March 2, 1954 E. G. PICKELS 2,670,898

CENTRIFUGE APPARATUS

Filed May 22, 1950 2 Sheets-Sheet 1

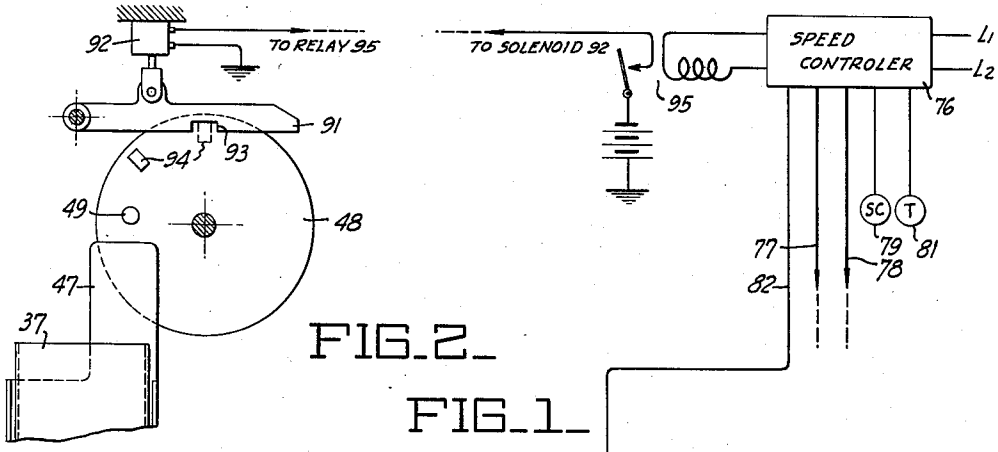
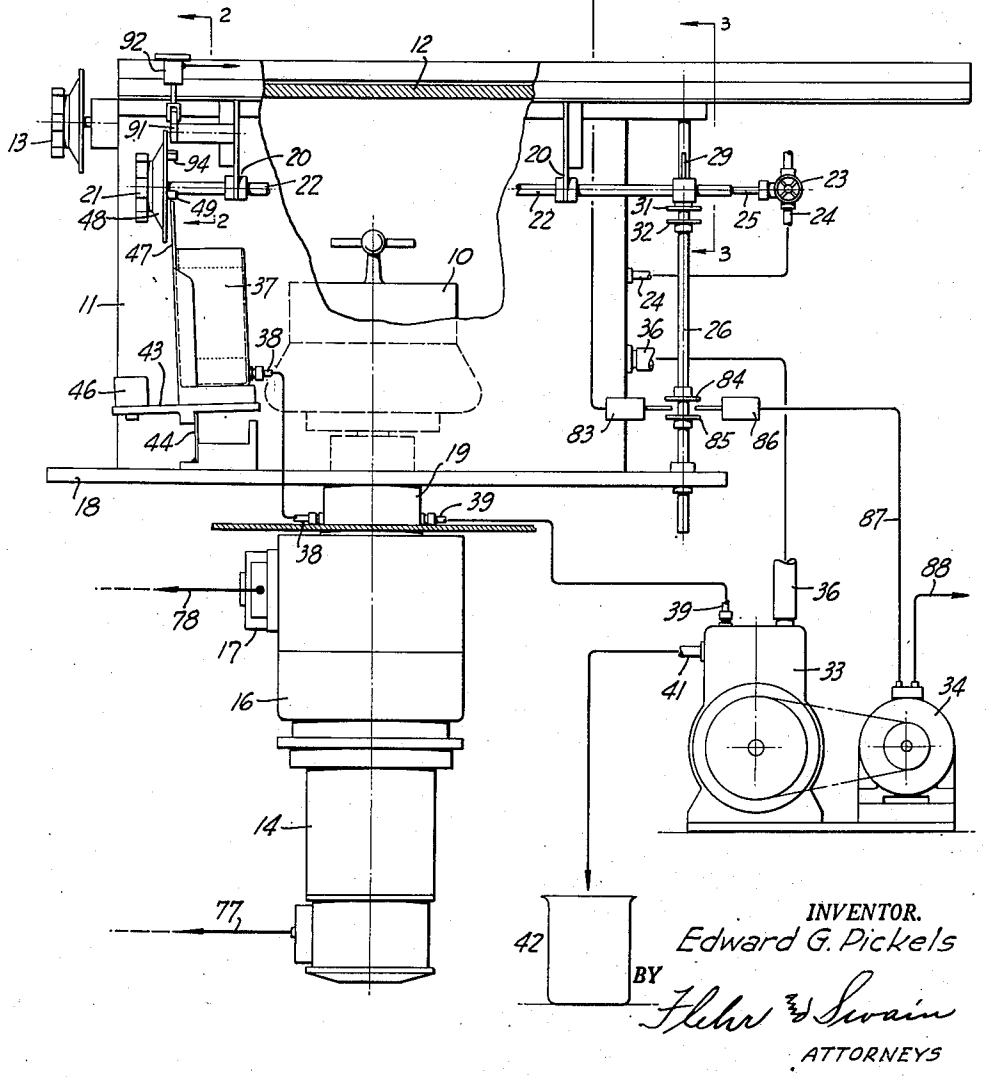


