US 20130251566A1

(19) United States
(12) Patent Application Publication
(10) Pub. No.: US 2013/0251566 A1
(43) Pub. Date: Sep. 26, 2013
Thipchuwong

(54) ROTARY COMPRESSOR WITH AN INSTALLED CIRCULATION CONTROL UNIT

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(21) Appl. No.: 13/261,628

(22) PCT Filed: Dec. 10, 2011

(86) PCT No.: PCT/TH2011/000047

§ 371 (c)(1), (2), (4) Date: May 28, 2013

(30) Foreign Application Priority Data

Oct. 12, 2010 (TH) 1001001581

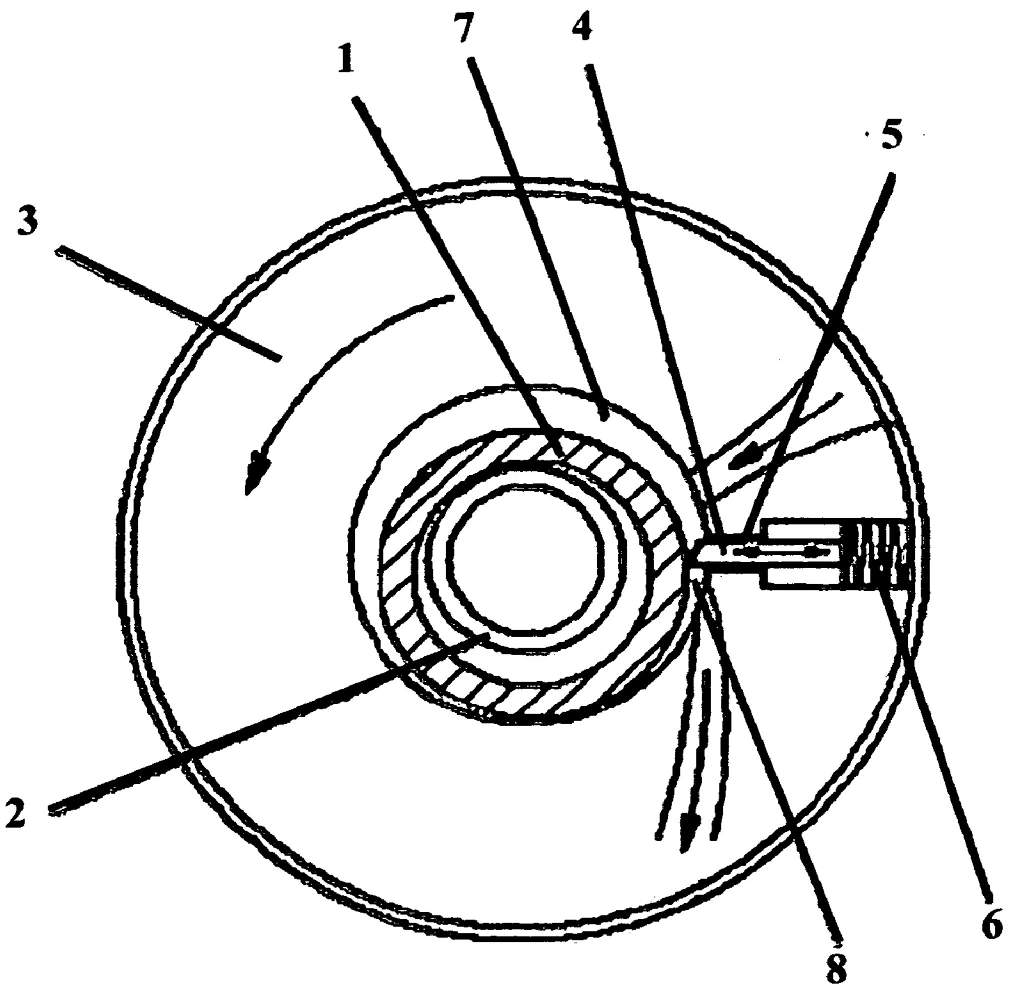
Publication Classification

(51) Int. Cl.
F04C 18/00 (2006.01)

(52) U.S. Cl.
CPC *F04C 18/00* (2013.01)
USPC **418/1**; 418/209

(57) ABSTRACT

This rotary compressor with an installed circulation control unit utilizes a method to control a rotary compressor to start or stop injecting refrigerant at a predetermined velocity by means of an electromagnetic coil that is installed onto the rotary compressor. The end of the electromagnetic coil is tenon-shaped and enters into a mortise that is formed on a vane or an arm of the rotary compressor so that the operation alternates between suction and compression at a predetermined period, enabling control of the rate of refrigerant circulation. In addition, the rotary compressor does not restart during its operation, which enhances the performance of the air-conditioning system, saves costs and energy, and enables the air-conditioning system to be easily maintained and repaired.



