This invention relates to pumps or compressors of the kind comprising a displacing piston disposed in a chamber so as to leave a crescent-shaped space between the piston and the chamber, the chamber having imparted to it a bodily circular or substantially circular movement without rotating about its axis so that the piston is caused by centrifugal action to rotate in the casing so that it travels round the wall thereof and draws fluid from an inlet and expels it through an outlet disposed respectively on opposite sides of a self-adjusting projection or vane which extends between the casing wall and the piston. In compressors of this kind it will be seen that there are eccentrically rotating masses and hitherto such compressors have had the drawback that they cannot be balanced so that the machine was apt to work in an unsteady and jerky manner and to be noisy. The object of the present invention is to provide such a compressor in which the moving parts shall be substantially balanced.

When an external force acts on a body in a given direction the body will be caused to move about a point, which will hereinafter be termed the centre of percussion of the body for such force, and if the body is suspended so as to be movable in all directions about this centre of percussion the application of the external force referred to will not produce any reaction at such point. The value of the external force does not affect the position of the centre of percussion but only the absolute speed of the movement which will be imparted to the body about such point by the force.

Further, in bodies of shapes which possess an axis of symmetry so that two of the principal moments of inertia thereof are equal, forces applied to the body in different directions but in a single plane at right angles to the axis of symmetry and in a direction passing through the axis of symmetry may possess a common centre of percussion. In the same way the resultant of systems of parallel forces acting on the body and which lies in the same single plane referred to above and passes through the axis of symmetry may have the same centre of percussion as a single force applied to the body in the same manner. Again, small deviations from the positions at which the forces are applied to the body only have slight effect on the positions of the individual centres of percussion so that at a mean point between the centres of percussion for the various forces whose centres of percussion lie close to one another there will be substantially no reaction due to the forces.

According to the present invention a compressor of the type described is so constructed and arranged that the various forces due to the rotating masses or the resultants of such forces have centres of percussion which coincide or approximately coincide so that during operation of the machine there will be at a single point substantially no reaction due to these forces. The casing of the machine is preferably supported so that any movement thereof takes place about the common centre of percussion for the various forces so that these forces have substantially no reaction at the point about which the casing can move.

Three alternative constructions according to the invention are diagrammatically illustrated by way of example in the accompanying drawings, in which Figure 1 is a sectional side elevation of one form of compressor formed as a unit with an electric motor for operating it. Figure 2 is a cross-section on the line II—II of Figure 1.

Figure 3 is a similar view to Figure 1 of an alternative form of compressor adapted to be driven from an external source of power. Figure 4 is a similar view to Figure 1 and 2 of a still further form of compressor in which the compressor and the motor for driving it are formed as a unit but the motor does not participate in the movement of the compressor chamber.
Figure 5 shows a form of mounting for the suspension of the swinging casing of a compressor according to this invention, and Figure 6 is a plan of the arrangement shown in Figure 5 with one of the discs removed.

In the construction shown in Figures 1 and 2 the machine comprises a housing 1 the upper end of which contains an electric motor 2 while secured to its lower end is the compressor casing 3. The housing 1 is suspended from the supports 5 so as to be movable about the point 4 by means of a flexible universal mounting comprising two stationary suspension brackets 6 connected by flexible metal strips 7 to lugs 9 on a ring 8 which in turn is connected to the housing 1 by further flexible metal strips 7a each secured at one end to lugs 6a on the housing and at its other end to lugs 9a on the ring 8, the resilient strips 7a being angularly displaced by 90° from the resilient strips 7 so that the housing 1 is permitted by the resilience of the strips 7 and 7a to rock about the centre 4.

Rigidly secured to the housing 1 is the stationary pole ring 10 of the electric motor 2, while the shaft 11 of this motor carrying the armature 12 is mounted at its upper and lower ends in bearings 13 and 14 in the housing. Rigidly mounted on the opposite ends of the motor shaft 11 are rotating masses 15 and 16, these masses being angularly displaced from one another by an angle of 180° so that when they are rotated by the motor they will, while their centrifugal action, tend to impart to the whole housing 1 a circular pendulum movement about the point 4.