FIG. 2.

FIG. 1.



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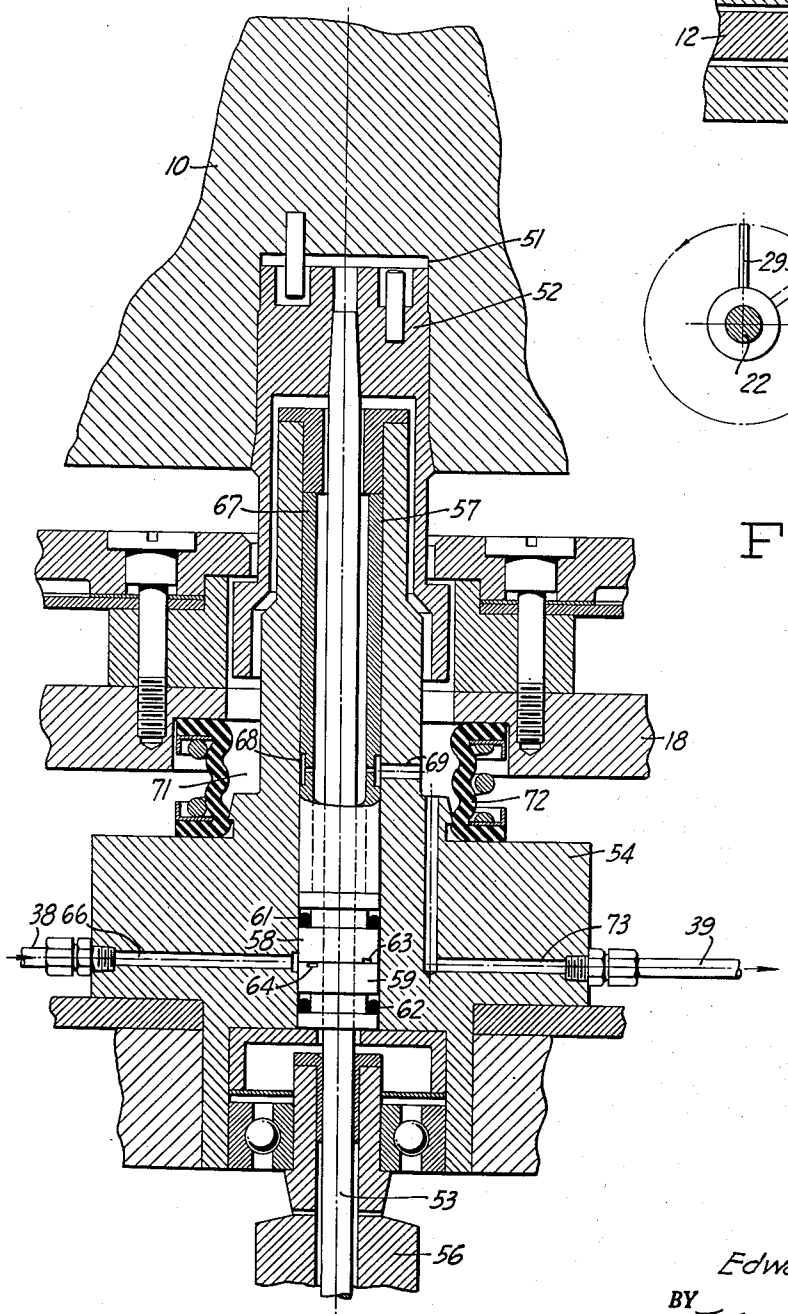
March 2, 1954 E. G. PICKELS 2,670,898

