March 1, 1955 S. J. STEENSEN 2,703,370

ELECTRIC COMPRESSOR OR PUMP MOTOR WITH ROLLING ROTOR

Filed July 2, 1952 4 Sheets-Sheet 1

Fig. 1.

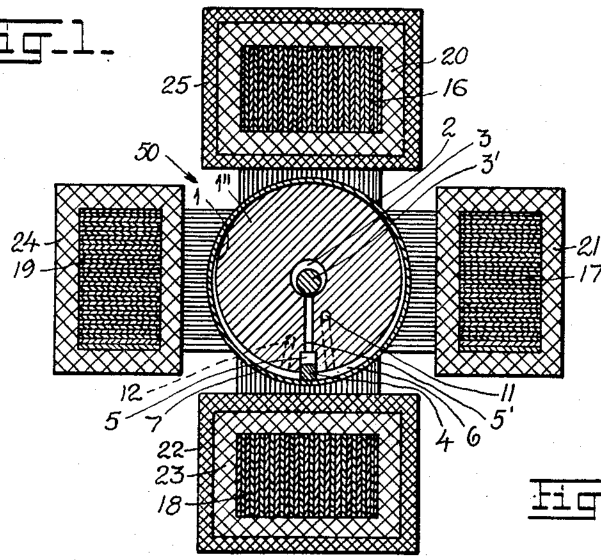

Fig. 3.

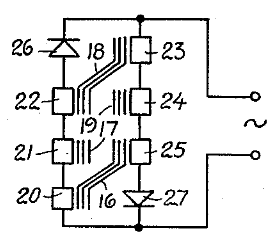

Fig. 2.

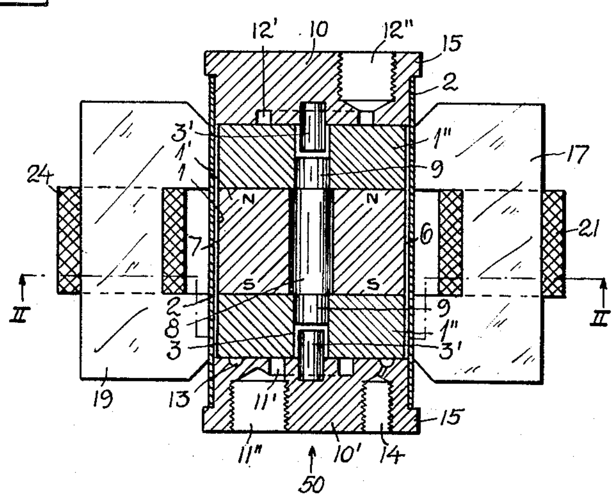

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Fig. 7.

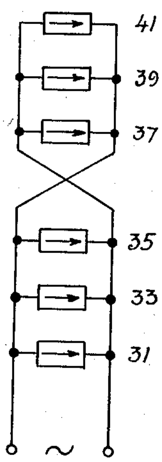

Fig. 4.

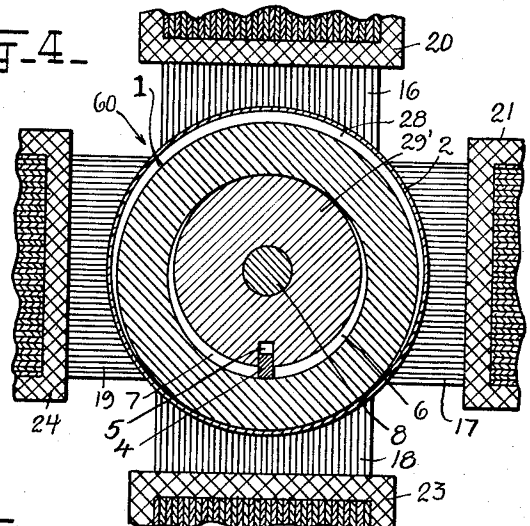

Fig. 5.

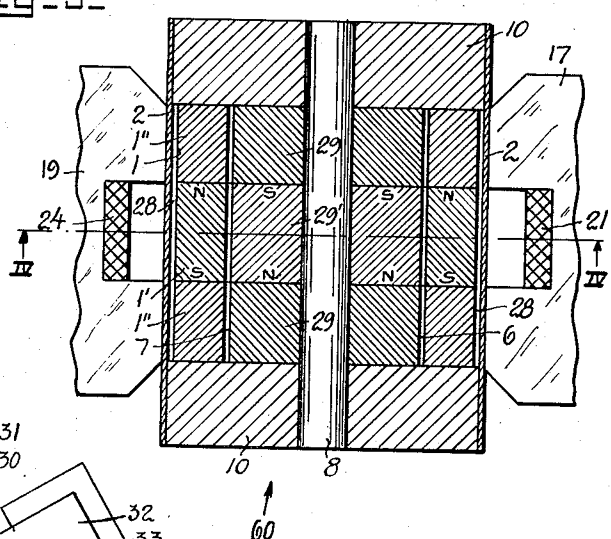

Fig. 6.

