to actuate said solenoid valve and vent fluid from said ram when said drive motor is de-energized. In this embodiment of the invention, a fluid-pressure sensitive electrical switch is advantageously interposed between said fluid pressure source of supply and said solenoid valve and connected in said drive motor electrical circuit for short-circuiting said drive motor when said ram has less than a predetermined fluid pressure operative to constrain said centrifuge basket brake actuating means. The provision of said fluid-pressure sensitive electrical switch is a safety measure to ensure that the drive motor is automatically de-energized and not damaged by continued operation and over-heating in the event that the centrifuge basket brake mechanism is accidentally actuated due to a pressure failure in the fluid-pressure source of supply.

The resonant reed and weight device are conveniently mounted on the centrifuge so as to be suspended axially above the basket suspension shaft of a suspended-basket type centrifuge, whilst the spring-loaded ram, the solenoid valve, and the secondary electrical switch are conveniently mounted on the centrifuge frame, the spring-loaded ram being suitably connected to the centrifuge brake mechanism. For this purpose, the assembly of the resonant reed and weight device, the switch actuating

member located to be struck by said resonant reed and weight device, and the primary electrical switch may be embodied in a housing fixed to a stub shaft mounted to freewheel stationarily on the upper end of the basket suspension shaft with the resonant reed and weight device suspended axially above the basket suspension shaft.

In order, however, that the invention may be fully understood, further reference will be made to the accompanying drawings, which illustrate said practical embodiment of the invention, and in which drawings:

FIG. 3 is a front elevational view partially broken away and in section of a suspended-basket type centrifuge equipped with arresting means constructed in accordance with the present invention, for the centrifuge basket when imbalance-of-rotation vibration occurs;

FIG. 4 is an enlarged front elevational view partially broken away and in section of the housing and motor de-energizing means assembly seen in FIG. 3;

FIG. 5 is a cross-sectional plan view taken at lines 5—5 of FIG. 3;

FIG. 6 is a cross-sectional plan view taken at lines 6—6 of FIG. 3; and

FIG. 7 is a diagrammatic view of the centrifuge drive motor electrical circuit and including the electrical switches specified above.

Referring to FIGS. 3 to 6 of the drawings, the suspended-basket type centrifuge illustrated therein is shown to consist of a frame formed by a pair of vertical channel members 1 joined by an overhead beam section 2, a centrifuge-basket casing 3 extending between said vertical channel members 1. Centrifuge basket 4 is suspended in said casing 3 by means of basket-suspension shaft 5 supported in bearing 6 located in overhead beam 2, the bearing 6 having a rubber liner 7 to provide flexibility in the suspension of centrifuge basket 4. Basket-suspension shaft 5 has a drive pulley 8 and a brake drum or pulley 9. Belt driving 10 connects drive pulley 8 with centrifuge drive motor 11 mounted on the centrifuge frame 1 by bracket 12. Basket suspension shaft 5 also has a coupling 13 fixed to the upper end of said shaft, a stub shaft 14 being fitted to freewheel stationarily in the coupling. Said coupling 13 may also have a dog clutch 13A, the dog clutch being operative only when a centrifuge plow (not shown) is employed, in which case a plow drive pulley (not shown) is fixed to frustum portion 14A of stub shaft 14 in lieu of the assembly shown fixed to said frustum, in order to rotate the basket suspension shaft 5 in a direction counterwise to the rotation direction of drive pulley 8, in the plowing the basket load for discharge from the basket. Basket brake mechanism 15 is suitably mounted on overhead beam 2 to co-act with brake drum 9.

Fixed to frustum 14A of stub shaft 14, in accordance with the invention, is a housing structure 16 which advantageously is restrained by chain 17 attached to the housing structure and to overhead beam 2, from gaining rotation momentum through stub shaft 14 freewheeling in coupling 13. Suspended from the top of the housing structure 16 and depending axially above the basket suspension shaft 5 is a spring steel resonant reed 18 having a weight 19 attached to the outer end of said reed. The mass of the reed and weight device is relatively small so that it responds quickly to centrifuge basket imbalance-of-rotation vibration and reaches amplitudes of say two inches in about 1.50 seconds, the weight 19 being chosen so that the reed and weight is tuned for resonance in sympathy with the natural frequency of vibration of the centrifuge basket 4. Limit-stop 20 protrudes from one side of the housing structure 16 to restrict the amplitude of oscillation of the reed and weight device, in order to lessen metal-fatigue rate of the reed. Extending from the other side of said housing structure 16 and located to be struck by said reed and weight device when resonating as indicated, is a switch actuating arm 21 of primary electrical switch or

microswitch 22, said microswitch 22 being included in the centrifuge drive motor electrical circuit for de-energization of said motor. Switch actuating arm 21 is so disposed in the housing structure and set that the reed and weight device is arranged to strike said switch arm within approximately 1.00 seconds of centrifuge basket imbalance-of-rotation vibration occurring.