CENTRIFUGE APPARATUS

Filed May 22, 1950

2 Sheets-Sheet 2

FIG_4_



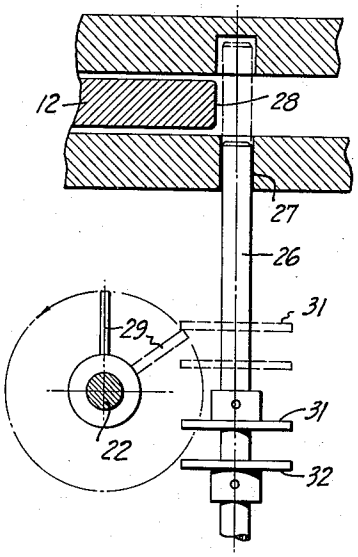


FIG_3_

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Patented Mar. 2, 1954

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UNITED STATES PATENT OFFICE

2,670,898

CENTRIFUGE APPARATUS

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Application May 22, 1950, Serial No. 163,392

13 Claims. (Cl. 233—1)

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This invention relates generally to centrifuge apparatus for laboratory separating operations, and particularly to apparatus of the ultra centrifuge type, wherein the rotor may be driven at speeds ranging up to 40,000 R. P. M. or more.

Ultra centrifuges generally employ a vacuum chamber in which the rotor is disposed, and which can be evacuated for the higher rotative speeds employed. The rotor is coupled to a driving spindle, which in turn connects with speed multiplying gearing and a driving motor, both located exterior of the vacuum chamber. Considerable care must be taken with such a machine in order to avoid operating hazards. For example it is inadvisable to operate the machine at rotative speeds ranging above about 5,000 R. P. M. without first taking the precaution to close and evacuate the vacuum chamber. Also one must take care to vent the vacuum at the end of a run, before attempting to open the vacuum chamber. I have found it desirable in such machines to provide a special type of seal about the driving spindle, and which seal is continuously supplied with oil. The operator must take care to maintain an adequate supply of oil for this seal in order that it may function properly during normal operation under vacuum.

In general it is an object of the present invention to provide centrifuge apparatus of the above type having safety features which obviate the principal operating hazards involved.

It is a further object of the invention to provide improved centrifuge apparatus having automatic provision for preventing operation at the higher rotative speeds when the vacuum chamber is open, or when the chamber is not locked in closed position, or when the vacuum pump is not operating.

It is another object of the invention to provide a machine of the above character with a manually operated starting member which makes certain that the venting valve for the vacuum chamber is closed before the vacuum pump is started.

Another object of the invention is to provide a centrifuge machine of the above character in which means is employed to prevent the start of a run if the amount of oil for supplying the vacuum seal is less than a predetermined amount.

Another object of the invention is to provide a simplified type of control for an ultra centrifuge, and which is characterized by a single manual operating member which when operated will serve to operate the locking means for the vacuum chamber cover, the vent valve for the vacuum chamber, and switching means for controlling

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operation of the vacuum pump. In conjunction with the object just stated, it is a further object of the invention to provide a novel interlock in conjunction with such manual control member, whereby it is impossible to unlock the cover during a normal high speed operation, and impossible to initiate a complete operating cycle without providing a proper quantity of oil for the vacuum seal.

Further objects and features of the invention will appear from the following description in which the preferred embodiments are set forth in detail in conjunction with the accompanying drawing.

Referring to the drawing:

Figure 1 is a schematic view partly in section illustrating centrifuge apparatus incorporating the present invention.

Figure 2 is an enlarged schematic view taken along the section line 2—2 of Figure 1.