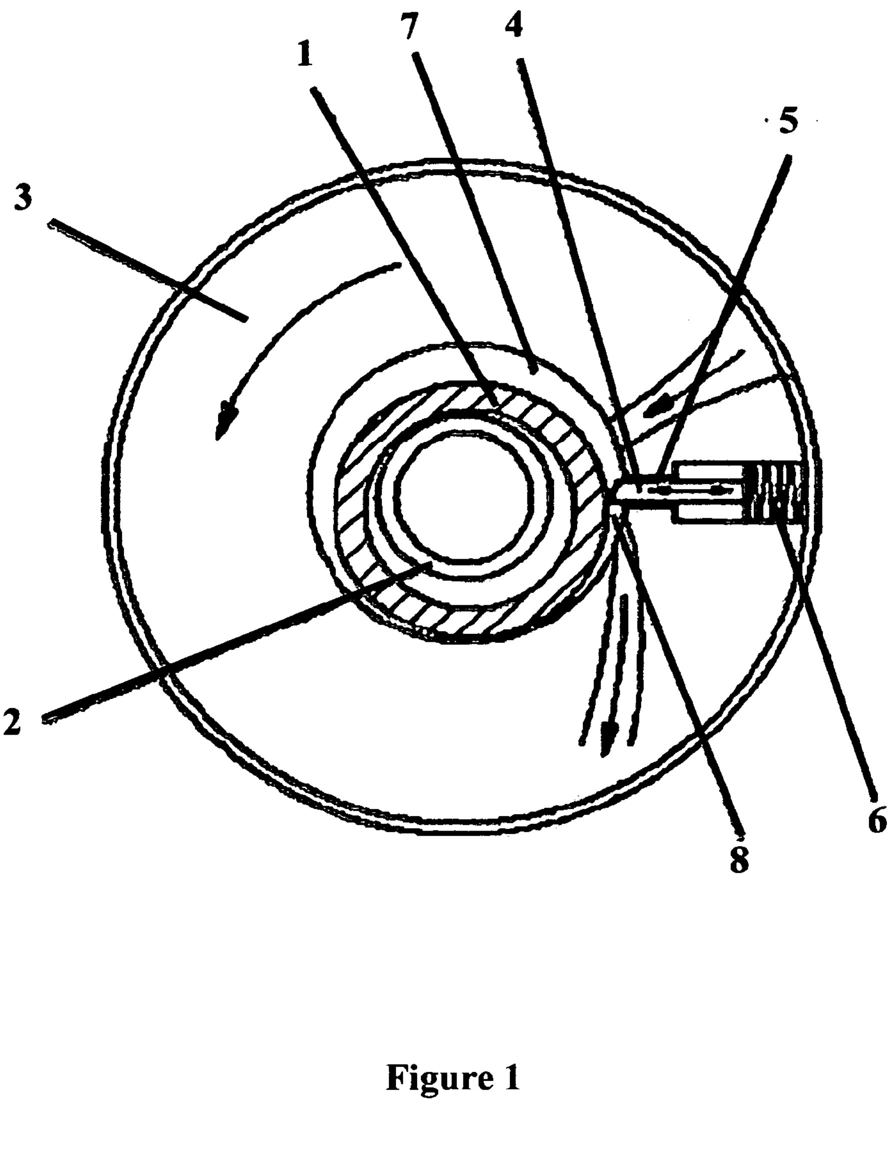


Figure 1

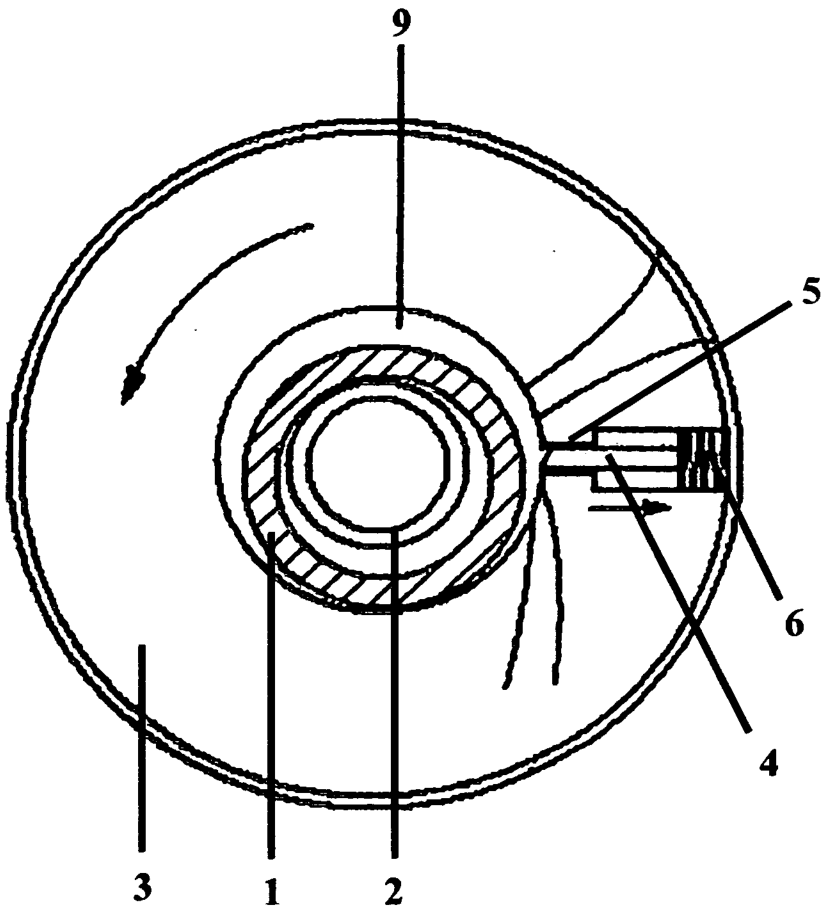


Figure 2

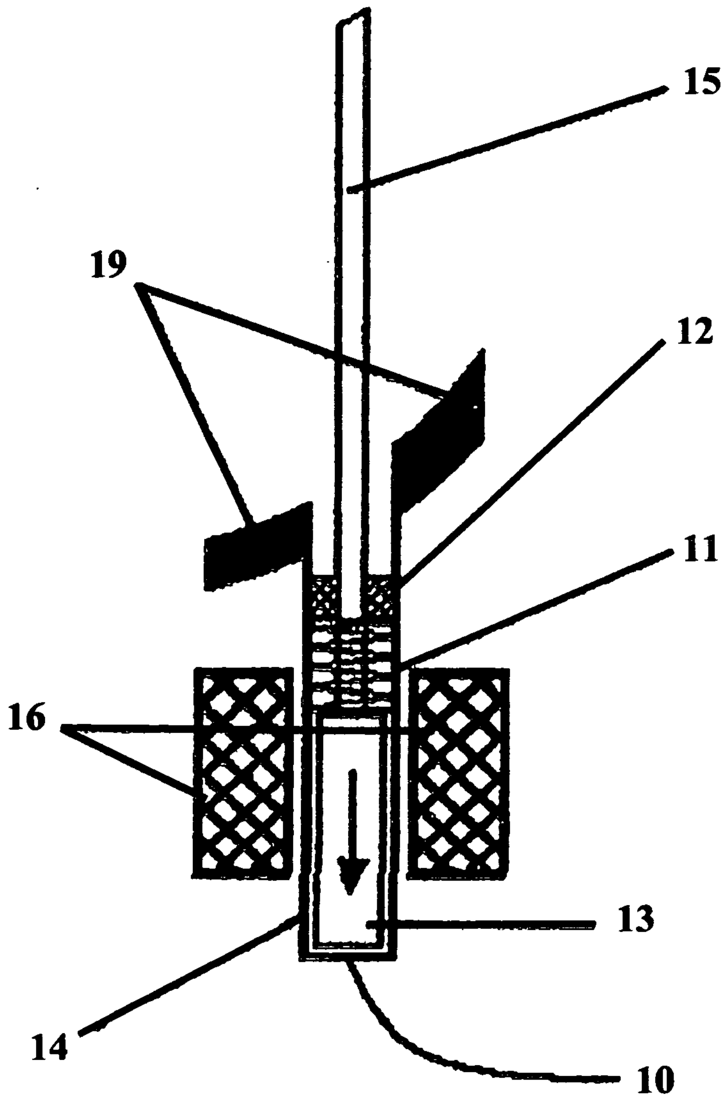
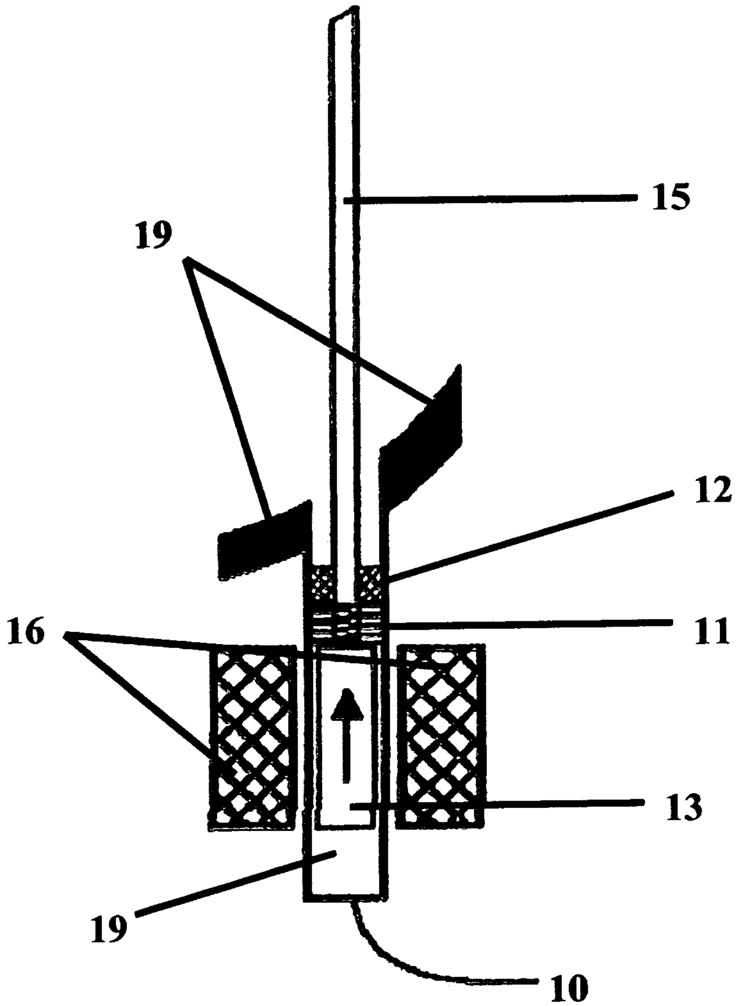


Figure 3



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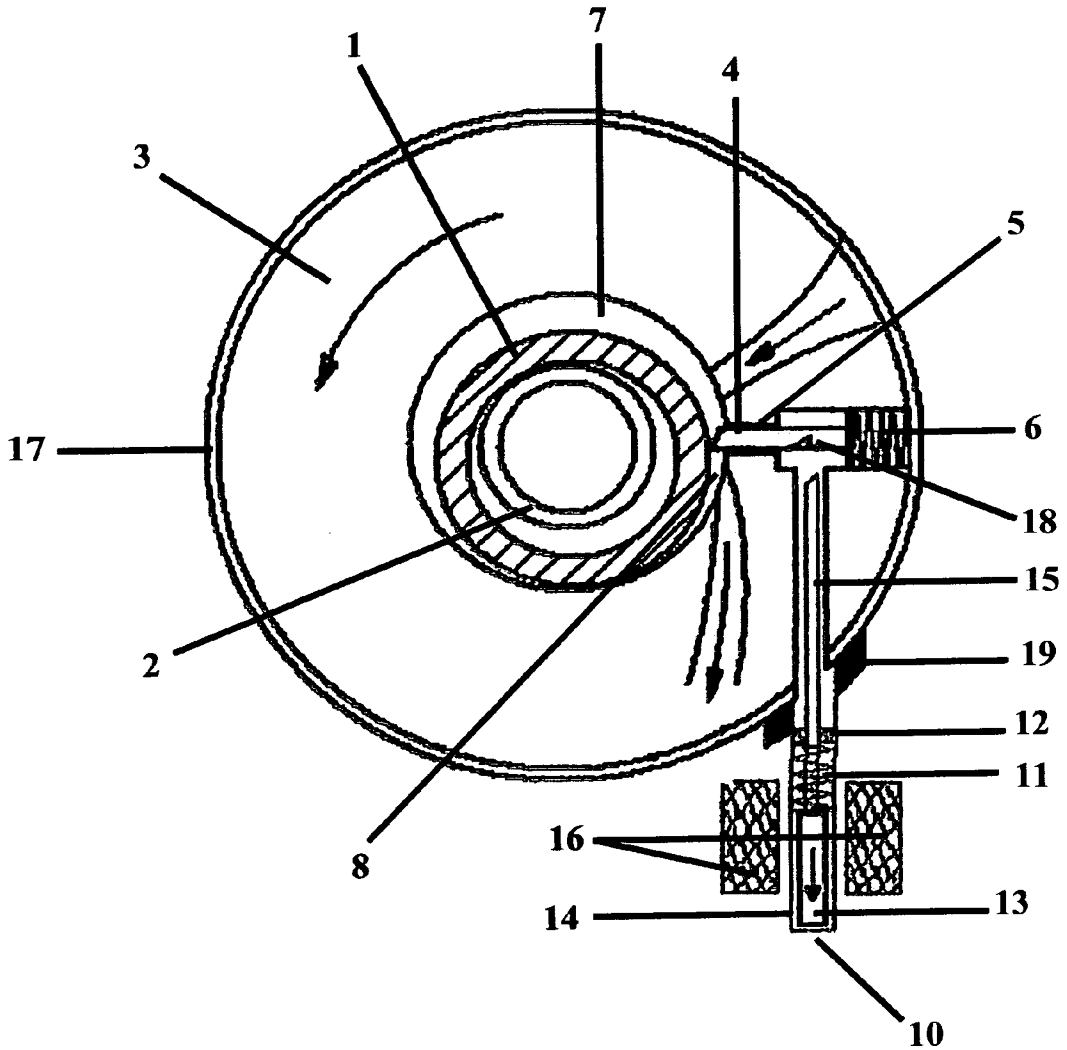

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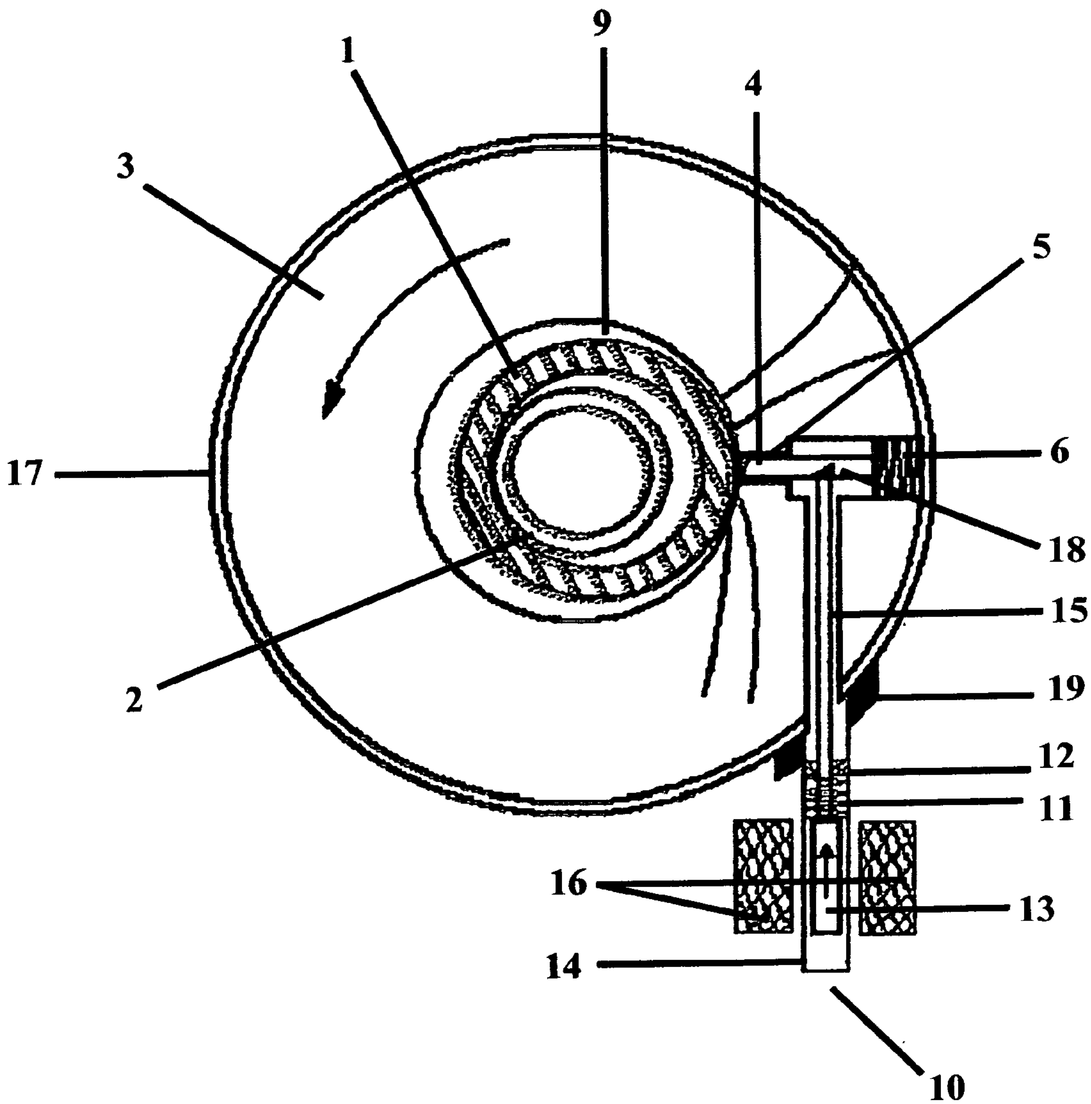