Brake drum 9 is engaged by basket friction-brake band 23 actuated by the basket brake mechanism 15. Said brake mechanism 15 consists of a fluid-pressure ram cylinder 24 pivotally mounted on supporting bracket 25 attached to the overhead beam 2 of the centrifuge frame and having a compression spring 26 reacting against ram plunger 27, the outer end of said ram plunger being pivotally connected to one end of lever 28 which is attached at the other end to pivot 29 mounted on a transverse member 30 of the centrifuge frame overhead beam 2. The ends of friction-brake band 23 are also attached to lever 28 and pivot 29, outward movement of ram plunger 27 causing said friction-brake band 23 to be tightened about brake drum 9 and exert a braking action on brake drum 9. Compression spring 26 urges braking operation of friction-brake band 23 in reacting against ram plunger 27 but is constrained from such operation by fluid-pressure admitted to ram cylinder 24 by fluid-pressure line 31 serviced from any suitable fluid pressure source of supply (not shown). A supply of air pressure is adequate for the purpose. Solenoid valve 32 is located in fluid-pressure line 31 to admit the supply of fluid pressure to ram cylinder 24 in constraining the compression spring 26 from operation of the brake, or, to vent fluid from said ram cylinder so that said compression spring 26 may effect operation of the brake. The solenoid valve 32 has a secondary electrical switch (not shown in FIGS. 3 to 6 but shown in FIG. 7) in the centrifuge drive motor electrical circuit for actuation to vent fluid pressure from ram cylinder 24 when said drive motor is de-energized. Also imposed in fluid-pressure line 31 and located between said solenoid valve 32 and the fluid pressure source of supply is fluid-pressure sensitive switch 33, which is connected in the centrifuge drive motor electrical circuit for short-circuiting energization of said drive motor when said ram cylinder 24 has less than a predetermined fluid pressure which is operative to constrain said compression spring 26 from actuating the brake.

Centrifuge drive motor 11 is provided with a conventional type of centrifugally operated electrical short-circuiting switch means 34 connected in the electrical circuit of said motor to short-circuit primary electrical switch or microswitch 22 and maintain said motor operative when the centrifuge basket 4 passes a speed of rotation causing vibrations corresponding to the natural frequency of vibration of the reed and weight device, in reaching the maximum speed of rotation of said basket. Switch means 34 is driven by belt-drive 35 from a pulley 36 on centrifuge clutch 37 of drive motor 11. Housing structure 16 may be enclosed by a woven metal gauze to form a cage for the protection of the resonant reed and weight device and incidentally prevent loss of the weight in the event that the spring steel of the resonant reed were to break due to metal fatigue.

FIG. 7 of the drawings shows an electrical circuit diagram suitable for the apparatus of the invention. In the circuit diagram, B represents the fluid-pressure sensitive switch 33 introduced into the circuit to prevent the centrifuge from operation until and unless there is a predetermined fluid or air pressure to operate the brake mechanism. The switch 33 is normally closed if the fluid pressure is sufficient to constrain the compression spring 26 from actuating the brake. The switch 33 will open only if the fluid or air pressure in the ram cylinder 24 is less than that predetermined for the purpose. D represents the electrical short-circuiting switch means 34 and operates to short circuit microswitch 22

and prevent microswitch 22 from denenergizing the centrifuge basket when accelerating through the speed exceeding that corresponding to the reed and weight device natural frequency of vibration. The short-circuiting switch D is normally closed and will not open until the centrifuge basket exceeds such speed. E represents the microswitch 22, which is normally closed and opens only when struck by the reed and weight device. F represents the centrifuge basket drive motor stop-start station switch. G represents the centrifuge basket drive motor relay supplying three phase current to said motor, when closed by pressing the start button of the stop-start station switch. H represents an auxiliary contactor normally open and coupled to the drive motor contactors for closing when the drive motor contactors are closed by pressing the start button. The closing of the auxiliary contactor H will energize the solenoid valve 32. J represents a fuse. K represents the solenoid valve 32 which opens when energized, admitting fluid or air pressure to ram cylinder 24 and constraining the brake from operation or releasing the brake after operation. The solenoid valve is designed to vent the ram cylinder 24 to apply the brake when de-energized, the arrangement being such that when the start button is pressed the solenoid valve is energized thus releasing the brake and allowing the centrifuge to rotate. When the microswitch 22 is actuated or the stop button is pressed the solenoid valve is de-energized thus venting the ram cylinder 24 and causing application of the brake. L represents a hold-in contactor which holds the three phase current and auxiliary contactor after the start button has been released, when the centrifuge basket is in the starting stage. M is a thermal overload to protect the centrifuge drive motor from overheating by so-called "two-phasing" of the three phase current supply.