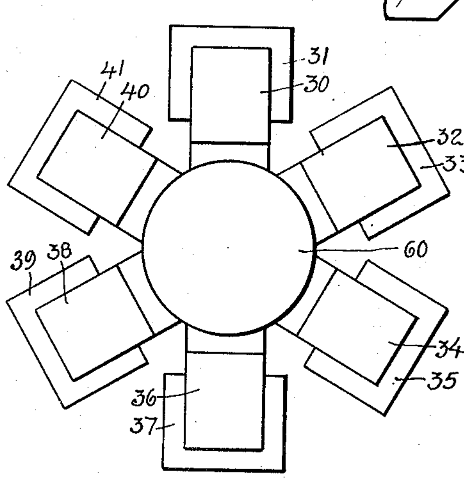

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Fig. 8

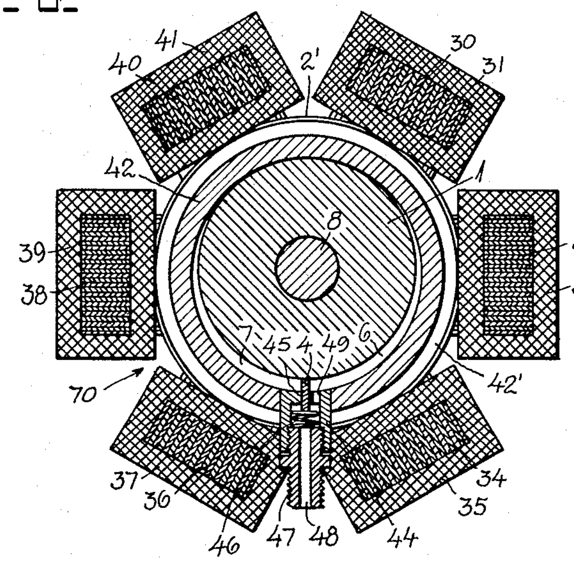
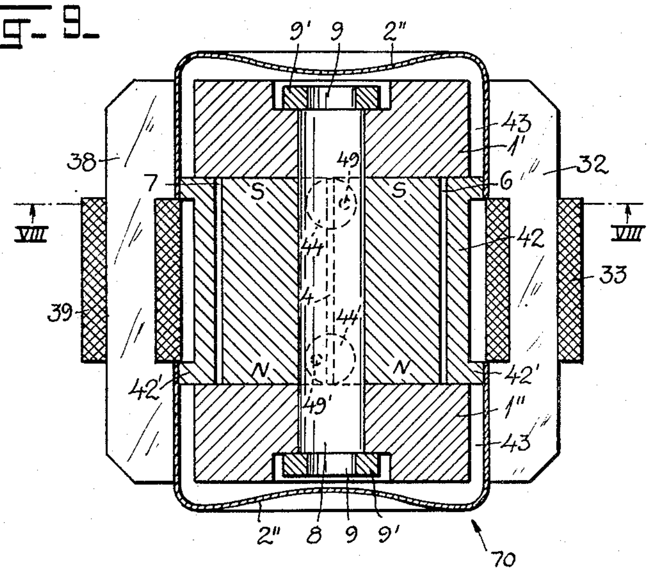