Figure 3 is an enlarged cross-sectional detail taken along the line 3—3 of Figure 1.

Figure 4 is a cross-sectional detail illustrating an oil lubricated vacuum seal for the drive spindle of the rotor.

Figure 1 of the drawing schematically illustrates a centrifuge comprising a rotor 10 disposed within the vacuum chamber 11. The vacuum chamber is provided with a cover 12 adapted to slide horizontally between open and closed positions, and adapted in closed condition to be sealed whereby the interior of the chamber can be evacuated. Suitable means can be used for moving the cover between open and closed positions, such as a cable operator, actuated by the rotatable knob 13.

Exterior of the vacuum chamber there is an electric driving motor 14, which serves to drive the spindle to which the rotor is coupled, through the speed multiplying gearing 16. This gearing, and the manner in which it is coupled to the rotor 10, can be constructed as disclosed and claimed in my copending application Serial No. 163,393, filed May 22, 1950, and entitled "Centrifuge Apparatus." As disclosed in said copending application a rate generator 17 is incorporated in connection with the drive, and connects with a speed controller as will be presently explained. Interposed between the drive means 16 and the bottom wall 18 of the vacuum chamber, there is a vacuum seal 19 as will be presently described.

Located at some convenient position there is a manually operated member 21 which may be in the form of a knob mounted upon the rotatable shaft 22. This shaft is rotatably supported by

suitable means 20 and may be provided with suitable stops whereby the angular movement is limited.

An air valve 23 is connected by pipe 24 to the interior of the vacuum chamber, and when this valve is open the interior of the chamber is vented to the atmosphere. The operating member 25 of the valve 23 is directly mechanically connected to the shaft 22. For the one operating position of member 21, the valve 23 is open, and for the other operating position it is closed. It is convenient to employ a valve of the globe type with a soft rubber seat and a threaded operating stem.

Locking means is provided for positively locking the cover 12 in closed position. Thus a rod 26 is slidably mounted alongside the vacuum chamber, and has its upper end (Figure 3) extending through the guide opening 27. The rear edge 28 of the cover clears the rod 26 when the cover is fully closed. Rod 22 carries a radially extending finger or arm 29, which when rotated in a counterclockwise direction as viewed in Figure 3, is adapted to engage between the two collars 31 and 32, which are mounted upon rod 26. Thus counterclockwise rotation of the rod 22 serves to lift the rod 22 into locking position, as illustrated in dotted lines in Figure 3.

With the arrangement described above it will be evident that manual operation of the knob 21 serves to simultaneously operate both the cover locking means and the vent valve for venting the vacuum chamber to the atmosphere.

During a normal run the interior of the vacuum chamber is evacuated by the pump 33, which is shown being operated by the electric motor 34. The suction side of the pump is connected to the vacuum chamber by a hose or pipe 36.

In order to provide lubricant for the seal 19 and for the vacuum pump during a normal run, an oil receptacle 37 is provided, which has a flexible fluid connection 38 to the seal 19. Another fluid connection 39 serves to connect the vacuum side of the seal 19 with the pipe 36 or directly to the suction side of the pump 33 as indicated. Oil overflowing from the vacuum pump is shown being discharged by line 41 to the catch pan 42.

The receptacle 37 is preferably associated with means whereby when this receptacle does not have an adequate amount of oil the knob 21 cannot be rotated to close the valve 23 and to close certain switches to be presently described. Thus the receptacle is supported by the mounting 43, which in turn is carried by the tongue or fulcrum 44. A counterweight 46 insures movements of the receptacle 37 to the left or to the right, depending upon the amount of oil present. A finger 47 extends upwardly from the mounting and in juxtaposition to one face of a disc 48 which is secured to or forms a part of the knob 21. The disc carries a lug or pin 49 which is adapted to engage the finger 47 for that position of the latter corresponding to the position which it assumes when there is an insufficient amount of oil in the receptacle 37 for a normal run. When an adequate amount of lubricating oil is in the receptacle 37, mounting 43 tips to the right to bring the finger 47 to an out-of-the-way position with respect to pin 49, thus permitting the knob 21 to be turned in a direction to close the valve 23, lock the cover, and operate the above mentioned switches.