In operation, when the start button of the stop-start station is pressed to start the centrifuge drive motor 11, current flows from the active lead of the circuit through switch B (which is closed due to sufficient air pressure in ram cylinder 24), through speed switch D (closed due to the centrifuge basket being stationary), through stop-start station, through relay G, through thermal overload switch M to the neutral lead. When relay G is energized it closes contactors L and H and the three phase drive-motor contactors, which start the centrifuge drive motor. With contactor H closed, the current flows from active lead through fuse J, then energizes solenoid valve K which releases the brake, allowing the centrifuge basket to rotate. When the start button is released, contactor L being closed causes the current to by-pass the start button and keep relay G energized thus maintaining the circuit active. As the centrifuge basket speed of rotation passes the critical speed corresponding to the natural frequency of vibration of the reed and weight device, switch D opens, making microswitch E active. In the event of centrifuge basket imbalance-of-rotation vibration occurring, microswitch E is opened by being struck by the reed and weight device thereby breaking the circuit to relay G. With relay G de-energized, contactors L and H open, causing solenoid valve K to be de-energized, whereupon the three phase current is cut from centrifuge drive motor and the brake is applied. When the stop button is pressed the circuit to relay G is broken, the centrifuge motor is de-energized and the brake is applied as in the case of centrifuge basket imbalance-of-rotation vibration.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. An imbalance-of-rotation arresting means for use with an industrial centrifuge equipped with a rotatably mounted centrifuge basket, an electrical drive motor associated with said centrifuge for driving said centrifuge basket, and a brake for retarding the rotational movement

of the centrifuge basket; said imbalance-of-rotation arresting means comprising a resonant reed device operatively associated with said centrifuge and being resonant-responsive to centrifuge basket imbalance-of-rotation frequency of vibration, said resonant reed device being substantially coaxially aligned with the center of rotation of said centrifuge basket, means operatively associated with said resonant reed device and said electrical drive motor for de-energizing said electrical drive motor, said last named means being actuated when said resonant reed device resonates responsive to said centrifuge basket imbalance-of-rotation frequency of vibration, means operatively associated with said resonant reed device and said brake for actuating said centrifuge basket brake when said resonant reed device resonates responsive to said centrifuge basket imbalance-of-rotation frequency of vibration, and means operatively connected to each of said last named means for restraining de-energization of said electrical drive motor and restraining actuation of said centrifuge basket brake when the frequency of vibration of the centrifuge basket corresponding to the natural frequency of vibration of said resonant reed device is encountered in reaching the maximum speed of rotation of said centrifuge basket.

2. An imbalance-of-rotation arresting means for use with an industrial suspended-basket type centrifuge equipped with a suspended centrifuge basket, an electrical drive motor associated with said centrifuge for driving said centrifuge basket, and a brake for retarding the rotational movement of the centrifuge basket; said imbalance-of-rotation arresting means comprising a resonant reed and weight device operatively associated with said centrifuge and being resonant-responsive to centrifuge basket imbalance-of-rotation frequency of vibration, said resonant reed and weight device being substantially coaxially aligned with the center of rotation of said centrifuge basket, means operatively connected to said electrical drive motor and being located to be struck by said resonant reed and weight device and de-energize said electrical drive motor when said resonant reed and weight device resonate responsive to said centrifuge basket imbalance-of-rotation frequency of vibration, means operatively associated with said resonant reed and weight device and said brake for actuating said centrifuge basket brake when said electrical drive motor is de-energized, and means operatively connected to each of said last named means for restraining de-energization of said electrical drive motor and restraining actuation of said centrifuge basket brake when the frequency of vibration of the centrifuge basket corresponding to the natural frequency of vibration of said resonant reed and weight device is encountered in reaching the maximum speed of rotation of said centrifuge basket.

3. An imbalance-of-rotation arresting means for use with an industrial suspended-basket type centrifuge equipped with a suspended centrifuge basket, an electrical drive motor associated with said centrifuge for driving said centrifuge basket, and a brake for retarding the rotational movement of the centrifuge basket; said imbalance-of-rotation arresting means comprising a resonant reed and weight device operatively associated with said centrifuge and being resonant-responsive to centrifuge basket imbalance-of-rotation frequency of vibration, said resonant reed and weight device being substantially coaxially aligned with the center of rotation of said centrifuge basket, drive motor de-energizing means operatively connected to said drive motor and comprising a primary electrical switch and switch actuating mechanism, means for locating said switch actuating mechanism to be struck by said resonant reed and weight device when said resonant reed and weight device resonates responsive to said centrifuge basket imbalance-of-rotation frequency of vibration, a secondary electrical switch operatively associated with said primary electrical switch and brake for actuating said centrifuge basket brake when said drive motor

is de-energized, and an electrical short-circuiting switch operatively connected to short-circuit said primary electrical switch and maintain energization of said drive motor until the centrifuge basket passes a speed of rotation corresponding to the natural frequency of vibration of said resonant reed and weight device in reaching the maximum speed of rotation of said centrifuge basket.