Fig. 9



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ELECTRIC COMPRESSOR OR PUMP MOTOR WITH ROLLING ROTOR

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Fig. 10

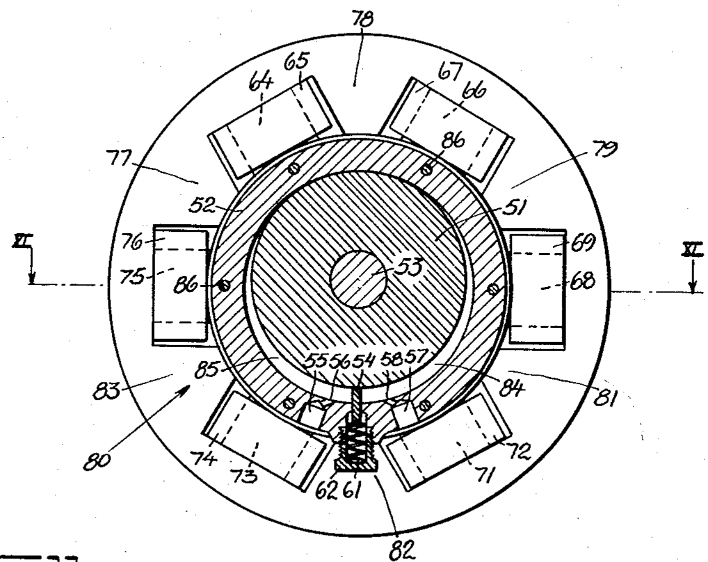
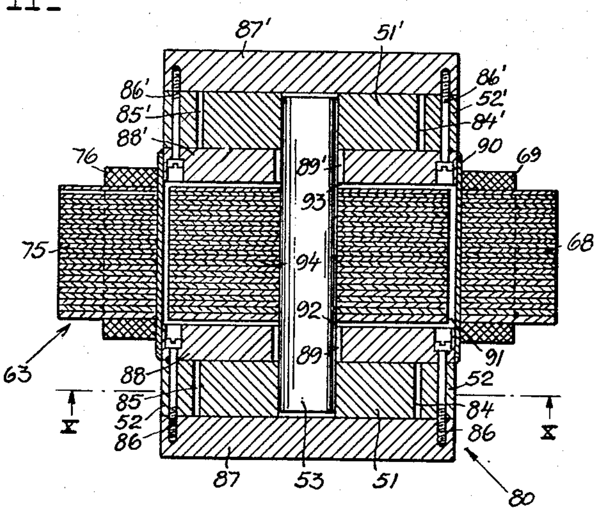


Fig. 11



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ELECTRIC COMPRESSOR OR PUMP MOTOR WITH ROLLING ROTOR

Sverre Johan Steensen, Ulleval Hageby, Oslo, Norway

Application July 2, 1952, Serial No. 296,798

14 Claims. (Cl. 310—82)

This invention relates to compressors or pumps of the type comprising a cylindrical piston rolling within a cylindrical pump housing, and having a magnetic driving means which applies the rolling movement to the piston through the wall of the pump housing. This magnetic drive avoids the necessity of providing a mechanical connection between the rolling piston and an outer driving means so that the compressor compartment may be completely sealed except for inlet and outlet ports, thus eliminating the necessity for stuffing boxes which will become leaky and require periodic maintenance and replacement.

The invention is especially concerned with the magnetic driving means.

It has previously been known that a rolling movement may be applied to a piston by means of magnets coupled with the piston through the cylindrical wall of the pump housing, in which case said wall is usually relatively thin. Such coupling does not require any direct mechanical connection between the piston and its driving means. Annular magnets, rotating concentric with and externally of the cylindrical pump housing and driven by a separate motor have been suggested. Also a magnetic field which is displaced stepwise along the circumference of the pump housing may be used, which field can be obtained by means of fixed electromagnets which are switched in and out in turn by a rotating multicontact switch.

The main object of the invention is to improve driving means of the type using a number of fixed electromagnets which are evenly distributed along the outer circumference of the cylindrical pump housing, and more specifically to avoid the necessity of using a rotating switch which has to be driven by a motor, or by a step by step magnet of the electromagnetic type.

This object is attained according to the invention, by dividing the coils of evenly distributed electromagnets into groups such that the resultant electromagnetic force of any group, when connected to an electric current source, is displaced up to 180 electric degrees relative to the resultant electromagnetic force of the adjacent group of coils.

Preferably, the rolling piston is magnetized in its axial direction, such as by means of an annular permanent magnet forming part of the piston.

These and other features of the invention will be readily understood from the description and from the drawings, in which

Fig. 1 shows a compressor in radial section along the broken line II—II in Fig. 2,

Fig. 2 is an axial section of the compressor shown in Fig. 1, and

Fig. 3 illustrates diagrammatically the electrical connection of the electromagnet coils of the compressor shown in Figs. 1 and 2.

Figs. 4 and 5 show a modified construction of the compressor in radial and axial section respectively, Fig. 4 being a section along the line IV—IV of Fig. 5.

Fig. 6 illustrates an embodiment of the magnetic driving means especially suitable for alternating current, and

Fig. 7 illustrates diagrammatically the electrical connections for the embodiment shown in Fig. 6.

Figs. 8 and 9 show a further embodiment of a compressor in radial section and axial section respectively, Fig. 8 being taken along the line VIII—VIII of Fig. 9, and

Figs. 10 and 11 show an embodiment of a double or twin compressor in radial and axial section respectively, Fig. 11 being taken along the line XI—XI of Fig. 10.