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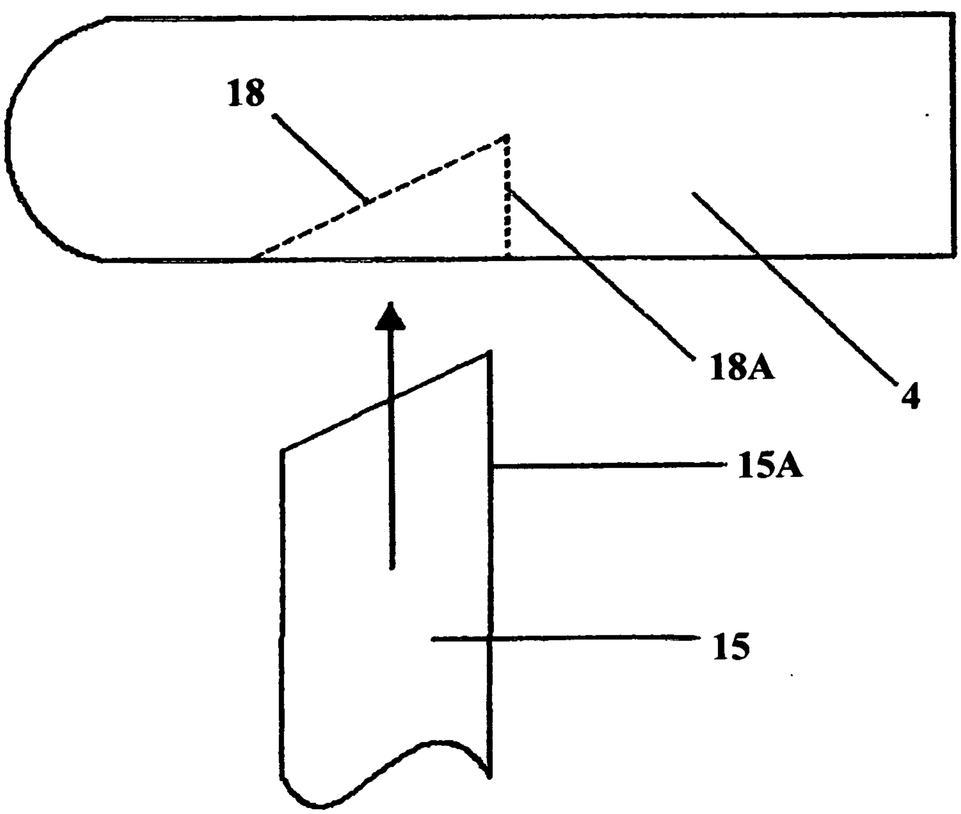
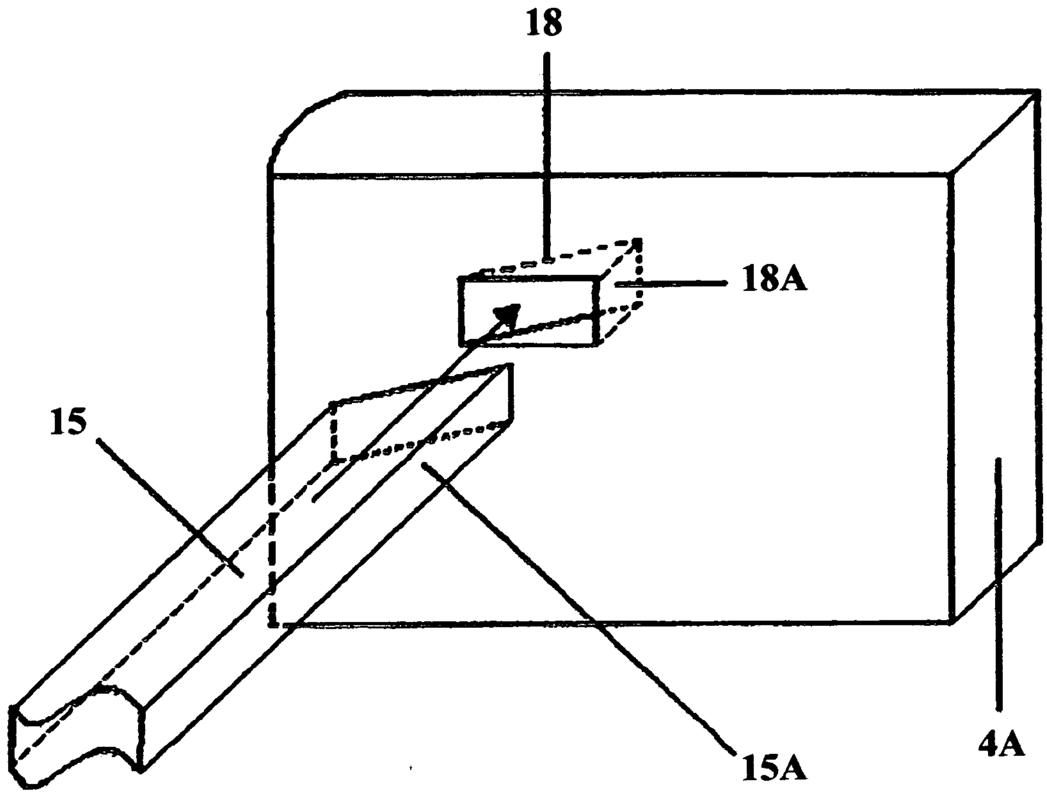


Figure 7



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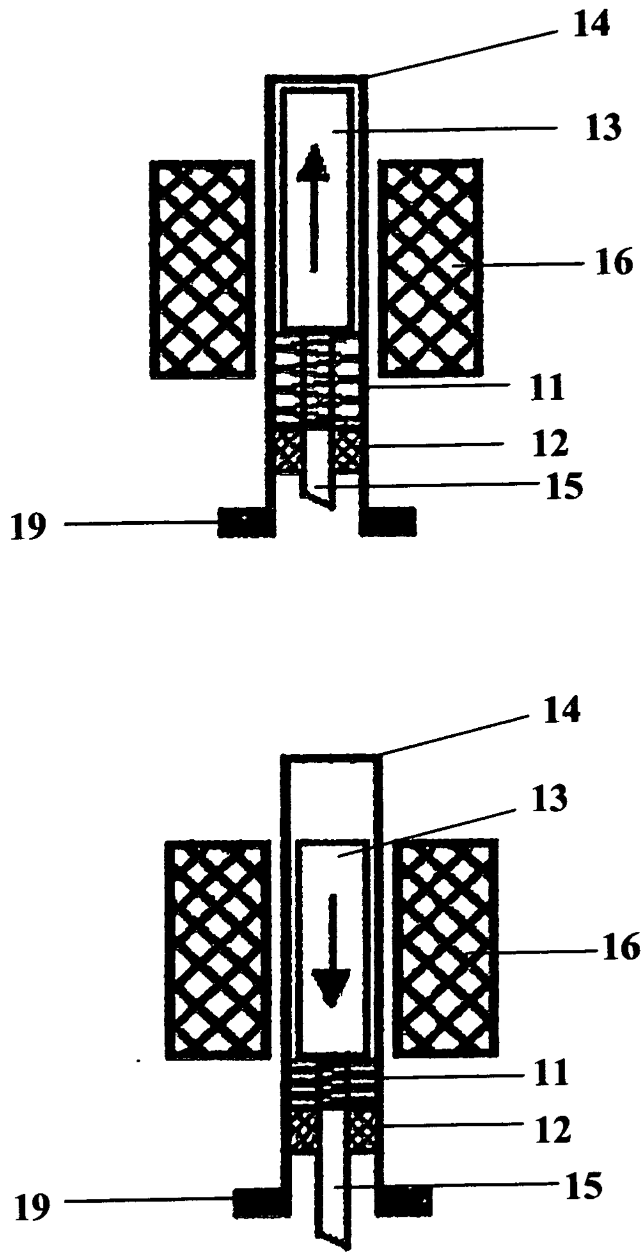