4. An imbalance-of-rotation arresting means for use with an industrial suspended-basket type centrifuge equipped with a suspended centrifuge basket, an electrical drive motor associated with said centrifuge for driving said centrifuge basket, and a brake for retarding the rotational movement of the centrifuge basket; said imbalance-of-rotation arresting means comprising a resonant reed and weight device operatively associated with said centrifuge and being resonant-responsive to centrifuge basket imbalance-of-rotation frequency of vibration drive motor, said resonant reed device being substantially coaxially aligned with the center of rotation of said centrifuge basket, de-energizing means comprising a switch actuating member, means for locating said switch actuating member to be struck by said resonant reed and weight device when said resonant reed and weight device resonates responsive to said centrifuge basket imbalance-of-rotation frequency of vibration, said motor de-energizing means also comprising a primary electrical switch operatively connected to said electrical drive motor and being adapted for actuation by said switch actuating member, centrifuge basket brake actuating means comprising a spring-loaded ram urging application of said brake to restrain movement of said centrifuge basket, means for applying fluid-pressure to said ram to constrain said centrifuge basket brake from operation, a solenoid valve operatively interposed between said ram and means for applying fluid-pressure and being adapted to optionally admit fluid under pressure to said ram or vent fluid from said ram, a secondary electrical switch operatively associated with said ram and being operatively connected to actuate said solenoid valve and vent fluid from said ram when said drive motor is de-energized, and an electrical short-circuiting switch operatively connected to short-circuit said primary electrical switch and maintain energization of said drive motor until the centrifuge basket passes a speed of rotation corresponding to the natural frequency of vibration of said resonant reed and weight device in reaching the maximum speed of rotation of said centrifuge basket.

5. Apparatus as in claim 4, wherein a fluid-pressure sensitive electrical switch is interposed between said means for applying fluid-pressure and said solenoid valve for short-circuiting said drive motor when said ram has less than a predetermined fluid pressure necessary to constrain said centrifuge basket brake actuating means.

6. An industrial suspended-basket type centrifuge comprising frame means, a basket suspension shaft operatively mounted on said frame means, an electrical drive motor operatively mounted on said frame means, a suspended centrifuge basket operatively mounted on said suspension shaft for rotative movement with respect to said frame means, a brake mechanism operatively mounted on said frame means for retarding rotational movement of said centrifuge basket, a brake pulley mounted on the suspension shaft and being in cooperative relationship with said brake mechanism for restraining movement of said centrifuge basket, said centrifuge having centrifuge basket imbalance-of-rotation arresting means comprising a resonant reed and weight device operatively mounted on said frame means and being resonant-responsive to centrifuge basket imbalance-of-rotation frequency of vibration, said resonant reed and weight device being substantially coaxially aligned with said suspension shaft, a switch actuating member operatively mounted on said frame means, means for locating said switch actuating member to be struck by said resonant reed and weight device when said resonant reed and weight device resonates responsive to said centrifuge basket imbalance-of-rotation frequency of

vibration, a primary electrical switch operatively connected to said electrical drive motor and being adapted for actuation by said switch actuating member, said resonant reed and weight device being suspended axially above the basket suspension shaft in proximate alignment with said switch actuating member, a spring-loaded ram mounted on the centrifuge frame means and being connected to the brake mechanism and urging application of the brake mechanism to restrain movement of said centrifuge basket, means for applying fluid pressure to said ram to constrain said centrifuge basket brake from operation, a solenoid valve operatively interposed between said ram and means for applying fluid-pressure and being adapted to optionally admit fluid under pressure to said ram or vent fluid from said ram, a secondary electrical switch operatively associated with said ram and being operatively connected to actuate said solenoid valve and vent fluid from said ram when said drive motor is de-energized, and an electrical short-circuiting switch operatively connected to short-circuit said primary electrical switch and maintain energization of said drive motor until the centrifuge basket passes a speed of rotation corresponding to the natural frequency of vibration of said resonant reed and weight device in reaching the maximum speed of rotation of said centrifuge basket.

7. Apparatus as in claim 6, wherein a fluid-pressure sensitive electrical switch is interposed between said means for applying fluid-pressure and said solenoid valve for short-circuiting said drive motor when said ram has less than a predetermined fluid pressure necessary to constrain said centrifuge basket brake actuating means.