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The compressor shown in Figs. 1 and 2, which is generally numbered **50**, consists of an inner cylindrical piston **1** which may roll along the inner wall of a cylindrical pump housing **2**. As will appear from Fig. 2, the piston is built up from an annular magnet **1'** which is magnetized in its axial direction as indicated in the conventional way by letters N and S, and two disk shaped end pieces **1''** of ferrous material which form pole shoes. These three parts, viz. the annular magnet and the two end pieces, are held together by a central bolt **8** the end portions **9** of which are of a somewhat reduced diameter. Furthermore, said piston has an axis parallel slot **5** which is radially directed and into which is inserted a separating wall **4** which is freely moveable radially in said slot **5**.

The pump housing consists of a thin metallic cylindrical sleeve **2** closed at both ends by end pieces **10** and **10'** which are pushed into the cylinder **2** and which have collars **15** resting against the ends of said cylinder. After having been pushed into the cylinder the end pieces are secured in said position in a pressuretight manner, such as by soldering or welding. The piston **1** is of such dimensions that it will have sliding fit between the endpieces **10** and **10'**, and some clearance within the cylindrical pump housing, so that it may roll along said cylindrical wall without moving axially. In the position shown in Fig. 1 the piston is in contact with the upper portion of the pump housing.

The space formed between the end pieces **10** and **10'**, the inner wall of the pump housing and the outer surface of the piston is divided into two compartments **6** and **7** by the separating wall **4**. One of these compartments is the suction compartment and the other the pressure compartment, dependent upon the rolling direction of the piston. Thus, when the piston is rolling clockwise as seen in Fig. 1, **7** will be the suction compartment and **6** the pressure compartment. Said compartments communicate with annular channels **11'** and **12'** in the end pieces **10'** and **10** respectively through borings **11** and **12** respectively in the piston. The annular channels **11'** and **12'** connect with inlet and outlet ports **11''** and **12''** respectively in the two end pieces **10** and **10'** respectively.

As appears from Figs. 1 and 2, the end pieces **10** and **10'** have centrally arranged pins **3'** which are directed into the pump housing and located within central bores **3** formed in the pole pieces **10** and **10'**, clearance being provided so that the piston **1** may rotate epicycloidally around the pins.

The rolling piston is driven magnetically by means of four electromagnets the cores **16**, **17**, **18** and **19** of which are evenly distributed along the outer circumference of the pump housing **2**. As may be seen in Fig. 2, said cores have the form of horse shoe magnets and are preferably formed of laminated iron. When magnetized by their respective coils, said magnetic cores act upon the permanently magnetized piston **1** through the thin cylindrical wall **2** and the air gaps represented by the compartments **6** and **7**, as may be seen in Figs. 1 and 2. The opposite magnet cores **16** and **18** are each provided with two coils, **20** and **25** being associated with core **16**, and **23** and **22** being associated with core **18**. Each of the other two magnets **17** and **19** have only one coil, **21** being associated with core **17** and **24** being associated with core **19**.

Said coils **20**, **21**, **22**, **23**, **24**, and **25** are divided into two groups, the coils **20**, **21** and **22** belonging to the first group and the coils **23**, **24**, and **25** to the second group. Said two groups of coils are switched in and out alternately by appropriate means to be described below.

An important feature of the invention resides in the choice of the number of turns in the three coils belonging to a group in such way that they will provide a different number of ampere-turns, increasing in the rolling direction of the piston. For instance, the three coils forming the first group, **20**, **21** and **22**, may have 100, 200 and 300 ampere-turns respectively. Thus, the resultant force of this group of magnet coils will not be located along the axis of the core **17** as would be the case if the coils contained an equal number of ampere-turns, but is displaced in the rolling direction of the piston relative to the axis of core 17. Thus, provided the above mentioned number of ampere-turns be used, for the first group the resultant of the magnetic force will be located at the corner between magnets 17 and 18. Correspondingly, for the second group, if coils 23, 24 and 25 have 100, 200, and 300 ampere-turns respectively, the resultant will be at the corner between magnets 17 and 19.

Assuming the right or first coil group, i. e. coils 20, 21 and 22, is supplied with current when the piston 1 is in the position shown in Fig. 1 the piston will be forced to roll along the right inner wall of the pump housing, i. e. clockwise towards the position which corresponds to the resultant magnetic force of said group of coils.

During the first interval of the movement the weaker magnet 17 will become more important than the stronger magnet 18, which is due to the fact that the air gap between the piston and magnet 17 is less than the air gap between the piston and magnet 18. However, during the rolling movement of the piston the air gap will be gradually reduced so that the piston will continue to roll until it has reached a 180° position, which is the position opposite to that of Fig. 1. In this latter position the lower part of the outer surface of the piston 1 will be in contact with the periphery of the pump housing 2 and the separating wall 4 will be forced into slot 5. During this part of the movement the liquid or the gas which may be present in compartment 6, will be pressed out through the channels 11 and 11′ and the outlet 11″. At the same time compartment 7 will increase in volume and cause liquid or gas to be drawn into the same through inlet 12″ and channels 12′ and 12.