Figure 9

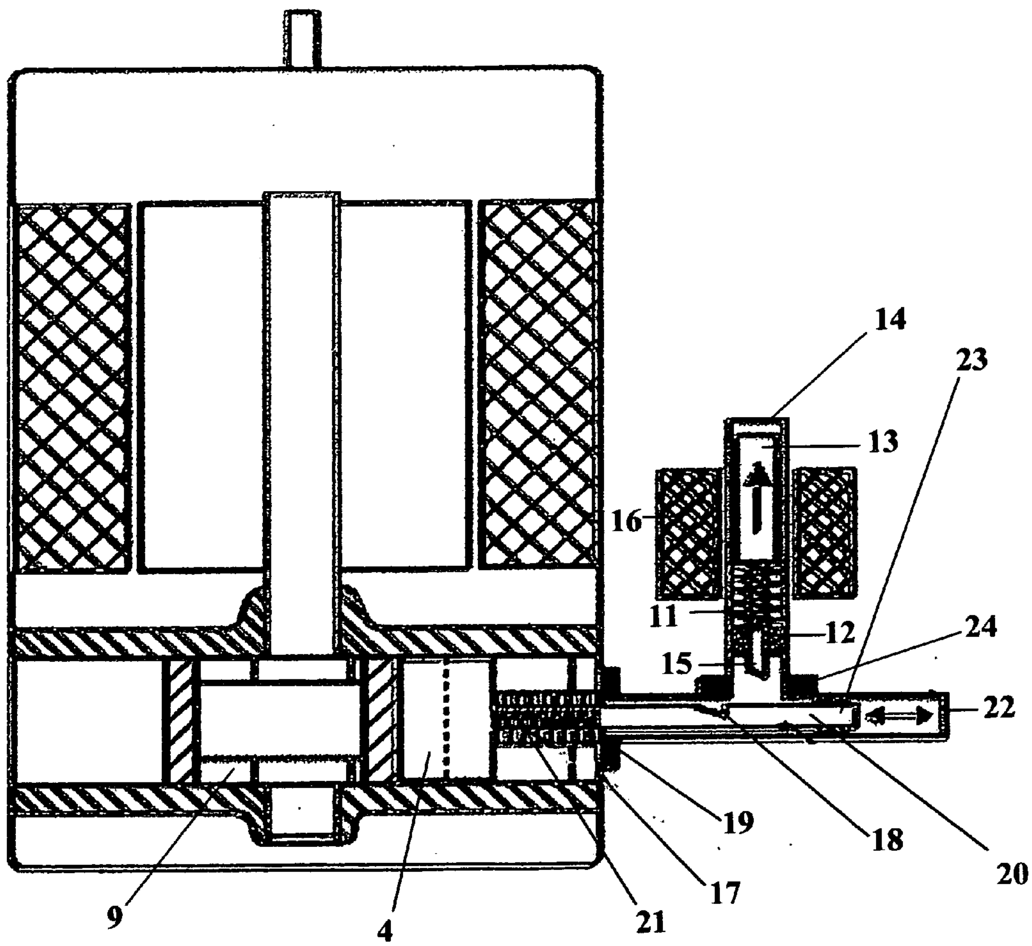


Figure 10

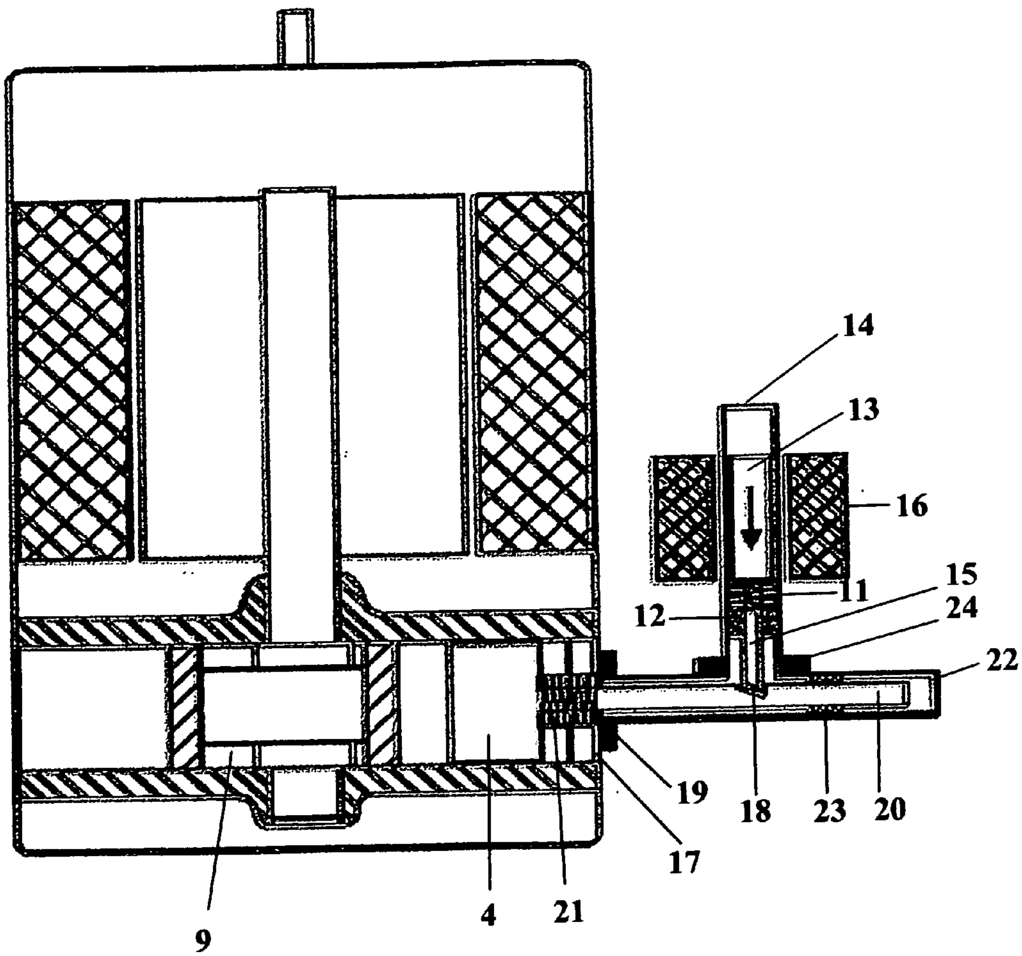
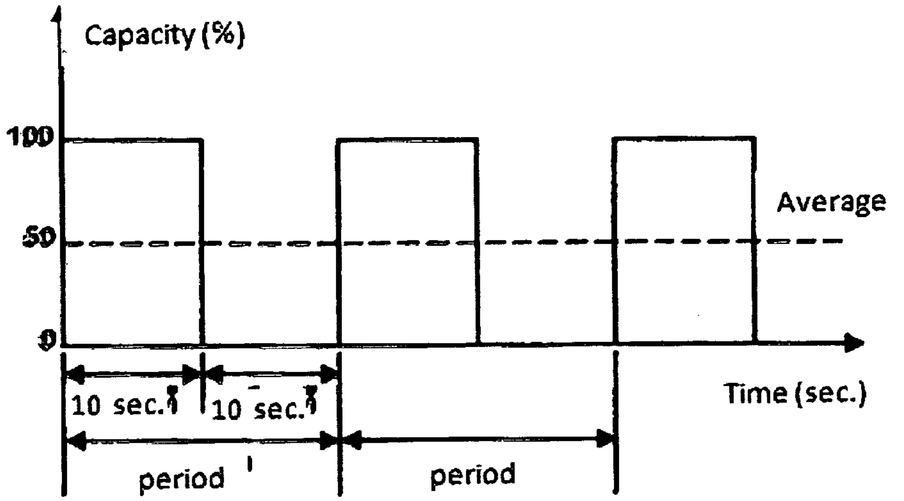


Figure 11



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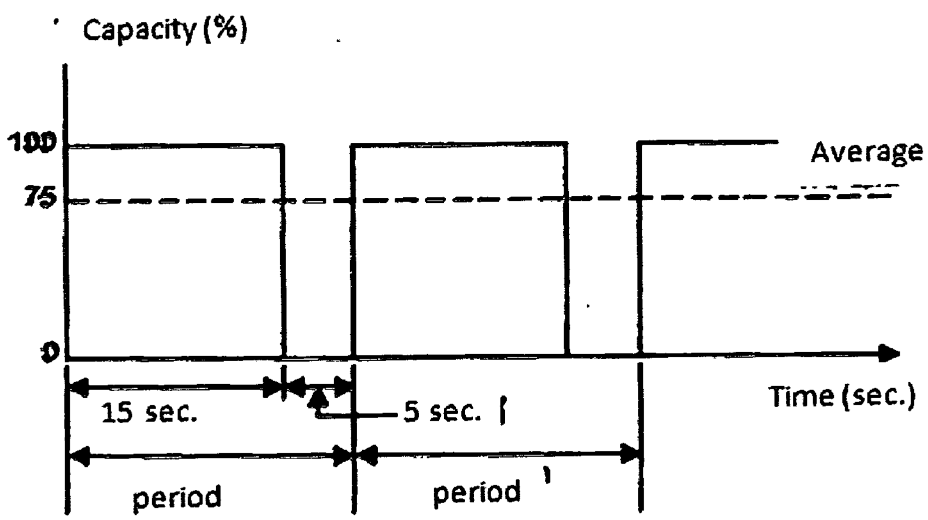

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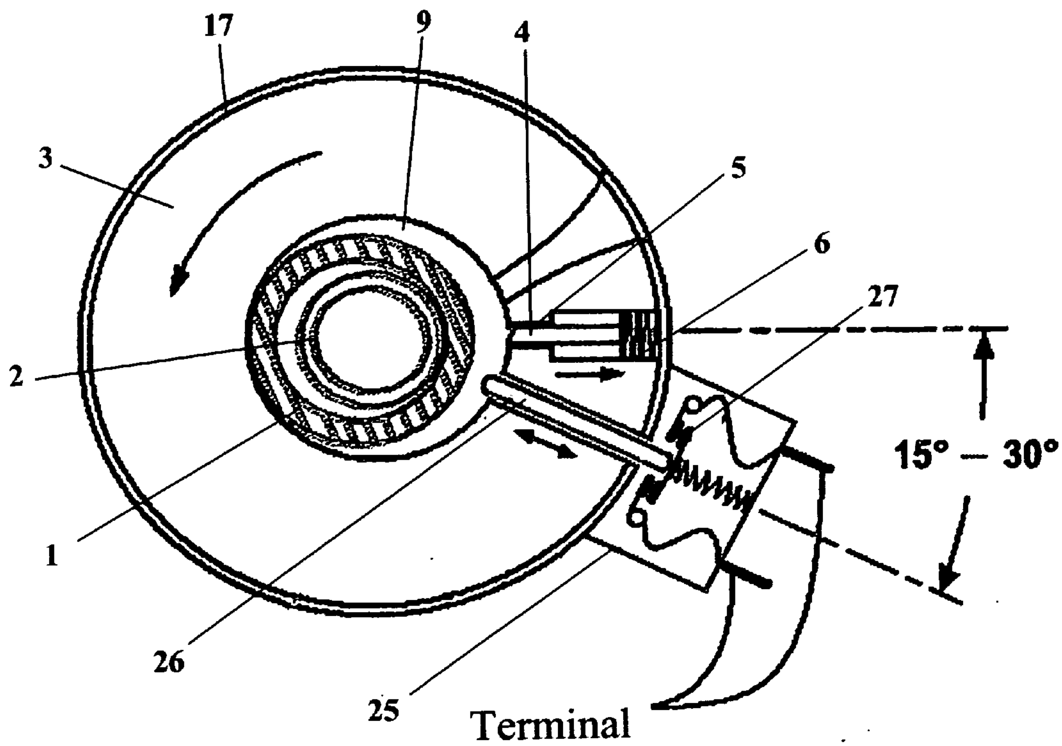