8. An industrial suspended-basket type centrifuge comprising frame means, a basket suspension shaft operatively mounted on said frame means, an electrical drive motor operatively mounted on said frame means, a suspended centrifuge basket operatively mounted on said suspension shaft for rotative movement with respect to said frame means, a brake mechanism operatively mounted on said frame means for retarding rotational movement of said centrifuge basket, a brake pulley mounted on the suspension shaft and being in cooperative relationship with said brake mechanism for restraining movement of said centrifuge basket, a stub shaft operatively mounted on the upper end of the suspension shaft to freewheel stationarily thereon, a housing fixedly mounted on said stub shaft, said centrifuge having centrifuge basket imbalance-of-rotation arresting means comprising the assembly of a resonant reed and weight device operatively mounted on said stub shaft and being resonant-responsive to centrifuge basket imbalance-of-rotation frequency of vibration, said resonant reed and weight device being substantially coaxially aligned with said suspension shaft, a switch actuating member operatively mounted on said housing, means for locating said switch actuating member to be struck by said resonant reed and weight device when said resonant reed and weight device resonates responsive to said centrifuge basket imbalance-of-rotation frequency of vibration, a primary electrical switch operatively connected to said electrical drive motor and being adapted for actuation by said switch actuating member, said resonant reed and weight device being suspended axially above the basket suspension shaft in proximate alignment with said switch actuating member, a spring-loaded ram mounted on the centrifuge frame means and being connected to the brake mechanism and urging application of the brake mechanism to restrain movement of said centrifuge basket, means for applying fluid pressure to said ram to constrain said centrifuge basket brake from operation, a solenoid valve operatively interposed between said ram and means for applying fluid pressure and being adapted to optionally admit fluid under pressure to said ram or vent fluid from said ram, a secondary electrical switch operatively associated with said ram and being operatively connected to actuate said solenoid valve and vent fluid from said ram when said drive motor is de-

energized, and an electrical short-circuiting switch operatively connected to short-circuit said primary electrical switch and maintain energization of said drive motor until the centrifuge basket passes a speed of rotation corresponding to the natural frequency of vibration of said resonant reed and weight device in reaching the maximum speed of rotation of said centrifuge basket.

9. Apparatus as in claim 8, wherein a fluid-pressure sensitive electrical switch is interposed between said means for applying fluid-pressure and said solenoid valve for short-circuiting said drive motor when said ram has less than a predetermined fluid pressure necessary to constrain said centrifuge basket brake actuating means.

10. An industrial suspended-basket type centrifuge comprising frame means, a basket suspension shaft operatively mounted on said frame means, an electrical drive motor operatively mounted on said frame means, a suspended centrifuge basket operatively mounted on said suspension shaft for rotative movement with respect to said frame means, a brake mechanism operatively mounted on said frame means for retarding rotational movement of said centrifuge basket, a brake pulley mounted on the suspension shaft and being in cooperative relationship with said brake mechanism for restraining movement of said centrifuge basket, a stub shaft operatively mounted on the upper end of the suspension shaft to freewheel stationarily thereon, a housing fixedly mounted on said stub shaft, said centrifuge having centrifuge basket imbalance-of-rotation arresting means comprising the assembly of a resonant reed and weight device operatively mounted on said stub shaft and being resonant-responsive to centrifuge basket imbalance-of-rotation frequency of vibration, said resonant reed and weight device being substantially coaxially aligned with said suspension shaft, a switch actuating member operatively mounted on said housing, means for locating said switch actuating member to be struck by said resonant reed and weight device when said resonant reed and weight device resonates responsive to said centrifuge basket imbalance-of-rotation frequency of vibration, a primary electrical switch operatively connected to said electrical drive motor and being adapted for actuation by said switch actuating member, said resonant reed and weight device being suspended axially above the basket suspension shaft in proximate alignment with said switch actuating member, a fluid pressure ram having a cylinder pivotally mounted on the centrifuge frame and having a ram plunger shiftably disposed within said cylinder, a lever pivotally mounted on the centrifuge frame and being attached at one end to the free end of the ram plunger, a friction-brake band operatively disposed about said suspension shaft for retarding rotational movement of said suspension shaft when said band is pulled to a taut condition, said friction-brake band being connected to the other end of said lever, a compression spring located within the ram cylinder to urge operation of the friction-brake band, a source of fluid under pressure, a fluid pressure line from said source of fluid connected to said ram cylinder to constrain said braking operation, a solenoid valve in said fluid pressure line and being adapted to optionally admit fluid to said ram or vent fluid from said ram, a secondary electrical switch operatively associated with said ram and being operatively connected to actuate said solenoid valve and vent fluid from said ram when said drive motor is de-energized, a fluid-pressure sensitive electrical switch interposed in said fluid pressure line between said source of fluid and said solenoid valve and being operatively connected to said drive motor for short-circuiting said drive motor when said ram has less than a predetermined fluid pressure necessary to constrain said ram from causing application of the friction-brake band, and an electrical short-circuiting switch operatively connected to short-circuit said primary electrical switch and maintain energization of said drive motor until the centrifuge basket passes a speed of rotation corresponding to the natural frequency of vibration of said resonant reed and

weight device in reaching the maximum speed of rotation of said centrifuge basket.