The separating wall 4 may be held against the inner wall of the pump housing 2 by means of some known means, such as a spring placed in the bottom of the slot 5, or by magnetic action, said separating wall 4 in such case being made from ferro-magnetic material.

When the piston 1 reaches its lowermost position the current supply to the first coil group is interrupted. Simultaneously the second group, comprising the coils 23, 24 and 25, is switched in so that the piston will continue its rolling movement.

Owing to the fact that the piston 1 has a smaller diameter than the inner wall of the pump housing 2, during operation the separating wall 4 will be displaced slowly along the inner circumference of the pump housing opposite to the movement of the piston. This has been taken into consideration by forming both communicating channels 11′ and 12′ as annular channels, whereby intake and exhaust may be accomplished irrespective of the position of the separating wall 4.

The periodic switching in and out of the coil groups may be carried out in different ways. For instance, both circuits may be controlled by an inverter of the pendulum type or the like, a direct current source being used. In Fig. 3 is shown diagrammatically how the compressor may be driven by an alternating current source. Each of the coil groups are connected in series with vacuum tubes, such as diode rectifiers 26 and 27 respectively, the series circuits being connected in parallel with an alternating current supply with the diodes arranged to conduct in opposite directions. The magnet cores have also been illustrated diagrammatically so as to show that the coils 22 and 23 as well as coils 20 and 25 are arranged on common cores respectively.

When, as in the present case, only two groups of magnet coils are used, the magnetic resultant vector will be displaced 180 geometrical or electrical degrees when the subsequent group is switched in, and, of the system be supplied with 50 cycle alternating current, the speed of the compressor piston will be 50 revolutions per second or 3000 revolutions per minute. If, for instance, four coil groups are used, the displacement of the magnetic resultant vector will still be 180 electrical degrees, but will be only 90 geometrical degrees. In this latter case the piston will rotate at half speed as compared with the two coil group embodiment, i. e. 1500 revolutions per minute. Obviously any even number of groups may be used, giving a speed which is equal to 3000 multiplied by $2/n$, in which n is the number of coil groups used.

Figs. 4 and 5 show the same driving system described above used on a modified construction of compressor, generally numbered 60. The rolling piston 1 consists of a thickwalled hollow cylinder which may roll on a fixed solid core 29, 29′. Said hollow cylinder 1 is arranged within a cylindrical housing consisting of a thin walled hollow cylinder 2 closed at each end by end pieces 10 in the same way, as the pump housing shown in Figs. 1 and 2. Whereas the hollow cylindrical piston 1 has direct contact with the core 29, 29′ it does not, at any point, touch the cylindrical wall 2, a very narrow space being present which is not visible in the drawing. The two chambers separated by the separating wall 4, are numbered 6 and 7, 6 being the pressure chamber and 7 being the suction chamber for clockwise rotation. Said separating wall 4 is inserted into a slot 5 in the core 29, 29′, which core is fixed, by an axial bolt 8, to both end pieces 10 and prevented from being turned about the bolt 8. The space between the rolling piston 1 and the cylindric housing 2 is numbered 28 and does not form part of the compressor compartment.

The compressor 60 as shown in Figs. 4 and 5 acts in the same way as that described above with reference to Figs. 1 and 2.

However, the modified construction has the advantage that the core 29, 29′ as well as the hollow cylindric piston 1 may be permanently magnetized, as by annular magnets 29′ and 1′ respectively, each having annular pole shoes 29 and 1″ respectively. This arrangement will give a more responsive action as compared with the first embodiment and a better contact between the fixed core 29, 29′ and the rolling piston 1. The driving means for the compressor according to Figs. 4 and 5 is as previously described in connection with Figs. 1, 2 and 3, and the operation is the same.

In Fig. 6 is shown a driving arrangement especially designated for alternating current. Six magnets 30, 32, 34, 36, 38 and 40 are evenly distributed along the outer circumference of the pump housing and divided into two groups each comprising three magnets, 30, 32, 34 and 36, 38, 40 respectively. Each of said magnets is provided with one magnetizing coil 31, 33, 35, 37, 39 and 41 respectively. The compressor itself may be of the same type as described above in connection with Figs. 4 and 5, and is therefore numbered 60, but it should be understood that a compressor as described in connection with Figs. 1 and 2 may be used with the driving system shown in Fig. 6.

The three coils of each group are arranged so that they will give a resultant magnetization in the same direction. The coiling direction of all the six coils is the same, which means that all will cause the same direction of magnetization for the same current direction. However, it should be understood that each group of coils may be coiled in opposite directions, provided they are fed so that the two groups will have opposite directions of magnetization simultaneously.