Figure 14

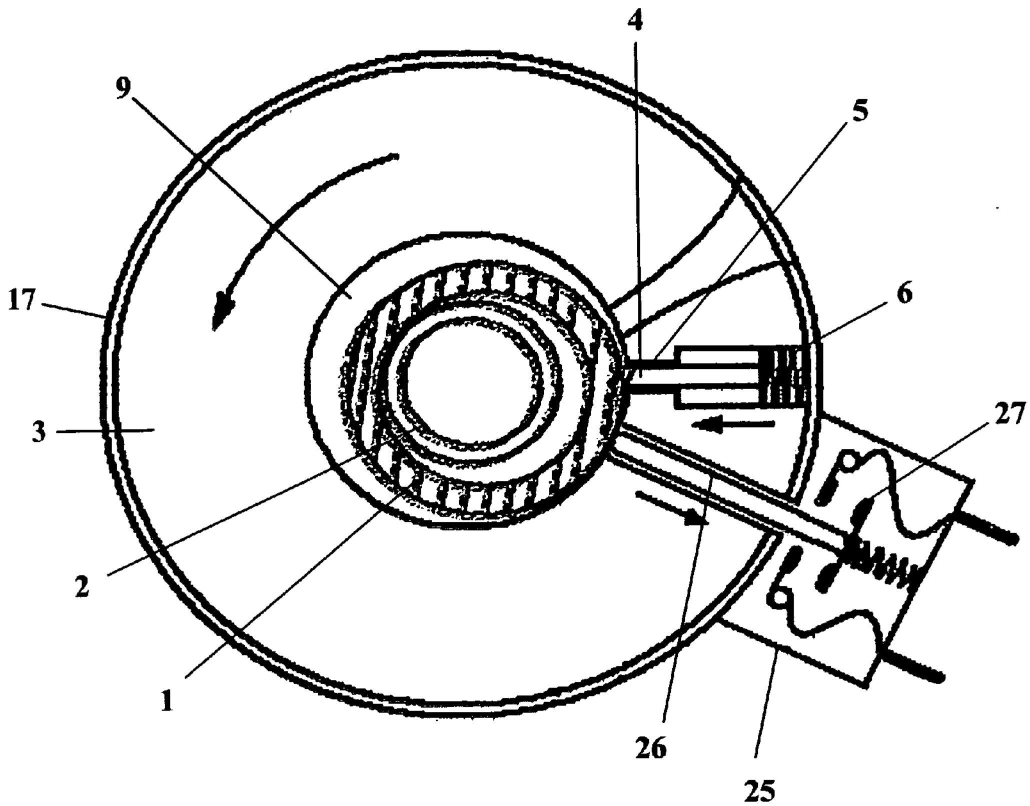


Figure 15

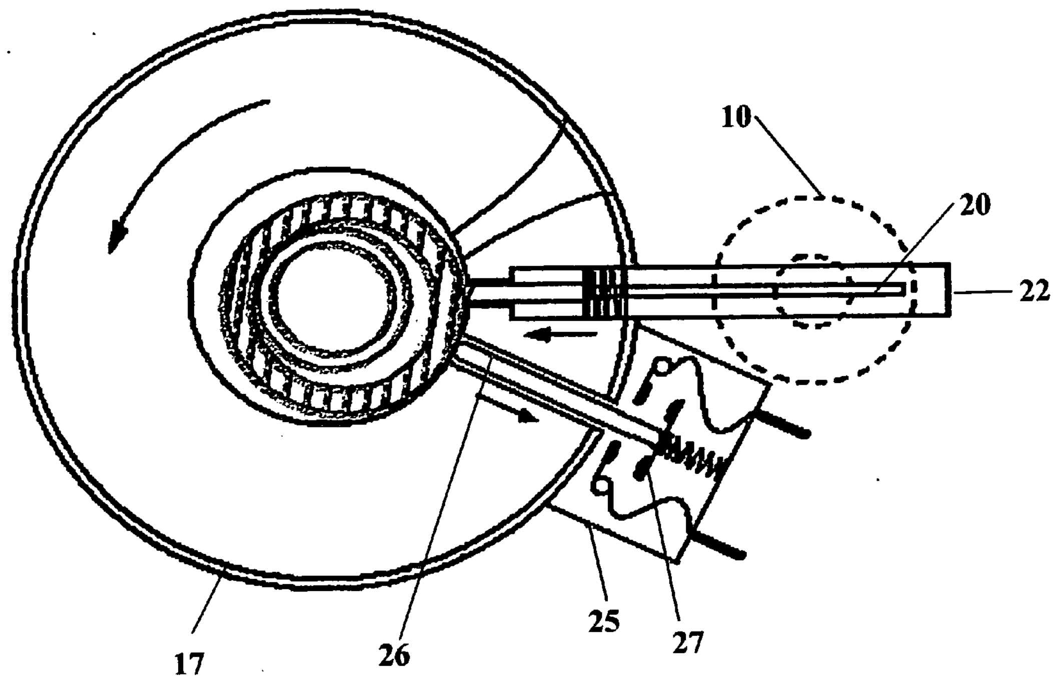
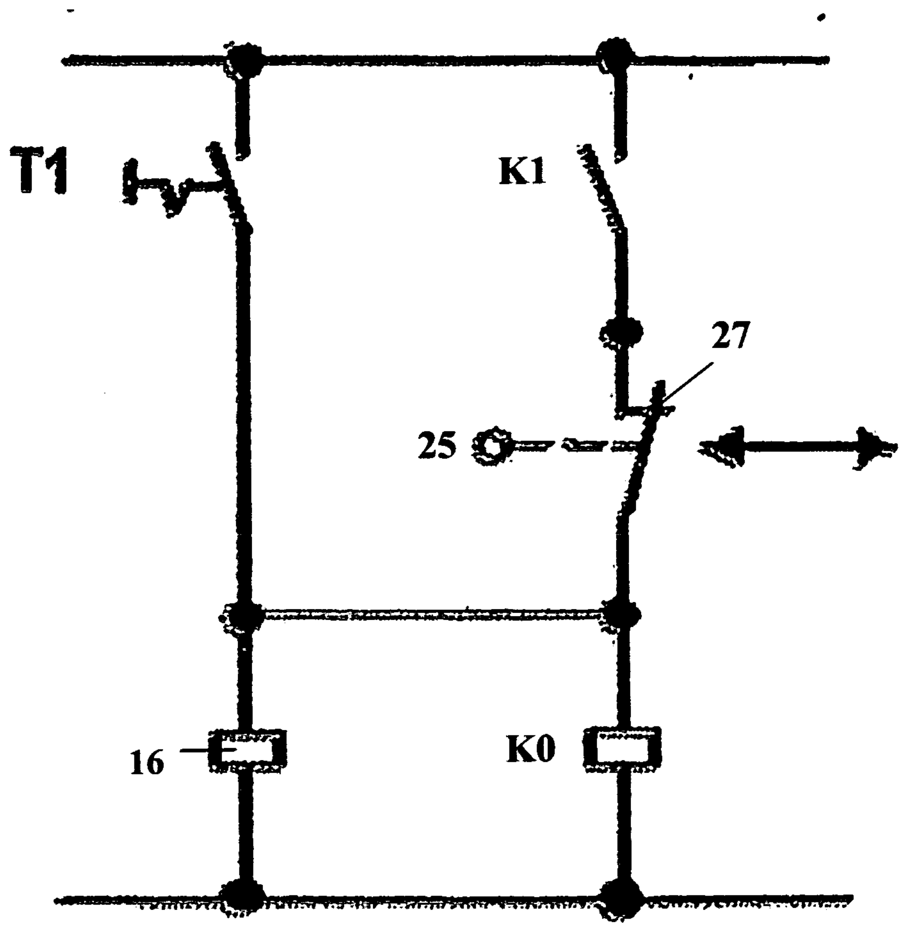


Figure 16



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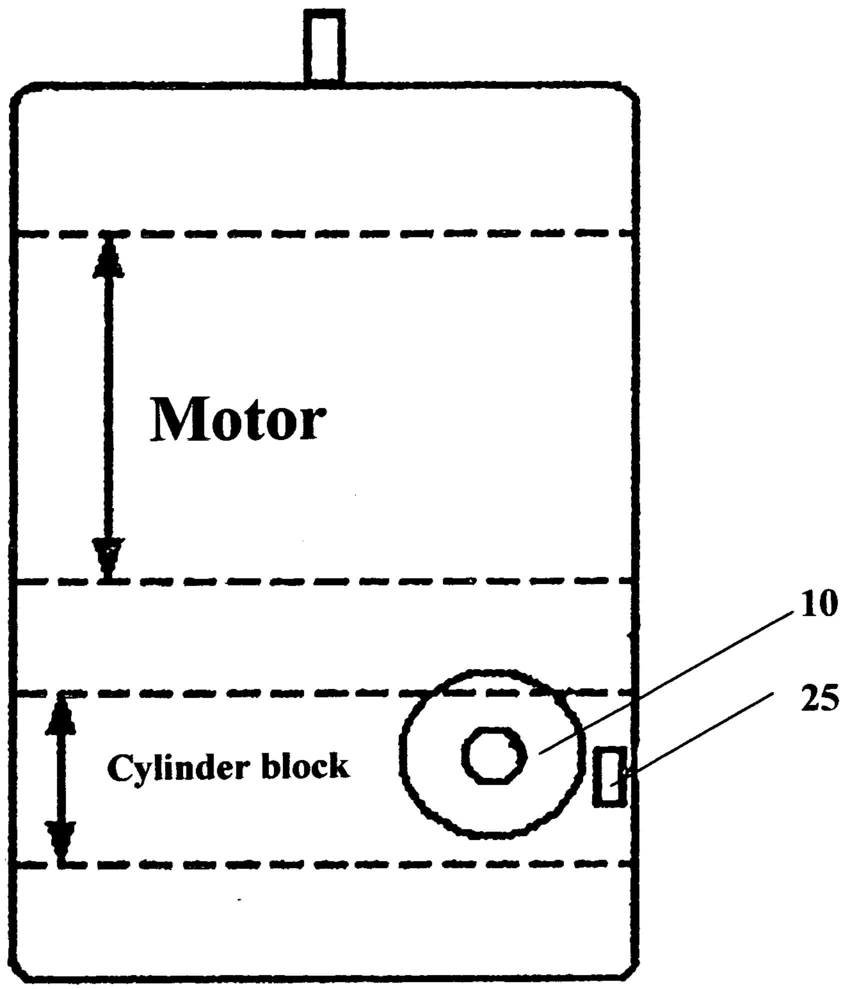