11. An imbalance-of-rotation arresting means for use with a gyratory apparatus equipped with a rotatably mounted gyratory member, a drive means associated with said gyratory apparatus for driving said gyratory member, and a brake for retarding the rotational movement of the gyratory member, said imbalance-of-rotation arresting means comprising a resonant reed device operatively associated with said gyratory apparatus and being resonant-responsive to the gyratory member imbalance-of-rotation frequency of vibration, said resonant reed device being substantially coaxially aligned with the center of rotation of said gyratory member, de-energization means operatively associated with said resonant reed device and said drive means for de-energizing said drive means, said de-energization means being actuated when said resonant reed device resonates responsive to said gyratory member imbalance-of-rotation frequency of vibration, and means operatively associated with said resonant reed device and said brake for actuating said brake when said resonant reed device resonates responsive to said gyratory member imbalance-of-rotation frequency of vibration.

12. An imbalance-of-rotation arresting means for use with an industrial centrifuge equipped with a rotatably mounted centrifuge basket, an electrical drive motor associated with said centrifuge for driving said centrifuge basket, and a brake for retarding the rotational movement of the centrifuge basket; said imbalance-of-rotation arresting means comprising a resonant reed device operatively associated with said centrifuge and being resonant-responsive to centrifuge basket imbalance-of-rotation frequency of vibration, said resonant reed device being substantially coaxially aligned with the center of rotation of said centrifuge basket, means operatively associated with said resonant reed device and said electrical drive motor for deenergizing said electrical drive motor, said last named means being actuated when said resonant reed device resonates responsive to said centrifuge basket imbalance-of-rotation frequency of vibration, and means operatively associated with said resonant reed device and said brake for actuating said centrifuge basket brake when said resonant reed device resonates responsive to said centrifuge basket imbalance-of-rotation frequency of vibration.

13. An imbalance-of-rotation arresting means for use with a gyratory apparatus equipped with a rotatably mounted gyratory member, drive means associated with said gyratory apparatus for driving said gyratory member and a brake for retarding the rotational movement of the gyratory member; said imbalance-of-rotation arresting means comprising a resonant reed device operatively associated with said gyratory apparatus and being resonant-responsive to the gyratory member imbalance-of-rotation frequency of vibration, said resonant reed device being substantially coaxially aligned with the center of rotation of said gyratory member, de-energization means operatively associated with said resonant reed device and said drive means for de-energizing said drive means, said de-energization means being actuated when said resonant reed device resonates responsive to said gyratory member imbalance-of-rotation frequency of vibration, means operatively associated with said resonant reed and said brake for actuating said brake when said resonant reed device resonates responsive to said gyratory member imbalance-of-rotation frequency of vibration, and means operatively connected to said last named means and said de-energization means for restraining de-energization of said drive means and restraining actuation of said brake when the frequency of vibration of the gyratory member corresponding to the natural frequency of vibration of said resonant reed device is encountered in reaching the maximum speed of rotation of said gyratory member.

14. An imbalance-of-rotation arresting means for use with a gyratory apparatus equipped with a rotatably mounted gyratory member, drive means associated with said gyratory apparatus for driving said gyratory member, and a brake for retarding the rotational movement of the gyratory member; said imbalance-of-rotation arresting means comprising vibration sensing means operatively associated with said gyratory apparatus and being responsive to the gyratory member imbalance-of-rotation frequency of vibration, said vibration sensing means being substantially coaxially aligned with the center of rotation of said gyratory member, de-energization means operatively associated with said vibration sensing means and said drive means for de-energizing said drive means, said de-energization means being actuated when said vibration sensing means detects a gyratory member imbalance-of-rotation frequency of vibration, means operatively associated with said vibration sensing means and said brake for actuating said brake when said vibration sensing means detects said gyratory member imbalance-of-rotation frequency of vibration, and means operatively connected to said last named means and said de-energization means for restraining de-energization of said drive means and restraining actuation of said brake when the frequency of vibration of the gyratory member corresponding to the natural frequency of vibration of said vibration sensing means is encountered in reaching the maximum speed of rotation of said gyratory member.

15. An imbalance-of-rotation arresting means for use with an industrial centrifuge equipped with a rotatably mounted centrifuge basket, an electrical drive motor associated with said centrifuge for driving said centrifuge basket, and a brake for retarding the rotational movement of the centrifuge basket; said imbalance-of-rotation arresting means comprising vibration sensing means operatively associated with said centrifuge and being responsive to centrifuge basket imbalance-of-rotation frequency of vibration, said vibration sensing means being substantially coaxially aligned with the center of rotation of said centrifuge basket, de-energization means operatively associated with said vibration sensing means and said electrical drive motor for de-energizing said electrical drive motor, said de-energization means being actuated when said vibration sensing means detects a centrifuge basket imbalance-of-rotation frequency of vibration, means operatively associated with said vibration sensing means and said brake for actuating said centrifuge basket brake when said vibration sensing means detects centrifuge basket imbalance-of-rotation frequency of vibration, and means operatively connected to each of said last named means for restraining de-energization of said electrical drive motor and restraining actuation of said centrifuge basket brake when the frequency of vibration of the centrifuge basket corresponding to the natural frequency of vibration of said vibration sensing means is encountered in reaching the maximum speed of rotation of said centrifuge basket.