Fig. 7 illustrates diagrammatically that all the coils are coiled in the same direction, as indicated by arrows within the rectangles symbolizing the coils.

When the alternating current is switched in, all six coils will act simultaneously. Owing to the fact that the piston is polarized, the force which acts on the piston will be doubled as compared with the driving embodiment according to Figs. 1, 2, 4 and 5, one magnet group pushing the piston away whereas the other group attracts the same.

In the embodiments described above with reference to Figs. 1, 2 and 4, 5 the magnetic driving means is of substantially the same axial length as the compressor itself. In many cases, however, it may be desirable or necessary to use a more powerful magnetic system which will give an increased pressure as compared with magnetic systems of the aforesaid embodiments.

Such need for an increased pressure may be met when the driving means and the compressor are separated in some way. Two such embodiments are now to be described with reference to Figs. 8, 9 and 10, 11, of which Fig. 8 is a section taken along line VIII—VIII in Fig. 9 and Fig. 11 is a section taken along line XI—XI in Fig. 10.

In Fig. 8 the compressor, generally numbered 70, may be of any type having a rolling piston. Said piston 1 is fixed to an axial bolt 8 and arranged within a compartment defined by the inner surface of an open-ended cylinder 42′ having collars or flanges 42′, and two thin-walled endcaps 2″. The inner wall of the cylinder 42 has a smaller diameter than the inner walls of the cylindric portion 2′ of the endcaps 2″, the latter diameter being the same as the outer diameter of the collars 42′.

By means of the axial bolt **8** and nuts or rings **9'** on the reduced ends **9** of said bolt **8**, two solid cylindrical iron bodies **1'** and **1''** are fixed to the ends of the piston **1**. Said nuts or rings **9'** are arranged in recesses in one end portion of said iron bodies **1'** and **1''** respectively, as shown. The diameter of said bodies is less than the inner diameter of the cylindric portions **2'** of the end caps **2''** so as to form annular gaps **43** therebetween. The end bodies **1'** and **1''** act as pole shoes for the piston **1** which forms a permanent magnet, as indicated in the conventional way by letters N and S. As will be understood said piston **1**, pole shoes **1'** and **1''** and bolt **8** form together a rigid system which will oscillate within the closed compressor compartment by means of magnetic forces applied thereto.

Due to the fact that there is a close fit between the ends of the open-ended cylinder **42** and the inner end surfaces of the pole shoes **1'** and **1''**, said end surfaces and said cylinder **42** define the compressor compartment.

Outside the compressor housing formed by the hollow cylinder **42** and the end-caps **2'**, **2''** are arranged six axis parallel electro-magnets consisting of laminated cores **30**, **32**, **34**, **36**, **38**, and **40** each having one magnetizing coil **31**, **33**, **35**, **37**, **39** and **41** respectively. As in the embodiments described above, said electro-magnets are evenly distributed along the outer circumference of the compressor housing.

As will be understood, the electro-magnets and the pole shoes **1'** and **1''** may have any practical axial length corresponding to a compressor compartment of a given size, so as to give a driving force of sufficient magnitude.

The pressure and suction compartments of the compressors are numbered **6** and **7** respectively, and are separated by a separating wall **4**, which is of the same length as the compressor compartment proper, and which is movable in a radial direction in a slot **45** in the wall of the cylinder **42**. Said separating wall **4** is urged against the outer surface of the piston **1** by springs **46** arranged within sockets **44** and **44'** which are inserted in a gas tight manner in the cylinder **42**, as shown in Figs. 8 and 9. The outer portion of said sockets **44** and **44'** have internal threads for nipples **47** which nipples have an outer flange and two threaded portions, as well as a bore **48** as illustrated in Fig. 8. The inner end walls of said sockets **44** and **44'** have slots **45** which are in line with the before-mentioned slot in the wall of the cylinder **42**, as well as openings **49** and **49'** respectively. Said last mentioned openings communicate with the pressure and suction compartments **6** and **7** respectively.

Between the portions of the outer edge of the separating wall **4** located within the sockets, and the inner ends of the nipples **47**, are placed coil springs **46**, the tension of which may be adjusted by screwing the nipples more or less into the sockets **44** and **44'**. The outer end of each of the nipples **47** is used to provide the outer connections to the pressure and suction compartment respectively.

In order that the piston **1** shall always have good contact with the inner wall of the hollow cylinder **42**, the air-gaps **43** between the pole shoes **1'** and **1''** and the inner wall of the cylindric portions of end caps **2''** are made slightly greater than the gaps between the piston **1** and the cylinder **42** forming the suction and pressure compartments **7** and **6**. Thereby is obtained the additional advantage that the pole shoes will not stick to the inner walls **2'**.