As previously stated the vacuum seal 19 can be made as disclosed in my copending application Serial Number 163,393. Such a seal is illustrated in Figure 4. The rotor 10 in this instance has its lower side provided with the opening or socket 51, which is adapted to receive the thimble-like driving member 52. Driving member 52 is attached to the upper end of the spindle 53. The spindle extends downwardly through the spud 54, and through the rigid hollow drive shaft 56. As described in the aforesaid application, the lower end of the drive shaft 56 has a driving connection with the lower end of the spindle.

The spud 54 is provided with a bore 57 through which the spindle 53 extends, and which accommodates the annular members 58 and 59. These members are bored to snugly fit the spindle 53, and are machined externally to loosely fit the bore 57. They are provided with peripheral grooves to receive the resilient O ring seals 61, 62, which serve to frictionally retain the members 58 and 59 against rotation, and to form seals between members 58 and 59 and the side surfaces of the bore 57. The adjacent end faces of members 58 and 59 are provided with radially extending grooves 63, 64, which serve to convey oil from the inlet duct 66, to the running clearance between member 58 and the spindle 53. Both the members 58 and 59 are held down in their operating positions by the sleeve 67. Above the member 58 the sleeve 67 is provided with a port 68, whereby oil collecting above member 58 may flow through this port, and then through duct 69 into the adjacent space 71 which is formed within the resilient seal sleeve 72. This seal can be formed of suitable material such as resilient rubber, and extends between the spud 54 and the chamber wall 18. Oil is drained from the space 72 through the duct 73. Ducts 66 and 73 connect respectively with the flow lines 38 and 39.

During normal operation of the machine, and assuming that the chamber surrounding the rotor is evacuated, oil is supplied from the receptacle 37 through line 38, duct 66, grooves 63, 64, and from thence upwardly through the clearance between member 58 and the spindle, to accumulate above member 58. From the space above member 58 such oil flows through port 68, duct 69, space 71, and from thence through duct 73 and line 38 to the lubricating system of the vacuum pump 33.

In conjunction with my machine it is desirable to employ a suitable speed controller 76 and preferably one of the electronic type. A suitable electronic speed controller for this purpose has been disclosed in an article entitled "Electronic speed control" by applicant and P. F. Scofield, published in Electrical Manufacturing, January 1950 edition, page 66. The controller in that instance is of the saturable reactance type, and may be employed to control acceleration, speed of operation, and deceleration. Line 77 (representing a multiconductor cable) represents circuit connections from the speed controller to the electric motor 14. Line 78 similarly represents circuit connections to the rate generator 17. Device 79 represents a speed control adjustment under the control of the operator, and which is associated with the circuits of the speed controller. Device 81 represents a timer which is likewise associated with the circuits of the speed controller, and serves to control the time period that the rotor is driven at a prescribed speed. Line 82 represents circuit connections to a controlling switch 83. As disclosed in the aforementioned publi-

cation, switch 83 when in one position can serve to limit the speed of operation of the rotor beyond a value such as 5,000 R. P. M. The operating member of switch 83 is shown extending between the two collars or discs 84 and 85, which are mounted on rod 26. Another switch 86 is shown connected by line 87 to the electrical motor 34 of the vacuum pump. Line 88 serves to connect the motor 34 to power supply lines, through a master switch (not shown). Switch 86 is likewise operated by vertical movements of the rod 26. When the rod 26 moves upwardly to locking position, the switch 86 is operated to energize the motor 34. Thus the motor 34 can be started in operation only when the cover is closed and locked in closed position. The cycling is such that as rod 26 moves upwardly, switches 86 and 83 are operated sequentially in the order named.