The compressor casing 3 contains a cylindrical bore 18 communicating with inlet and outlet passages 19 and 20 and containing a displacer piston 24 between which and the bore 18 is left a crescent-shaped working space, the displacer piston 24 being provided at opposite ends with flywheel or inertia members A and B. Extending from a slot in a cylindrical wall of the bore 18 between the inlet and outlet passages 19 and 20 is a vane 27 pressed into contact with the displacer piston 24 by a spring 28 while a non-return valve 29 is provided in the outlet passage 20 as shown.

The operation of the compressor is as follows. When the motor 2 is brought into operation the centrifugal forces 21 and 22 due to the weights 15 and 16 cause the machine housing 1 to execute a circular pendulum movement about the point 4 in such a manner that the axis of gravity 26 of the housing will move on the surface of a cone the stationary axis of which is the common axis of gravity 23 of the whole apparatus, half the angle of aperture of the cone being equal to the angle a indicated in Figure 1. Owing to this circular pendulum movement of the casing 1, the displacer piston 24 will be caused to rotate in or roll round the wall of the cylindrical bore 18 and, when the machine is working without load, this displacer piston will at all times be angularly displaced relatively to the mass 15 about the axis 26 of the housing by approximately 180°, the direction of rotation of the mass bodies 15, 16, 24, A and B of the rotating pendulum movement of the machine housing being the same.

The displacer piston 24 draws in through the inlet pipe 19 into the suction chamber the fluid to be compressed and delivers the compressed fluid to the delivery pipe 20 through the non-return valve 29, the suction and delivery chambers being separated by the spring pressed vane 27. When the apparatus is thus in operation there is a difference of pressure between the suction and the delivery sides of the displacer piston so that this piston will no longer be displaced by an angle of approximately 180° from the weight 15 about the axis 25 but will lag to an extent dependent upon the difference in pressure on the two sides thereof, i.e. upon the work being performed by the compressor.

The arrangement and disposition of the three masses 15, 16, 24, A and B which rotate and therefore exert forces on the housing, is such that the centre of percussion of the housing due to the centrifugal force 25 produced by the piston mass 24 A and B and also the centre of percussion of the housing due to the centrifugal forces 21 and 22 produced by the rotating masses 15 and 16 coincide at the point 4 which has been chosen as the point about which the housing is free to rock. It will thus be seen that during operation of the machine no reaction will be produced on the fixed supports 5 by the forces due to the rotating masses 15, 16, 24, A and B with the result that a smooth running of the machine free from disturbances will be ensured.

In the construction shown in Figure 3 the machine comprises a machine housing 30 rigidly mounted within which is the compressor casing 31. The machine housing 30 is suspended from its upper end by a ball member 40 engaging a part-spherical socket 41 in a support 42 so that the housing can have a circular pendulum movement about the point 44, the extent of this movement being limited by the pin 43 passing through an aperture in the socket 41. Supported in bearings 37, 38 in the housing 30 so as to be coaxial with the compressor casing is a shaft 36 having an eccentric weight 33 at its lower end and having mounted on its upper end a pulley 39 whereby rotation can be imparted to the shaft and hence to the weight 33. Centrifugal force due to this weight thus acts on the housing and causes it to execute a circular pendulum movement about the point 44. As
shown the pulley 39 is obliquely mounted on the end of the shaft 36 so that in spite of the circular pendulum movement of the housing this pulley will rotate about a substantially stationary axis. The arrangement of the pulley is further such that the axis of the belt for driving it is situated in the horizontal plane drawn through the centre 44 of the ball joint so that the pull on the belt does not affect the circular pendulum movement of the housing.

Formed within the compressor casing 31 is a cylindrical piston chamber 48 around which rolls the piston 35 so as to draw fluid from an inlet passage 49 and expel it through an outlet passage 48, the arrangement being generally similar to that illustrated in Figures 1 and 2.

The operation is also generally similar to that of the construction shown in Figures 1 and 2. The machine housing 30 is caused to have a circular pendulum movement about the point 44 by reason of the eccentricity of the rotating weight 33 and, under the action of this circular pendulum movement the piston 35 is caused to roll round the piston chamber 48.