The stationary part of the driving means, consisting of six electro-magnets evenly distributed along the outer circumference of the compressor housing, is also in this case divided into two or three groups dependent upon whether direct current and inverter, single phase or three phase alternating current is used.

In the embodiment according to Figs. 10 and 11 an inverse principle is used as compared with the embodiment just described. In this case the driving means is arranged in the middle, and two compressors on either side of said driving means. The compressors are generally numbered **80** and **80'**, and are of exactly the same size and capacity, so that it will only be necessary to describe one of them. The rolling piston **51** is placed within the cylindrical compressor compartment defined by a thick-walled ring member **52** and two cylindric end walls **87** and **88** clamped to said ring **52** by throughgoing screws **86**, as shown in the drawing. The separating wall **54** is inserted in an axis parallel slot in the ring **52**, and is urged by the spring **61** kept in place by a radially arranged socket **62** threaded into the ring **52**. The pressure and suction compartments are numbered **84** and **85** respectively.

The visible corresponding parts defining the other compressor compartment are numbered **51'**, **52'**, **86'**, **87'** and **88'** respectively.

The pistons **51** and **51'** are fixed to either end of a bolt **53**, the middle portion of which carries a cylindric armature **94** which is laminated, as shown, and arranged within a compartment defined by a thin-walled sleeve **90** closed at both ends in gas-tight manner by the inner cylindric end walls **88** and **88'** belonging to the compressors **80** and **80'** respectively, as shown in Fig. 11.

In this way the middle compartment comprising the armature **94**, as well as the two compressor compartments, are completely sealed but may communicate with one another. However, there will be no communication between said compartments, which is due to the fact that the pistons **51** and **51'** have a sliding fit between their respective end walls.

In the present case the stationary part of the driving means consists of a laminated stator **63** formed with inwardly directed cores **64**, **66**, **68**, **71**, **73** and **75** carrying magnetizing coils **65**, **67**, **69**, **72**, **74** and **76** respectively and intermediate portions **77**, **78**, **79**, **81**, **82** and **83**.

The armature **94** has good clearance between the end-walls **88** and **88'**, and the difference between the inner diameter of the sleeve **90** and the outer diameter of said armature **94** is slightly larger than the difference between the inner diameter of the rings **52** and **52'** and the outer diameter of the respective pistons **51** and **51'**, so as to ensure that the pistons will always be in good contact with the inner wall of the respective compressor compartments, and to prevent sticking of the armature. The gap between the armature **94** and the sleeve **90** is numbered **91**. Corresponding gaps are present between the bolt **53** and the central bores on the inner end walls **88** and **88'**, which gaps are numbered **89** and **89'** respectively.

The compressors have inlet and outlet openings **55** and **57** respectively, formed by bores in the rings **52** and **52'**, which openings communicate with inlet and outlet ports **56** and **58** respectively leading into the pressure and suction compartments **84** and **85** respectively, near the separating wall **54**. Said bores **55** and **57** are preferably threaded so as to be connectable, in a gas-tight manner, with tubes, as will be obvious to those skilled in the art.

The driving means operates substantially in the same manner as previously described, the coils **65**, **67**, **69**, **72**, **74** and **76** being divided into groups and connected with a current supply as previously described. In the present case, however, it is not possible to use a polarised armature with the advantage of pulling as well as pushing forces. Therefore, the groups of coils can not be supplied with current simultaneously but must be switched in and out in sequence.

It is evident that the invention is not restricted to the embodiments shown and described above. So the number of magnets may be increased and divided into further groups. For instance, if four groups are used, as already mentioned, the compressor will rotate with half speed as compared with the compressors described above. It is also obvious that the arrangement according to Fig. 6 may be used in connection with direct current and an inverter. In the same way the arrangement according to Fig. 6 may also be used in connection with a three-phase alternating current supply, the six coils being divided into three groups and each group connected to one phase. In this way a rotating field is established which will cause the piston to roll in the desired direction. In connection with three-phase supply the number of magnets may be increased, for instance to nine, with three magnets per group and phase.

I claim:

1. A motor comprising a cylindrical rotor arranged to rotate epicycloidally within a cylindrical housing, said rotor including a centrally disposed permanent magnet arranged to polarize the rotor in an axial direction, and magnetic driving means including a plurality of electromagnets distributed around the outer periphery of the cylindrical housing, said electromagnets cooperating with the permanently magnetized rotor to produce the epicycloidal rotation.