In addition to the safety features previously described, I preferably provide a lock-out arrangement whereby when the machine is operating under normal conditions, with the cover closed and a vacuum applied to the rotor, knob 21 cannot be turned to unlock the cover until after the end of the run and after the rotor has been decelerated to a safe value. Thus a latch arm 91 is mounted adjacent the disc 48, and is operatively connected to the solenoid 92. A notch 93 in this latch arm is adapted to engage a lug 94 which is carried by the disc 48. When the disc 48 is in a position corresponding to locked position of the rod 26, the lug 94 assumes a position directly below the notch 93, and is latched in this position by the arm 91, until solenoid 92 is energized. A simple energizing circuit for the solenoid 92 is shown being controlled by relay 95, which in turn has its winding connected to the speed controller 76. For all speeds of operation above a given value, such as say above 5,000 R. P. M., the solenoid 92 remains de-energized, and therefore the knob 21 is locked against being manually returned to starting position. However at the conclusion of the run, when the speed of operation of the rotor drops down below 5,000 R. P. M., solenoid 92 is energized to lift the latch 91, and thus permit manual rotation of the knob back to starting position.

Operation of my complete machine can be reviewed as follows: Before a run is started the cover 12 is opened, the valve 23 is in venting position, and the pin 49 is located above the finger 47. Assuming that the speed controller 76 is energized, the operator may drive the rotor 10 at a selected speed below a given maximum value, which for example may be 5,000 R. P. M. Separate manually initiated switch buttons may be provided for this purpose.

In order to carry out a run at higher speeds and with the chamber 11 evacuated, the operator closes the cover 12 as by turning knob 13. Assuming that receptacle 37 has an adequate amount of oil the knob 21 is turned clockwise from start to running position. During such rotation of the knob 21 and shaft 22, the venting valve 23 is turned from open to closed positions, the rod 26 is elevated to lock the cover closed, and as rod 26 completes its movement switch 86 is operated to start the vacuum pump and thereafter switch 83 is operated to permit the higher speeds of rotation. By means of a suitable starting switch associated with the speed controller, the operator now starts the rotor in operation, and the speed controller accelerates the rotor to the speed which the operator has selected. Thereafter the rotor is maintained at the selected speed for the period of time for which the timing device 81 has been set. At the end of the set time period, the motor 14 by action of the controller is automatically decelerated.

While the rotor is running above a speed of say 5,000 R. P. M., the operator cannot rotate the knob 21 back to starting position, because of the lock-out provided by the latch 91. At the end of the run, and after the rotor has been decelerated below 5,000 R. P. M., the latch 91 is automatically released, and then the operator may turn knob 21 back to starting position, whereby the switches 83 and 86 are operated to impose a speed limitation on the rotor and to stop the vacuum pump, the cover is unlocked and valve 23 turned to open position to vent the vacuum chamber. Thereafter knob 13 can be turned to open the cover.

In addition to the article in Electrical Manufacturing, reference is made to two copending applications filed of even date herewith in the name of P. F. Scofield and entitled "Vacuum Chamber Construction" and "Motor Control Equipment." The first of said applications discloses and claims features of a vacuum chamber construction suitable for use with the present invention, and the second discloses a complete electronic circuit for automatic motor speed control and which can be used to provide the speed controller 76.

I claim:

1. In centrifuge apparatus of the type including a centrifuge rotor disposed in a chamber which is adapted to be evacuated and having a cover movable between open and closed positions, mechanical means for locking the cover in closed position, valve means for venting the chamber to the atmosphere, and common manually operated means for releasing said locking means and for operating the valve means to vent the chamber.

2. In centrifuge apparatus of the type including a centrifuge rotor disposed in a chamber which is adapted to be evacuated and having a cover movable between open and closed positions, mechanical means including a member movable between limiting positions for positively locking the cover in closed position, means including a manually operated member for actuating said first named member, means including an air valve movable between open and closed positions for either venting the chamber to the atmosphere or closing communication with the atmosphere to permit evacuating the chamber, and means forming a mechanical connection between said valve and said manually operated operating member whereby said air valve is operated simultaneously with locking and unlocking operations.

3. In centrifuge apparatus of the type including a centrifuge rotor disposed in a chamber which is adapted to be evacuated and which has an upper cover movable between open and closed positions, a rod movable between limiting positions for either mechanically locking the cover in closed position or permitting opening of the cover, a rod adapted to be manually rotated, means forming a mechanical connection between said rods whereby upon turning said manually rotated rod said first named rod can be moved between its limiting positions, an air valve connected to the vacuum chamber and adapted when open to vent the vacuum chamber to the atmosphere, and a mechanical connection from said air valve to said manually operated rod to cause

operation of said air valve simultaneously with operation of said locking rod.