16. A gyratory apparatus comprising frame means, a gyratory member shaft operatively mounted on said frame means, an electrical drive motor operatively mounted on said frame means, a suspended gyratory member operatively mounted on said suspension shaft for rotative movement with respect to said frame means, a brake mechanism operatively mounted on said frame means for retarding rotational movement of said gyratory member, a brake pulley mounted on the suspension shaft and being in cooperative relationship with said brake mechanism for restraining movement of said gyratory member, said gyratory apparatus having imbalance-of-rotation arresting means comprising a resonant reed and weight device resonant-responsive to gyratory member imbalance-of-rotation frequency of vibration, said resonant reed and weight device being substantially coaxially aligned with the gyratory member shaft, a switch actuating member operatively mounted on said frame means, means for locating said switch actuating member to be

struck by said resonant reed and weight device when said resonant reed and weight device resonates responsive to said imbalance-of-rotation frequency of vibration, a primary electrical switch operatively connected to said electrical drive motor and being adapted for actuation by said switch actuating member, said resonant reed and weight device being suspended axially above the suspension shaft in proximate alignment with said switch actuating member, a spring-loaded ram mounted on the frame means and being connected to the brake mechanism and urging application of the brake mechanism to restrain movement of said gyratory member, means for applying fluid pressure to said ram to constrain said centrifuge basket brake from operation, a solenoid valve operatively interposed between said ram and means for applying fluid-pressure and being adapted to optionally admit fluid under pressure to said ram or vent fluid from said ram, a secondary electrical switch operatively associated with said ram and being operatively connected to actuate said solenoid valve and vent fluid from said ram when said drive motor is de-energized, and an electrical short-circuiting switch operatively connected to short-circuit said primary electrical switch and maintain energization of said drive motor until the gyratory member passes a speed of rotation corresponding to the natural frequency of vibration of said resonant reed and weight device in reaching the maximum speed of rotation of said gyratory member.

17. An industrial suspended-basket type centrifuge comprising frame means, a basket suspension shaft operatively mounted on said frame means, an electrical drive motor operatively mounted on said frame means, a suspended centrifuge basket operatively mounted on said suspension shaft for rotative movement with respect to said frame means, a brake mechanism operatively mounted on said frame means for retarding rotational movement of said centrifuge basket, a brake pulley mounted on the suspension shaft and being in cooperative relationship with said brake mechanism for restraining movement of said centrifuge basket, said centrifuge having centrifuge basket imbalance-of-rotation arresting means comprising vibration sensing means operatively mounted on said frame means and being responsive to centrifuge basket imbalance-of-rotation frequency of vibration, said vibration sensing means being substantially coaxially aligned with said basket suspension shaft, a switch actuating member operatively mounted on said frame means, means for locating said switch actuating member to be struck by said vibration sensing means when said vibration sensing means detects centrifuge basket imbalance-of-rotation frequency of vibration, a primary electrical switch operatively connected to said electrical drive motor and being adapted for actuation by said switch actuating member, said vibration sensing means being suspended axially above the basket suspension shaft in proximate alignment with said switch actuating member, a spring-loaded ram mounted on the centrifuge frame means and being connected to the brake mechanism and urging application of the brake mechanism to restrain movement of said centrifuge basket means for applying fluid pressure to said ram to constrain said centrifuge basket brake from operation, a solenoid valve operatively interposed between said ram and means for applying fluid pressure and being adapted to optionally admit fluid under pressure to said ram or vent fluid from said ram, a secondary electrical switch operatively associated with said ram and being operatively connected to actuate said solenoid valve and vent fluid from said ram when said drive motor is de-energized, and an electrical short-circuiting switch circuit operatively connected to short-circuit said primary electrical switch and maintain energization of said drive motor until the centrifuge basket passes a speed of rotation corresponding to the natural frequency of vibration of said vibration sensing means in reaching the maximum speed of rotation of said centrifuge basket.