2. A motor comprising a cylindrical rotor arranged to rotate epicycloidally within a cylindrical housing, said rotor including a centrally disposed permanent magnet and a pair of cylindrical, ferro-magnetic pole shoes concentrically disposed at the poles of said permanent magnet, means securing said magnet and pole shoes as a unit for epicycloidal rotation within the housing, and magnetic driving means including a plurality of electromagnets distributed around the outer periphery of the cylindrical housing, said electromagnets cooperating with the permanently magnetized rotor to produce the epicycloidal rotation.

3. A motor comprising a cylindrical rotor arranged to rotate epicycloidally within a cylindrical housing, said rotor including a centrally disposed permanent magnet and a pair of cylindrical, ferro-magnetic pole shoes concentrically disposed at the poles of said permanent magnet and having their outer peripheries extending axially, means securing said magnet and pole shoes as a unit for epicycloidal rotation within the housing, and magnetic driving means including a plurality of electromagnets distributed around the outer periphery of the cylindrical housing, the cores of said electromagnets being of horseshoe configuration with the poles of said horseshoes in contact with the outer periphery of the housing in juxtaposed relationship to the periphery of the rotor pole shoes, said electromagnets cooperating with the permanently magnetized rotor to produce the epicycloidal rotation.

4. A motor comprising a cylindrical rotor arranged to rotate epicycloidally within a cylindrical housing, said rotor being magnetized by a centrally disposed permanent magnet arranged to polarize the rotor in an axial direction, and magnetic driving means including a plurality of electromagnets evenly distributed around the outer periphery ofthe cylindrical housing, the coils of said electromagnets being divided into groups so that when one of said groups is energized by an electric current the resultant magnetic vector of the group is positioned 180 electrical degrees from the resultant magnetic vector of an adjacent group, the electromagnets cooperating with the permanently magnetized rotor to produce the epicycloidal rotation.

5. A rotor comprising a cylindrical rotor arranged to rotate epicycloidally within a cylindrical housing, said rotor including a centrally disposed permanent magnet and a pair of cylindrical, ferro-magnetic pole shoes concentrically disposed at the poles of said permanent magnet, means securing said magnet and pole shoes as a unit for epicycloidal rotation within the housing, and magnetic driving means including a plurality of electromagnets evenly distributed around the outer periphery of the cylindrical housing, the coils of said electromagnets being divided into groups so that when one of said groups is energized by an electric current the resultant magnetic vector of the group is positioned 180 electrical degrees from the resultant magnetic vector of an adjacent group, the electromagnets cooperating with the permanently magnetized rotor to produce the epicycloidal rotation.

6. A motor according to claim 4 in which the number of ampere-turns in the magnetizing coils belonging to any group of electromagnets increases from coil to coil in the rolling direction of the rotor.

7. A motor according to claim 4 in which four electromagnets are evenly distributed around the outer periphery of the housing, two of the opposite electromagnets having two coils each while the remaining two opposite electromagnets have one coil each.

8. A motor according to claim 4 in which there are two coil groups, each of the coils of a group being connected in series with each other and with a diode rectifier, the two series circuits thus formed being connected in parallel with a source of single-phase alternating current with the series circuits oppositely polarized whereby the series circuits will be alternately energized by a current flowing in opposite directions.

9. A motor comprising a cylindrical rotor arranged to rotate epicycloidally within a cylindrical housing, said rotor being a hollow cylinder open at both ends, a stationary, cylindrical inner core coaxial with the housing, said core having an outer periphery about which the rotor rotates epicycloidally, the inner diameter of the rotor being greater than the diameter of the core whereby a chamber is formed between the outer periphery of the core and the inner periphery of the rotor, and magnetic driving means including a plurality of electromagnets distributed around the outer periphery of the cylindrical housing.

10. A motor according to claim 9 in which the rotor includes a centrally disposed permanent magnet arranged to polarize the rotor in an axial direction.

11. A motor according to claim 9 in which the inner core includes a centrally disposed permanent magnet arranged to polarize the inner core in an axial direction.

12. A motor according to claim 9 in which the rotor includes a centrally disposed permanent magnet arranged to polarize the rotor in an axial direction and the inner core includes a centrally disposed permanent magnet arranged to polarize the inner core in an axial direction, the magnets having reverse polarity whereby the rotor and core are oppositely magnetized.

13. A motor according to claim 4 in which there are two groups of coils, each of said coils being wound in the same direction, the coils of each group being connected in parallel with each other and with a source of single-phase alternating current, the polarity of the two groups being reversed whereby the resultant magnetization of the two groups is reversed.

14. A motor according to claim 4 in which two groups of coils are connected to a common source of single phase alternating current, the coiling direction of each of said coils being chosen so that the resultant magnetization of one group of coils is opposite to the resultant magnetization of the other group.

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