4. In centrifuge apparatus of the type including a centrifuge rotor disposed in a chamber which is adapted to be evacuated by a vacuum pump, the chamber having a cover movable between open and closed positions, mechanical means for locking the cover in closed position, a manually operated member movable between limiting positions for releasing said locking means to permit opening of the cover or for causing said locking means to lock the cover in closed position, circuit means including a switch to control operation of the vacuum pump, and means for effecting operation of said controlling switch responsive to operation of said locking means.

5. In centrifuge apparatus of the type including a centrifuge rotor disposed in a chamber which is adapted to be evacuated by a vacuum pump, the chamber having a cover movable between open and closed positions, mechanical means for locking the cover in closed position, valve means for venting the chamber to the atmosphere, circuit means including a control switch for controlling operation of said vacuum pump, and common manually operated means for releasing said locking means and for operating the valve means to vent the chamber and for operating said control switch, whereby said vent valve is operated to vent the vacuum chamber when said manually operated means is operated to unlock the cover, and whereby said controlling switch is operated to effect operation of the vacuum pump only when said manually operated means is operated to lock the cover in closed position.

6. In centrifuge apparatus of the type including a centrifuge rotor disposed in a chamber which is adapted to be evacuated and which has a cover movable between open and closed positions, together with a drive spindle to which the rotor is coupled and drive means exterior of the chamber for turning the spindle; vacuum sealing means surrounding the spindle, said sealing means having provision for introducing and removing oil from the same, an oil supply reservoir having a fluid flow connection to said sealing means, balanced means for mounting said reservoir and including a member assuming limiting positions responsive to the amount of oil in the reservoir, a manually operated member adapted to be moved to initiate an operation of the rotor, and means serving to cause said first member when in one position of the same to lock said last named member against movement to start a run.

7. In centrifuge apparatus of the type including a centrifuge rotor disposed in a chamber which is adapted to be evacuated and having a cover movable between open and closed positions, the rotor being coupled to a drive spindle which is driven by means located externally of the chamber, the chamber being adapted to be evacuated by a vacuum pump, oil lubricated sealing means forming a vacuum seal about the spindle, said sealing means having provision for introducing oil to and removing oil from the same, an oil reservoir having a fluid connection to said oil sealing means to supply oil to the same, a balanced mounting for said reservoir adapted to assume either one of two positions depending upon the amount of oil in the reservoir, a fluid connection from the oil sealing means to said vacuum pump for removal of oil from the vacuum sealing means, circuit means for controlling operation of the vacuum pump including a control switch, locking means for locking the cover in closed position, venting means for the vacuum chamber including an air valve, common manually operated means for operating said locking means, for operating said air valve and for operating said controlling switch to interrupt operation of said vacuum pump when said locking means is released, and means for preventing operation of said last named means when the oil in the reservoir is less than a predetermined amount.

8. In centrifuge apparatus of the type including a centrifuge rotor disposed in a chamber which is adapted to be evacuated and having a cover movable between open and closed positions, means including a manually operated member movable between limiting positions for locking the cover in closed position, means including a manually operated member for actuating said first named member, means including an electrical switch adapted to be operated by movement of said last named member in a direction to cause locking of the cover, a vacuum pump connected to the chamber and adapted to be started in operation by operation of said switch, and a venting valve for the vacuum chamber adapted to be moved between closed and venting positions and mechanically connected to be operated by movements of said manually operated member.

9. In centrifuge apparatus of the type including a centrifuge rotor disposed in a chamber which is adapted to be evacuated and having a cover movable between open and closed positions, the rotor being adapted to be driven by means under the control of a speed controller whereby the driving speed can be adjusted over a wide range, means including a member movable between limiting positions for locking the cover in closed position, means including a manually operated member for actuating said first named member, a pair of electrical switches adapted to be operated by movements of said manually operated member, a vacuum pump for the vacuum chamber, circuit connections from one of said switches to said vacuum pump to start the vacuum pump in operation when said manually operated member is turned to lock the cover in closed position, and circuit connections from said second one of said switches to said speed controller to permit higher speeds of rotation when the cover is closed and locked.