The whole arrangement is such that the centre of percussion of the housing due to the centrifugal force 46 produced by the eccentric mass 33 and the centre of percussion of the housing due to the force 47 exerted thereon by the piston coincide at the point 44 so that there is no reaction exerted by these forces on the support 42 and a steady operation of the machine thus tends to take place.

In the construction shown in Figure 4 the apparatus comprises a machine housing 55 which is suspended by means of a universal support 56 and a bracket 57 from a fixed frame 58. Mounted in the housing 55 is an electric motor comprising a stator 60 and a rotor 63 mounted on a shaft 64 carried in bearings 61, 62 in the housing. Mounted on the lower end of the motor shaft 64 is a radial arm 65 and a counterbalancing weight 66 and carried by the radial arm 65 at a point eccentric with respect to the axis of the shaft 64 is a bearing 69 with which engages the upper end of a compressor casing 67 which is connected at its lower end by an arm 70 and a universal coupling 71 to the housing 55 as shown. A displacer piston 72 operating within the compressor casing is adapted to draw fluid from an inlet passage 77 and deliver it through an outlet passage 78, these passages being connected by helical portions 75, 76 arranged around the arm 70 to inlet and outlet pipes 73, 74 passing through the housing 55, the helical portions 75, 76 constituting an elastic connection to permit of the movements of the compressor casing 67 relatively to the housing.

In this construction rotation of the shaft 64 imparts to the compressor casing through the bearing 69 a rotary pendulum movement about the universal joint 71 so as to cause the displacer piston 72 to roll round in the compressor chamber and thus draw fluid from the inlet passage 77 and expel it through the outlet passage 78. Assuming that the piston 72 always operated at the same compression pressure so that at any movement it occupied a definite known angular position relatively to the weight 66 the centrifugal forces due to this piston as well as those due to the rotary pendulum movement of the casing could be balanced by the flywheel weight 68. Owing, however, to differences in pressure at which the compressor operates the position of the displacer piston 72 relatively to the weight 66 may vary and will in fact vary during each revolution. Thus the forces due to the movement of the piston 72 will vary throughout each revolution and the reaction on the arm 63 due to these forces will result in the latter rotating at a variable angular velocity and will at the same time produce a reaction on the bearings 61, 62 tending to produce a swinging pendulum movement of the housing 55.

According to the present invention the housing 55 is suspended at the centre of percussion thereof for the above forces so that these forces will not exert any reaction on the fixed support 58.

Instead of the universal suspension devices of a resilient or other kind, as shown in Figures 1 and 2 or in Figure 4, or of the ball and socket type as in Figure 3, some other form of self-aligning flexible suspension device may be employed. For example the compressor may be suspended as shown in Figures 5 and 6 by a spindle 80 to the upper end of which is connected a disc 81 having a conical lower face 82 which engages with the similarly conical upper face 83 of a further disc 84 surrounding a tubular projection constituting part of a rigid supporting frame 88. The arrangement is such that as the shaft 80 swings due to the circular pendulum movement of the compressor the surface 82 rolls round on the surface 83, the position of the apices of the two cones formed by these surfaces coinciding and remaining immovable. The angle of aperture of the cones is the supplement of the angle between the common axis of gravity of the casing and the masses carried thereby considered as a whole and the axis of gravity of the casing considered alone. Line contact is thus produced between the two conical faces during operation of the machine.

In order to prevent rotation of the pin 80 about its axis a fixed or resilient pin 86 may be passed through the point 85 about which the shaft swings and may engage recesses 87 in the fixed support 88.

It is to be understood that any one of the three compressors illustrated may be sus-
pended in various ways so as to be capable of the desired circular pendulum movement but not to be rotatable about their common axes of gravity. Further, various resilient or flexible materials, such as leather, balata or steel strips may be used for suspending the machine so as to avoid noise. Again, the pipes leading from the compressor casing are preferably secured to the fixed part of the apparatus at a point close to the point about which the housing swings so as to reduce as far as possible the bending of such pipes, these pipes preferably being twisted for example helically, spirally or conically between the point where they leave the swinging casing or housing and the point where they are secured to the stationary parts so as to provide the desired flexibility. Again, where power is transmitted to the apparatus from an external source instead of employing a pulley as shown in Figure 3, bevel gears or universal joint connections may be employed.