Figure 18

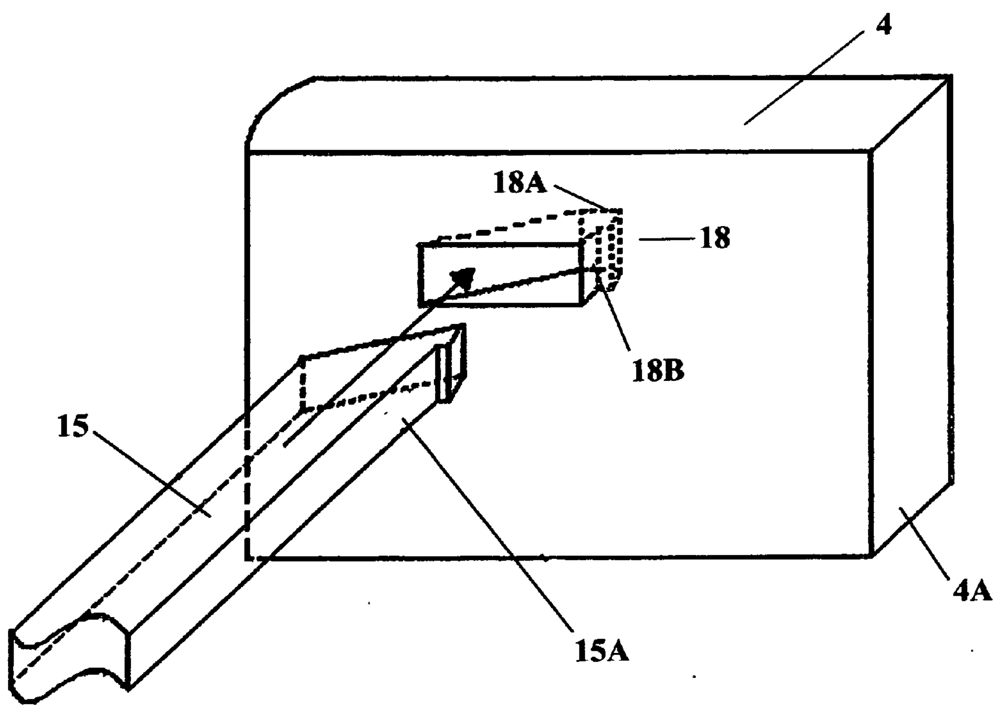

Figure 19

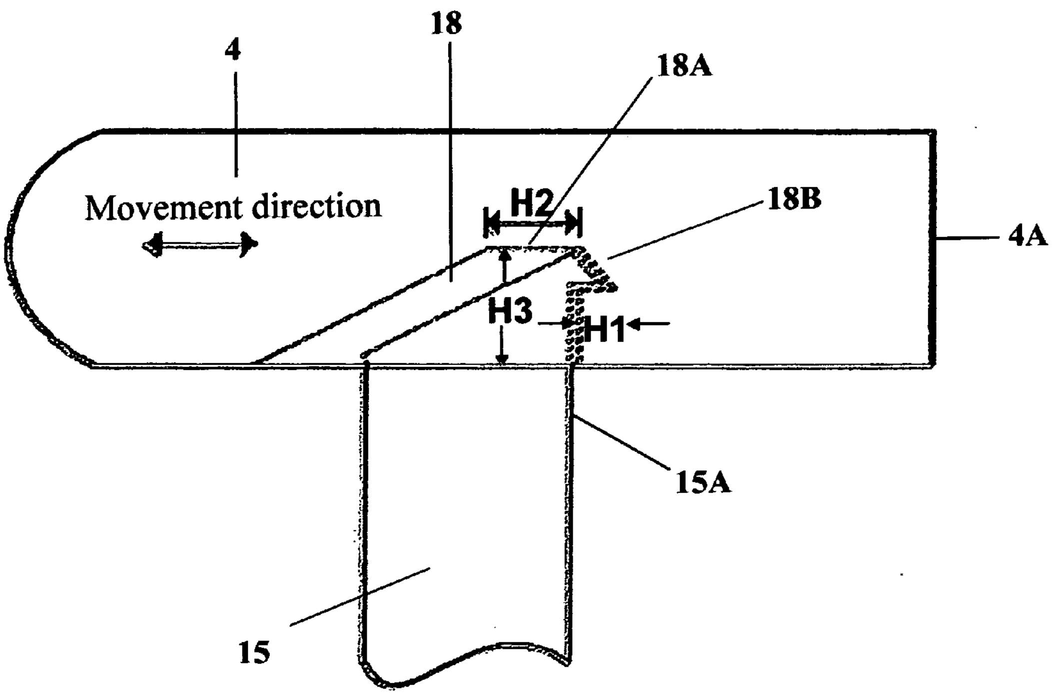

Figure 20

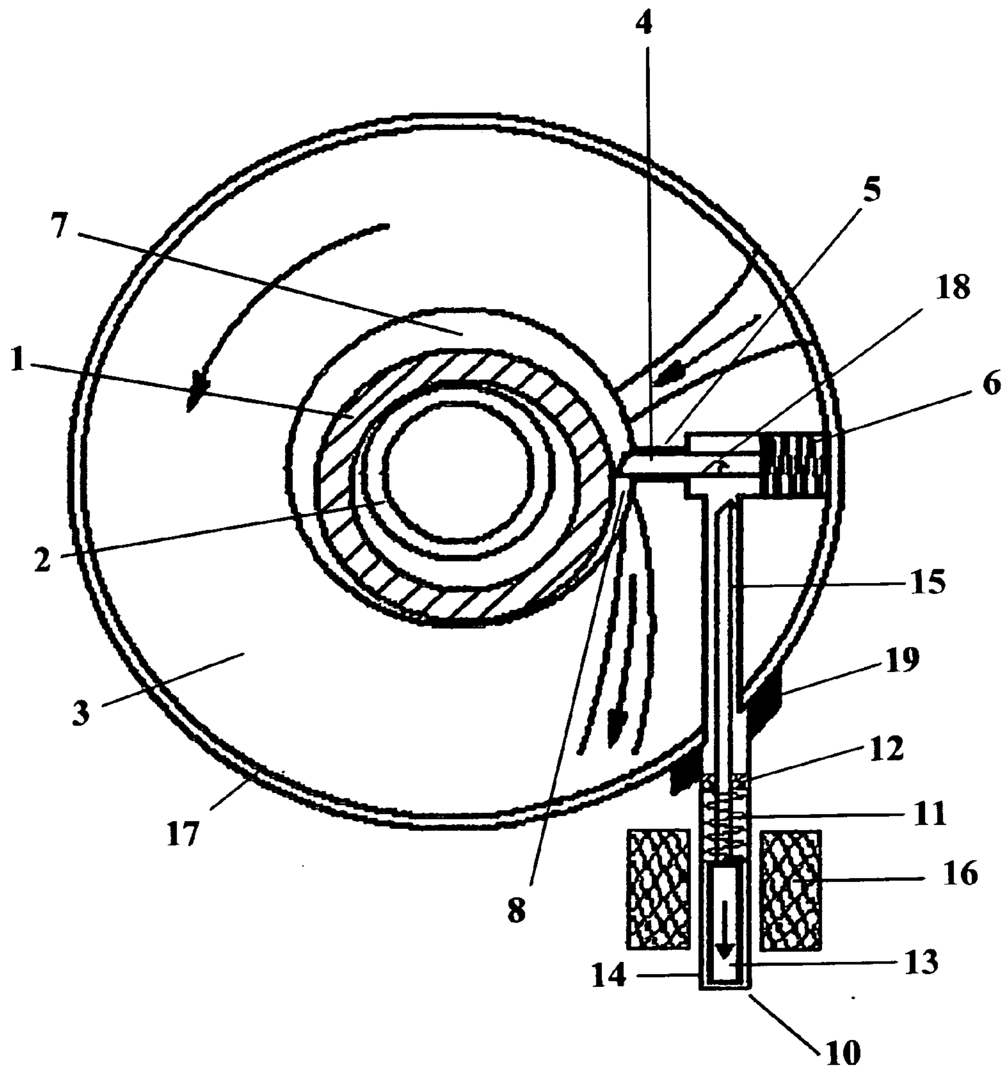

Figure 21

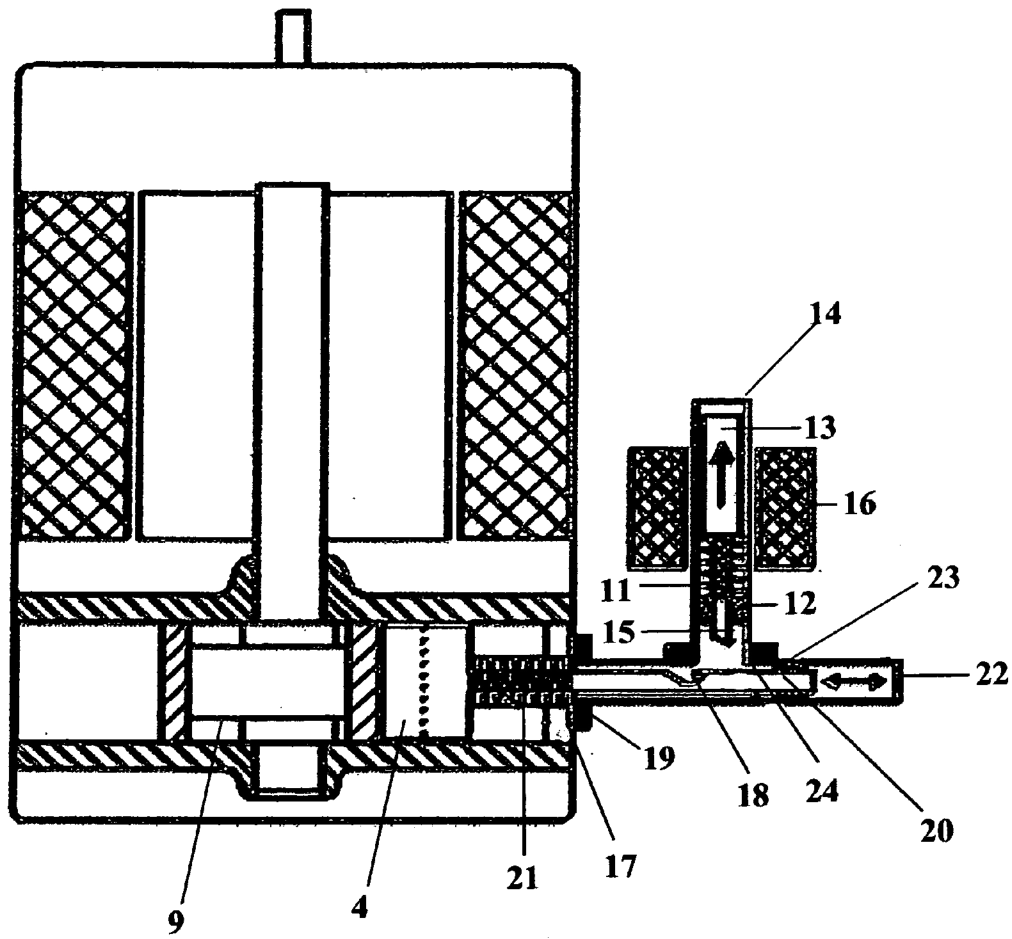

Figure 22

ROTARY COMPRESSOR WITH AN INSTALLED CIRCULATION CONTROL UNIT

FIELD OF INVENTION

[0001] The present invention relates to a rotary compressor and more particularly to a rotary compressor with an installed circulation control unit.

BACKGROUND OF THE INVENTION

[0002] An inverter air conditioning system is an air conditioning system the capacity of which is controlled by the volume of refrigerant circulation resulting from controlling the cycle speed of its compressor. However, such inverter compressor uses an electrical frequency method, which is technologically complicated, expensive, and difficult to repair.

[0003] Therefore, this rotary compressor with an installed circulation control unit disclosed under this patent application is developed to solve the above problems with its system being less complicated, economical, and easy to repair.

SUMMARY OF THE INVENTION

[0004] This rotary compressor with an installed circulation control unit utilizes a method to control a rotary compressor to start or stop injecting refrigerant at a designated velocity by means of an electromagnetic coil that is installed onto the rotary compressor. The tip of the electromagnetic coil is tenon-shaped and enters into a mortise that is formed on a vane that separates a compression compartment into two parts, i.e. a suction chamber and a compression chamber, so that the operation of such compression compartment alternates between suction and compression at a designated period, enabling control of the rate of refrigerant circulation.