18. A gyratory apparatus comprising frame means, a gyratory member suspension shaft operatively mounted on said frame means, an electrical drive motor operatively mounted on said frame means, a suspended gyratory member operatively mounted on said suspension shaft for rotative movement with respect to said frame means, a brake mechanism operatively mounted on said frame means for retarding rotational movement of said gyratory member, a brake pulley mounted on the suspension shaft and being in cooperative relationship with said brake mechanism for restraining movement of said gyratory member, said gyratory apparatus having imbalance-of-rotation arresting means comprising vibration sensing means operatively mounted on said frame means and being responsive to gyratory member imbalance-of-rotation frequency of vibration, said vibration sensing means being substantially coaxially aligned with said gyratory member suspension shaft, a switch actuating member operatively mounted on said frame means, means for locating said switch actuating member to be struck by said vibration sensing means when said vibration sensing means detects imbalance-of-rotation frequency of vibration, a primary electrical switch operatively connected to said electrical drive motor and being adapted for actuation by said switch actuating member, said vibration sensing means being suspended axially above the suspension shaft in proximate alignment with said switch actuating member, a spring loaded ram mounted on the frame means and being connected to the brake mechanism and urging application of the brake mechanism to restrain movement of said gyratory member, means for applying fluid pressure to said ram to constrain said centrifuge basket brake from operation, a solenoid valve operatively interposed between said ram and means for applying fluid pressure and being adapted to optionally admit fluid under pressure to said ram or vent fluid from said ram, a secondary electrical switch operatively associated with said ram and being operatively connected to actuate said solenoid valve and vent fluid from said ram when said drive motor is de-energized, and an electrical short-circuiting switch operatively connected to short-circuit said primary electrical switch and maintain energization of said drive motor until the gyratory member passes a speed of rotation corresponding to the natural frequency of vibration of said vibration sensing means in reaching the maximum speed of rotation of said gyratory member.

19. An industrial suspended-basket type centrifuge comprising frame means, a basket suspension shaft operatively mounted on said frame means, an electrical drive motor operatively mounted on said frame means, a suspended centrifuge basket operatively mounted on said suspension shaft for rotative movement with respect to said frame means, a brake mechanism operatively mounted on said frame means for retarding rotational movement of said centrifuge basket, a brake pulley mounted on the suspension shaft and being in cooperative relationship with said brake mechanism for restraining movement of said centrifuge basket, said centrifuge having centrifuge basket imbalance-of-rotation arresting means comprising a resonant reed and weight device operatively mounted on said frame means and being resonant-responsive to centrifuge basket imbalance-of-rotation frequency of vibration, said resonant reed and weight device being substantially coaxially aligned with said suspension shaft, a switch actuating member operatively mounted on said frame means, means for locating said switch actuating member to be struck by said resonant reed and weight device when said resonant reed and weight device resonates responsive to said centrifuge basket imbalance-of-rotation frequency of vibration, a primary electrical switch operatively connected to said electrical drive motor and being adapted for actuation by said switch actuating member, said resonant reed and weight device being suspended axially above the basket suspension shaft in proximate alignment with said switch actuating member, a spring-loaded ram mounted on the

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centrifuge frame means and being connected to the brake mechanism and urging application of the brake mechanism to restrain movement of said centrifuge basket means for applying fluid pressure to said ram to constrain said centrifuge basket brake from operation, a solenoid valve operatively interposed between said ram and means for applying fluid-pressure and being adapted to optionally admit fluid under pressure to said ram or vent fluid from said ram, and a secondary electrical switch operatively associated with said ram and being operatively connected to actuate said solenoid valve and vent fluid from said ram when said drive motor is de-energized.

References Cited by the Examiner

UNITED STATES PATENTS

1,600,249	9/1926	Sando	210—144
1,946,725	2/1934	Andrews et al.	210—144

15

16

2,261,936	11/1941	Johnson	210—368 X
2,612,766	10/1952	Smith et al.	210—144 X
2,624,464	1/1953	Morrison	210—144
2,647,386	8/1953	Keiper	210—144 X
2,731,113	1/1956	Huser et al.	210—368 X
2,802,916	8/1957	Adams et al.	
2,846,541	8/1958	Evans et al.	
2,878,937	3/1959	Worst	210—144
2,895,023	7/1959	Blum	210—144 X
3,051,313	8/1962	Stelli	210—144
3,117,926	1/1964	Starr et al.	210—144

FOREIGN PATENTS

1,256,550	2/1961	France.
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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,226,016

December 28, 1965

Mervyn George Couper et al.

It is certified that error appears in the above identified patent and that said Letters Patent are hereby corrected as shown below:

Column 1, line 69, for "on", second occurrence, read -- or --; column 2, lines 31 and 34, for "ensue", each occurrence, read -- ensure --; line 45, after "comprises a" insert -- resonant --; line 46, strike out "nant"; line 47, strike out "quency"; column 4, line 49, strike out "the", first occurrence; column 5, line 21, for "an" read -- and --; column 6, line 32, for "reelased" read -- released --; column 7, line 41, for "resonate" read -- resonates --; column 8, line 51, for "cosntrain" read -- constrain --; column 13, line 2, for "red" read -- reed --; column 15, line 6, for "an dmeans" read -- and means --.

(SEAL)

Signed and sealed this 22nd day of July 1969.

Attest:

Edward M. Fletcher, Jr.

Attesting Officer

WILLIAM E. SCHUYLER, JR.

Commissioner of Patents