10. In centrifuge apparatus of the type including a centrifuge rotor disposed in a chamber which is adapted to be evacuated and having a cover movable between open and closed positions, the rotor of said chamber being driven by means under the control of a speed controller whereby the driving speed can be adjusted over a wide range, means including a member movable between limiting positions locking the cover in closed position, means including a manually operated member for actuating said first named member, a switch adapted to be actuated upon operation of said manually operated member, a vacuum pump connected to evacuate the chamber and having circuit connections to said switch whereby the vacuum pump is started in operation when said manually operated member is operated to lock the cover, latch means adapted to lock said manually operated member in a position which it occupies when the cover is fully locked, and circuit means responsive to said speed controller for releasing said latch means when

the speed of the rotor is less than a predetermined value whereby for operating speeds below said value the apparatus can be operated with the can in either open or closed position.

11. In centrifuge apparatus of the type including a centrifuge rotor disposed in a chamber which is adapted to be evacuated by a vacuum pump, the chamber having a cover movable between open and closed positions, the rotor being driven by means controlled by a speed controller adjustable over a wide speed range to set the speed of operation, means for locking the cover in closed position, valve means for venting the chamber to the atmosphere, circuit means including a control switch for controlling operation of the vacuum pump, circuit means including another control switch for conditioning the speed controller to prevent higher speeds of rotation of the rotor beyond a predetermined value, common manually operated means for actuating said locking means and for operating the valve means to vent the chamber and for operating said control switches, whereby when said manually operated means is operated to lock the cover, the vent valve is closed, the vacuum pump is started in operation, and the second control valve is operated to permit said higher speeds of operation, latch means for locking said manually operated means in the position which it occupies when the cover is fully locked, and circuit means actuated by said speed controller for causing release of said latch means when the rotor is operating at a speed below said predetermined speed.

12. In centrifuge apparatus of the type including a centrifuge rotor disposed in a chamber which is adapted to be evacuated and having a cover movable between open and closed positions, means for locking the cover in closed position, a manually operable member movable between limiting positions for operating said locking means, a vacuum pump having a pneumatic connection with the chamber, an electric motor for driving the pump, an energizing circuit for driving the motor, a switch in said circuit for controlling operation of the motor, and means responsive to movement of said manually operable member in a direction to lock said cover for operating said switch to energize said motor.

13. In centrifuge apparatus of the type including a centrifuge rotor disposed in a chamber which is adapted to be evacuated, the chamber

having a cover movable between open and closed positions and the rotor being driven by means controlled by a speed controller which is adjustable to set the speed of operation to a selected value, mechanical means for locking the cover in closed position, a valve having a pneumatic connection with the interior of the chamber and serving to vent the chamber to atmosphere, a motor for driving the vacuum pump, an electrical circuit for energizing the motor, a first control switch included in said circuit and serving to control energizing of the motor, circuit means including a second control switch for conditioning the speed controller to prevent speeds of rotation of the rotor beyond a predetermined value, a manually operable member movable between limiting positions, means forming an operating connection between said member and said locking means, a connection between said member and said valve to position the valve to vent the chamber when the cover is unlocked and to close the valve when the cover is locked, and means operating said first control switch responsive to operation of said manually operable member, operation of said first control switch when said member is turned to effect locking of the cover serving to energize the circuit to said motor to drive the vacuum pump, operation of said second switch responsive to turning said member to effect locking of the cover serving to condition said speed controller to permit speeds of operation in excess of said predetermined speed, latch means for locking said manually operated member in the limiting position which it occupies when the cover is locked, and circuit means activated by said speed controller for causing release of said latch means when the rotor is operating at a speed below said predetermined speed.

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References Cited in the file of this patent

UNITED STATES PATENTS

Number	Name	Date
2,209,723	Ayres	July 30, 1940
2,261,936	Johnson	Nov. 11, 1941
2,447,330	Grebmeier	Aug. 17, 1948

FOREIGN PATENTS

Number	Country	Date
577,522	Germany	June 1, 1933
585,044	Germany	Sept. 28, 1933