[0005] The intention for developing this rotary compressor with an installed circulation control unit disclosed under this patent application is to control the rate of refrigerant circulation in an air-conditioning system so that the rotary compressor does not restart during its operation, which enhances the performance of the air-conditioning system, saves costs and energy, and enables the air-conditioning system to be easily maintained and repaired.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] FIG. **1** shows a conventional rotary compressor in a full-load operational mode.

[0007] FIG. **2** shows a conventional rotary compressor in a no-load operational mode.

[0008] FIG. **3** shows an electromagnetic coil with no supply of electric current.

[0009] FIG. **4** shows the electromagnetic coil with supply of electric current.

[0010] FIG. **5** shows the electromagnetic coil that is installed onto the rotary compressor in the first embodiment and with no supply of electric current.

[0011] FIG. **6** shows the electromagnetic coil that is installed onto the rotary compressor in the first embodiment and with supply of electric current.

[0012] FIG. **7** shows the features of a vane on which a mortise is formed and the tenon of an armature **15**.

[0013] FIG. **8** shows a perspective view showing the features of a vane on which a mortise is formed and the tenon of an armature **15**.

[0014] FIG. **9** shows the electromagnetic coil the armature **15** of which is altered to become shorter in length.

[0015] FIG. **10** shows the electromagnetic coil according to FIG. **9** that is installed on the rotary compressor in the second embodiment and with no supply of electric current.

[0016] FIG. **11** shows the electromagnetic coil according to FIG. **9** that is installed on the rotary compressor in the second embodiment and with no supply of electric current.

[0017] FIG. **12** is a diagram showing the rotary compressor with controllable circulation's controlled operation according to periods fixed at 50% circulation rate.

[0018] FIG. **13** is a diagram showing the rotary compressor with controllable circulation's controlled operation according to periods fixed at 75% circulation rate.

[0019] FIG. **14** shows the rotary compressor on which the electromagnetic coil is installed in the first embodiment together with an installed limit switch in a no-load operational mode.

[0020] FIG. **15** shows the rotary compressor on which the electromagnetic coil is installed in the first embodiment together with the installed limit switch in a full-load operational mode.

[0021] FIG. **16** shows the rotary compressor on which the electromagnetic coil is installed in the second embodiment together with the installed limit switch in a full-load operational mode.

[0022] FIG. **17** shows a circuit that is used for controlling the function of a coil **16**.

[0023] FIG. **18** shows a side view of the rotary compressor in the first embodiment to show the positions where the electromagnetic coil and the limit switch are installed.

[0024] FIG. **19** shows the features of the vane on which the mortise is formed and modified into a notch and the tenon of the armature **15** that is modified into a slanted tooth.

[0025] FIG. **20** shows the operation of the vane on which the mortise is formed and modified into a notch and the tenon of the armature **15** that is modified into a slanted tooth.

[0026] FIG. **21** shows the electromagnetic coil that is installed on the rotary compressor in the first embodiment as well as the vane on which the mortise is formed and modified into a notch and the tenon of the armature **15** that is modified into a slanted tooth.

[0027] FIG. **22** shows the electromagnetic coil that is installed on the rotary compressor in the second embodiment as well as the vane on which the mortise is formed and modified into a notch and the tenon of the armature **15** that is modified into a slanted tooth.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0028] A conventional rotary compressor's structure and parts contain a rolling piston **1** that is inserted on a crankshaft **2**, which is inside a cylinder **3** (the cylinder and the cylinder block of the rotary compressor are in one single piece), a vane **4** that moves along a slot **5** of the cylinder **3**, and a spring **6** that is contained in the slot **5** to force the vane **4** to contact with the rolling piston **1** during the rotary compressor's operation in a full-load mode.

[0029] According to FIG. **1**, which shows a conventional rotary compressoris in a full-load operational mode, the vane **4** contacts with the rolling piston **1** constantly and separates a piston chamber into 2 parts, i.e. a suction chamber **7** and compression chamber **8**, respectively. Therefore, when the crankshaft **2** rotates anticlockwise, the rolling piston **1** will also rotate anticlockwise. And, because of the blockage of the vane **4**, a suction force is pcoreuced in the suction chamber **7** and pressure is pcoreuced in the compression chamber **8**. While the rolling piston **1** is wiping to inject refrigerant, the vane **4** will move back and forth along the slot **5** by the push of the rolling piston **1**, the bounce of the spring **6** and the pressure of a refrigerant injection system.

[0030] According to FIG. **2**, which shows a conventional rotary compressor is in a no-load operational mode, the vane **4** is pressed into the slot **5** entirely and the piston chamber **7** and the piston chamber **8** combine to form a single chamber, i.e. a piston chamber **9**, which induces a condition where there is no suction force or pressure regardless of the position of the rolling piston **1**. At this stage, the rotary compressor is in a no-load operational modeoperational, which consumes the least electric current.

[0031] Based on this principle, the rotary compressor with controllable circulation disclosed under this patent application is developed and it is a development of the ability to control the operation or the opening and closing of the vane **4** by means of an electromagnetic coil that is installed onto the rotary compressor.

[0032] According to FIG. **3**, which shows the structure of an electromagnetic coil **10** with no supply of electric current into a coil **16**, a spring **11**, which is installed between a bushing **12** and an armature **13**, forces the armature **13** to slide completely inside an armature shield **14** at all time. One end of an armature core **15** is joined with the armature **13** and the other end is in a wedge form. This armature core **15** can slide back and forth along the channel of the bushing **12** as a result of the pressure of the spring **11** and the suction force of the coil **16** applied on the armature **13**.

[0033] According to FIG. **4**, which shows the structure of the electromagnetic coil **10** with supply of electric current into the coil **16**, the armature **13** is induced to overcome the elastic force of the spring **11** and to move up to the same level as the coil **16**. At the same time, the armature core **15** moves up. This method of function is then used to control the operation of the rotary compressor in several ways as further described.

[0034] According to FIG. **5**, the installation of the electromagnetic coil **10** onto the rotary compressor in the first embodiment to control the opening and closing of the vane **4** is further described as follows:

[0035] The rotary compressor (as shown in FIG. **1**) is bored horizontally to make a hole that is at the same level of and perpendicular to the vane **4**. This hole passes through a shield **17** and the cylinder block **3** of the rotary compressor until it reaches the slot **5** where the vane **4** is installed. The size of the hole is small enough for the armature core **15** to move back and forth fitly. Then, the vane **4** is pressed into the slot **5** entirely and an area where the bored hole intersects with the vane **4** is to be observed. A mortise is then formed on this particular area of the vane **4** (as shown in FIG. **7**). Then, the electromagnetic coil **10** (as shown in FIG. **3**) is installed at the bored hole and welded firmly at the joint of a flange **19** (Shape may differ according to the surface of the piece to be installed.) and the shield **17** of the compressor so as to ensure that there is no leakage. The length of the armature core **15** is determined by the distance from the armature **13** in a condition where electric current is supplied to the coil **16** until the tenon of the armature **15** is inserted entirely on a mortise **18** of the vane **4**, which is simultaneously pushed by the rolling piston **1** to slide into the slot **5** completely.

[0036] Because of the installation of the electromagnetic coil **10** onto the rotary compressor in the first embodiment with no supply of electric current, the vane **4** moves freely, enabling the rotary compressor to suck and compress normally. At this stage, the rotary compressor is in a full-load operational mode.

[0037] According to FIG. **6**, when electric current is supplied into the coil **16** of the electromagnetic coil **10** that is installed onto the rotary compressor in the first embodiment, the armature **13** will be sucked to the same level of the coil **16** and it will push the armature core **15** upward at the same time as the rolling piston **1** pushes the vane **4** to move entirely into the slot **5**, making the mortise **18** on the vane **4** to be exactly in the same line of the tenon of the armature **15**. Therefore, the tenon of the armature **15** enters into the mortise **18** as a result of the push of the armature **13** and is attached to the vane **4**, i.e. by attaching a side **18**A to a side **15**A (referring to FIG. **7** and FIG. **8**) so as not to return to the piston chamber **9**. At this stage, the rotary compressor is in a no-load operational mode as described in FIG. **2**.

[0038] When the supply of electric current into the coil **16** stops, the spring **11** will push the armature **13** back into its shield **14** and the vane **4** will become free (according to FIG. **5**). Then, the rotary compressor resumes is in a full-load operational mode and it will further alternate between no-load and full-load operational modes.

[0039] According to FIG. **9**, the electromagnetic coil, which has the same structure and function as shown in FIG. **3** and FIG. **4**, but the armature core **15** of which is shorter, and the shape of the flange **19** of which differs depending on the surface of the piece on which it is to be installed, is used for installation on the rotary compressor in the second embodiment to control the opening and closing of the vane **4**.

[0040] According to FIG. **10** and FIG. **11**, a conventional rotary compressor is connected to a connection arm **20** from the vane **4**. The size of the arm **20** must be at the right size to allow insertion through the spring **21** and past the shield **17** of the rotary compressor and it should be long enough to enable installation of the electromagnetic. A tube **22** is then used to cover the arm **20** inside of which a bushing **23** supports the arm **20** to provide stability and to ensure that the arm **20** is not detached from a bushing **23** at all times even when the vane **4** slides into the piston chamber **9** entirely. Thereafter, a hole is bored on the top surface of the tube **22** between the shield **17** of the rotary compressor and the bushing **23**. The electromagnetic coil **10** of FIG. **9** is further installed at this bored hole **24**. Then, the vane **4** is pushed into the slot **5** entirely and the mortise **18** is to be formed on the arm **20** at the area to which the tenon of the armature core **15** points.

[0041] Thus, the length of the armature core **15** can be calculated at the period when electric current is supplied into the coil **16** and when the rolling piston **1** pushes the vane **4** inside the slot **5** entirely (as shown in FIG. **11**) by measuring from the end that connects with the armature **13** to the tenon of the armature core **15** while it is inserted inside the mortise **18** of the arm **20** entirely. From this point, all joints are to be welded firmly to ensure that there is no leakage during operation, which is similar to the operation of the electromagnetic coil **10** that is installed on to the rotary compressor in the first embodiment as described above under FIG. **5** and FIG. **6**.

[0042] Because of such ability to control the opening and closing of the vane **4**, it is possible to control the circulation rate of refrigerant in an air-conditioning system by controlling electric current supplied into the electromagnetic coil **10**

at designated periods and under the difference of room temperature as shown in the diagrams of FIG. **12** and FIG. **13**.

[0043] FIG. **12** is a diagram showing control of periods of the rotary compressor according to the present invention, control of periods of electric current supply into the coil **16** in each period is shown by the diagram. According to this particular diagram, 1 period equals 20 seconds and the electric current supply stops for 10 seconds, during which the rotary compressor is in a full-load operational mode (100%). Likewise, during 10 seconds of electric current supply, the rotary compressor is in a no-load operational mode (0%). Both periods cover 20 seconds and thus the averaged value of circulation rate can be calculated as follows:

[0044] 20 seconds operation in 1 period (20 seconds) =100% output

[0045] Thus, 10 seconds operation in 1 period (20 seconds)=50% output

[0046] Therefore, 1 period (20 seconds) results in 50% circulation rate and averaged capacity of 50%.