I claim:

1. A compressor-apparatus, comprising a driving-system, a compressing-system, and at least one casing-system mounted to revolve and swing about a single point, said compressing-system being mounted to be actuated by the centrifugal forces set up by said swinging casing-system, said systems reacting respectively on each other to produce respective centers of instantaneous rotation, the said systems being arranged and mounted to mutually react on each other to cause the said respective centers of instantaneous rotation to coincide in a single common point for the entire apparatus, the apparatus being pivotally suspended as a whole at a point thereof related to the various reactions of the systems on each other that the centers of instantaneous rotation are maintained substantially immobile and fixed.

2. A compressor according to claim 1, in which the apparatus has a gravity-axis for the casing-system and the compressing system has a housing and the apparatus is suspended at the point of claim 1 so as to permit movement of the apparatus in such directions as are sufficient to allow the gravity-axis of the casing-system to move under said forces in a vertical-conical path with the apex of the cone coinciding with the suspension point of the compressor housing and with the common center of instantaneous rotation, whereby to make half the angle of aperture of the cone no less than the angle between the gravity-axis of the compressor-housing and the gravity-axis of the said housing together with the masses directly supported thereby.

3. A compressor according to claim 1, in which there are means for suspending the compressing system housing immobile as to rotating about its axis of gravity, but free to undergo a circular pendulum movement of translation under the influence of said forces.

4. A compressor according to claim 1, in which there is a housing for the three systems and for the entire apparatus, and the rotatable means are eccentrically mounted on an axis stationary relative to said housing, masses acting on said housing, and means for making said masses act on said housing to produce a circular pendulum movement of the whole apparatus.

5. A compressor as recited in claim 1, in which there is a housing for the entire apparatus, a container for the compressor-system mounted within said housing, and means for moving the compressor-container within said housing in a circular-pendulum path, said means including a rotatable member, and an eccentric, positive connection between said compressor container and said rotatable member.

6. A compressor as recited in claim 1, in which there is a housing for the entire apparatus, rotatable masses eccentrically mounted on an axis stationary relative to said housing, and a motor for rotating said masses, said motor being rigidly associated with said housing.

7. A compressor as recited in claim 1, in which there is a housing for the entire apparatus, rotatable masses eccentrically mounted on an axis stationary relative to said housing, and means for rotating said masses from a remote source of power.

8. A compressor as recited in claim 1, in which there is a housing for the entire apparatus, rotatable masses mounted eccentrically on an axis stationary relative to said housing, mechanical power-transmission means for rotating said masses by a remote source of power, and a driving connection therebetween, said power-transmission means being disposed eccentrically with respect to the suspension-point of said housing, whereby the driving connection member is rotated about a virtually stationary axis.

9. A compressor as recited in claim 1, in which there is a housing for the compressor system, a rotatable mass eccentrically mounted on an axis stationary relative to the housing, and a motor for driving the rotatable mass to impart circular-pendulum movement to the compressing system, said motor having a motor-housing, the compressor system housing and the motor housing being connected unitarily and thereby forming the housing for the entire apparatus.

10. A compressor as recited in claim 1, in which there is a housing for the entire apparatus and the compressing system is pivotally and resiliently mounted within said housing by means for permitting relative movement of said compressing system about the center of movement of the apparatus housing under the centrifugal forces acting in said compressing-system.
11. A compressor as recited in claim 1, in which there is a housing for the entire apparatus, a fixed support, a conical disc thereon, a main shaft, a conical disc thereon in engagement with said first disc to thereby support the entire apparatus, the common conical-apex of both discs being situated substantially coincident with the center of instantaneous rotation of the housing as regards the said centrifugal forces.

In testimony whereof I have affixed my signature.

OSCAR SIMMEN.