[0047] FIG. **13** is a diagram showing control of periods of the rotary compressor according to the present invention, control of periods of electric current supply into the coil **16** in each period is shown by the diagram. According to this particular diagram, 1 period equals 20 seconds. When the electric current supply is stopped for 15 seconds and is further supplied for 5 seconds, this will result in 75% circulation rate and averaged capacity of 75%.

[0048] As mentioned above, it is clear that, the control system of an air-conditioning system that uses the rotary compressor according to the present invention never shuts the rotary compressor down during operation and the rotary compressor does not restart during operation, which saves energy that is caused by electrical surge or transient. During such operation, the system's capacity can be controlled and adjusted as needed by controlling the averaged capacity obtained from alternating between full-load and no-load operational modes in 1 period as described above.

[0049] However, during alternation from a no-load operational mode to a full-load operational mode, the vane **4** moves freely into the piston chamber **9** while the rolling piston **1** moves at high velocity, which may cause damage from a sudden impact or after being used for a certain period of time. Therefore, a limit switch **25**, which is a normally closed limit switch, is attached onto the shield **17** of the rotary compressor to prevent damage from the impact between the vane **4** and the rolling piston **1**.

[0050] According to FIG. **14**, which shows the rotary compressor on which the electromagnetic coil **10** is installed in the first embodiment, the normally closed limit switch **25** is installed onto the shield **17** of the rotary compressor according to the present invention at a 15 to 30 degree angle from the line of the vane **4** in a direction opposite to the rotational movement of the rolling piston **1** and the center of which is situated on the center of the crankshaft **2**. The shield **17** of the rotary compressor according to the present invention is further bored at this particular area until the bored hole reaches the piston chamber **9** and a size of the bored hole is exactly the same as a size of a limit arm **26**. Thereafter, the limit arm **26** is inserted through this hole. The length of the limit arm **26** is determined by the length from the surface of the rolling piston **1** while pressing the limit arm **26** to the position where the limit arm **26** retracts into the hole entirely and pushes a contact plate **27** of the limit switch **25** apart (as shown in FIG. **15**). With respect to such installation of the limit switch **25**, firm welding between the shield of the limit switch **25** and the shield **17** of the rotary compressor is required to ensure that there is no leakage.

[0051] According to FIG. **16**, which shows the rotary compressor on which the electromagnetic coil **10** is installed in the second embodiment, the normally closed limit switch **25** is also installed.

[0052] According to FIG. **17**, in order to control the operation in a no-load mode, a thermostat T**1** triggers the coil **16** and a contactor K**0** to operate. Alternatively, a contact K**1** of the contactor K**0** and the contact **27** of the limit switch **25**, which are serialized together, can convey electric current to trigger the coil **16** and the contactor K**0**.

[0053] When the operation is switched into a full-load mode, the thermostat T**1** will be open but electric current can still pass through the contact K**1** and the contact **27** so the coil **16** can still operate. However, when the rolling piston **1** moves to contact the limit arm **26**, which causes the contact **27** to be apart as shown in FIG. **15**, the coil **16** then stops operating and thus releases the vane **4** at the same time as the rolling piston **1** moves to this position at high velocity. As a result, there is no impact and the rolling piston **1** can suction and compress normally. Therefore, operation can alternate without causing any damage.

[0054] FIG. **18** shows a position of the installation of the electromagnetic coil **10** and the limit switch **25** from a side view of the rotary compressor that is perpendicular to the vane **4**. In fact, the position of the electromagnetic coil **10** can be either on the left or on the right of the vane **4**, and can be either higher or lower than the midpoint of the vane **4** as may be deemed appropriate.

[0055] In addition, a modification of the mortise **18** and the tenon of the armature **15** to prevent damage from the impact between the vane **4** and the rolling piston **1** instead of installing the normally closed limit switch **25** are also possible as follows:

[0056] FIG. **19** is a three-dimensional view of the structure of the armature core **15** and the vane **4** of which the mortise **18** and the tenon of the armature core **15** have been modified and the direction of movement of the armature core **15** before inserting into the mortise **18** of the vane **4**.

[0057] FIG. **20** shows the structure of the armature core **15** and the vane **4** of which the mortise **18** and the tenon of the armature core **15** have been modified and a slanted tooth is formed. The tip of slanted tooth is formed on a side **15**A and has a width H**1** as minimal as possible to ensure that it is able to mesh without disconnecting. Then, a side **18**A of the mortise is expanded towards a side **4**A for a minimal width H**2**, which must be slightly larger than the width of the slanted tooth of the tenon of the armature core **15**, and the depth of the mortise H**3** is maintained throughout the expanded width H**2**. Then, a mortise for the slot of slanted tooth is formed on the innermost angle of a side **18**B to support the tooth of the tenon of the armature core **15** with which it is to mesh, or a tooth in another shape may be formed alternatively at the tenon of the armature core **15** to mesh to the mortise on the vane **4** without disconnecting.

[0058] As a result of the mesh in this nature while the rotary compressor is in a no-load operational mode, the vane **4** is still partially inside the piston chamber **9**, which enables the vane **4** to slide freely along the slot **5** as driven by the force of the rolling piston **1**, the bounce of the spring **6**, and the pressure of refrigerant applied on the side **4**A in every cycle as long as electrical current is supplied to the coil **16**, which does not adversely affect the operation.

[0059] When alternating to a full load operational mode, the electric current supplied to the coil **16** is cut off. Then, the bounce of the spring **11** forces the armature **13** back to its initial position inside the armature shield **14**. However, the armature **13** is unable to retract to its initial position since the slanted tooth of the tenon of the armature core **15** still meshes to the mortise **18**B that is formed on the mortise **18**. When the vane **4** is pushed by the rolling piston **1** to move into the slot **5** entirely, the slanted tooth of the tenon of the armature core **15** becomes free and it detaches and moves back from the vane **4** following the movement of the armature **13** and the bounce of the spring **11**. The vane **4** is then released on the top surface of the rolling piston **1** appropriately, causing no impact or damage. The operation of the rotary compressor on which the electromagnetic coil **10** is installed and the mortise **18** and the vane **4** of which are modified can alternate between full load and no-load operational modes without requiring the limit switch **25**.

[0060] FIG. **21** shows the rotary compressor on which the electromagnetic coil **10** is installed in the first embodiment (as shown in FIG. **5**) with modifications in the mortise **18** of the tenon of armature core **15**. When no electric current is supplied into the coil **16**, the tenon of the armature core **15** does not insert into the mortise **18** of the vane **4** and it moves freely following the push of the rolling piston **1**, the bounce of the spring **6** and the pressure of refrigerant applied on the side **4**.**1**. At this stage, the rotary compressor is in a full load operational mode.

[0061] However, when electric current is supplied into the coil **16**, the armature **13** will overpower the bounce of the spring **11** to be in the same line with the coil **16** and the armature core **15** will move up to push the vane **4** until the rolling piston **1** pushes the vane **4** into the slot **5** entirely. The tenon of the armature core **15** enters into the mortise and is attached thereto as long as electric current is supplied to the electromagnetic coil **16**. At this stage, the rotary compressor is in a no-load operational mode.

[0062] FIG. **22** shows the rotary compressor on which the electromagnetic coil **10** is installed in the second embodiment (as shown in FIG. **10**) with modifications in the mortise **18** on the arm **20** and the tip of the armature core **15** that is formed to be a slanted tooth and without using the limit switch L**0**. When electric current is not supplied into the coil **16**, the armature **13** will retract to the opening of the shield **14**. However, when electric current is not supplied into the coil **16**, the armature **13** will be sucked to be in the same line with the coil **16**, the operational control of which is the same as that of the rotary compressor on which the electromagnetic coil is installed in the first embodiment as shown in FIG. **21**.

THE BEST METHOD OF THIS INVENTION

[0063] As described in Detailed Description of The Preferred Embodiments.

1-8. (canceled)

9. A rotary compressor with a refrigerant flow-controlling unit capable of regulating flow of refrigerant in and out of said compressor where said controlling unit is installed onto said compressor in such a manner that moving of a vane (**4**) to separate a suction chamber (**7**) from a compression chamber (**8**) during an operation cycle of said compressor for a predetermined interval is controllable.

10. A rotary compressor of claim **9**, where said flow-controlling unit comprises an element (**15**) capable of being activated to allow its one projecting end engaging into a mortise (**18**) in said vane (**4**) to hold said vane in a predetermined position and period to make the compressor in a 'no-load' condition or inactivated to move said end out of said mortise to allow said compressor in a 'full-load' condition.

11. A rotary compressor of claim **10** where said projecting end of said element (**15**) can be either in a form of simple slanted end or a slanted tooth or any shape to engage in a complementary mortise in said vane (**4**).

12. A rotary compressor of claim **10** where an additional limit switch (**25**) is installed optionally to said compressor such that upon contact of a rolling piston (**1**) on an arm (**26**) of said switch causes detaching of contact plates (**27**) of said switch resulting in stop supplying of electric current into a coil (**16**) to make said coil (**16**) in 'OFF' position, where function of said coil (**16**) is to activate said element (**15**) when electric current is supplied to make it in 'ON' position.

13. A rotary compressor of claim **9** where one set to function comprises a rolling piston (**1**) with a crankshaft (**2**) mounted in a cylinder (**3**) having a vane (**4**) movable to and fro along a slot (**5**) upon contacting said rolling piston or pushing of a spring (**6**), and where a refrigerant flow-controlling unit is installed to each of said set;

and where there may be either one or multiple sets in one rotary compressor where said assembly as multiple sets helps to minimize the energy consumption as program can be set to turn on and off just one or more sets at a particular time point for a predetermined period to allow most efficient use of an air-conditioning system.

14. A unit for controlling of flow of refrigerant in a rotary compressor comprises an element (**15**) capable of moving when activated to have its projecting end engage into a mortise in a vane (**4**) of said rotary compressor to hold said vane in a predetermined position and period, where said element housed in a structure (**10**, **16**) to allow it to function properly.

15. A method for controlling flow of refrigerant in a rotary compressor comprising steps of:

installing a unit for controlling flow of refrigerant in and out said compressor, to be mounted through a shield (**17**) of at least one set to function of said compressor,

activating an element (**15**) of said unit to move and engage its projecting end into a mortise in a vane (**4**) of said rotary compressor to hold said vane in a predetermined position and period.

16. A rotary compressor of claim **10**, where said flow-controlling unit alternatively comprises an element (**15**) capable of being activated to allow its one end engaging into a mortise (**18**) in a tube (**22**) connecting to said vane (**4**) to hold said vane in a predetermined position and period to make the compressor in a 'no-load' condition or inactivated to move said end out of said mortise to allow said compressor in a 'full-load' condition.

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