US 20150167672A1

(19) United States

(12) Patent Application Publication

Stones et al.

(10) Pub. No.: US 2015/0167672 A1

(43) Pub. Date: Jun. 18, 2015

(54) **SCROLL COMPRESSOR**

(71) Applicant: **Edwards Limited**, Crawley, West Sussex (GB)

(72) Inventors: **Ian David Stones**, Felbridge (GB); **Alan Ernest Kinnaird Holbrook**, Pulborough (GB)

(21) Appl. No.: **14/412,905**

(22) PCT Filed: **Jun. 10, 2013**

(86) PCT No.: **PCT/GB2013/051517**

§ 371 (c)(1), (2) Date: **Jan. 5, 2015**

(30) **Foreign Application Priority Data**

Jul. 6, 2012 (GB) 1212026.7

Publication Classification

(51) **Int. Cl.**

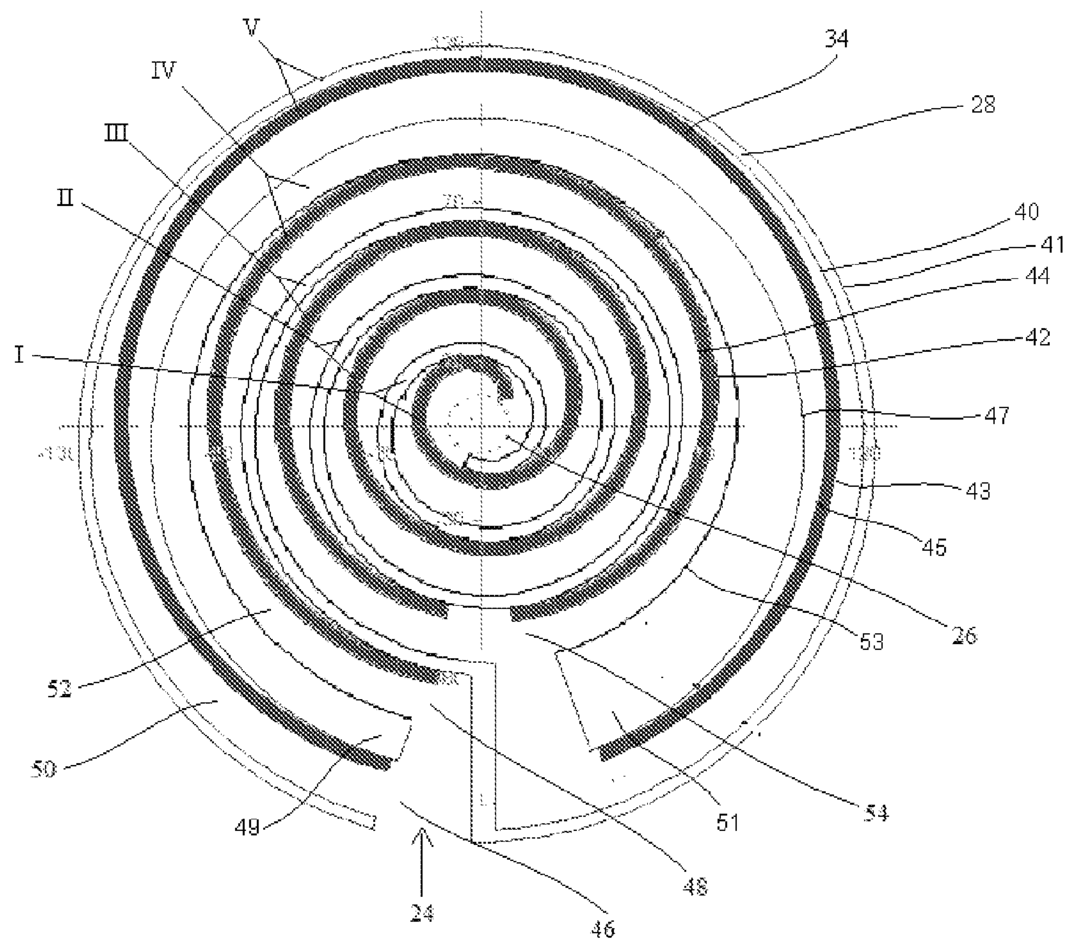
F04C 23/00	(2006.01)
F04C 28/24	(2006.01)
F04C 18/02	(2006.01)

(52) **U.S. Cl.**

CPC ***F04C 23/003*** (2013.01); ***F04C 18/0269*** (2013.01); ***F04C 28/24*** (2013.01)

(57) **ABSTRACT**

The present invention relates to a scroll compressor comprising a scroll pumping arrangement comprising two scrolls each having a scroll wall with inner and outer scroll wall surfaces which co-operate with respective outer and inner scroll wall surfaces of the other scroll wall providing two pairs of co-operating surfaces which, on relative orbiting motion of the scrolls, pump fluid from an inlet to an outlet of the arrangement, the scroll walls having a respective plurality of wraps I, II, III, IV, V between the inlet and the outlet and wherein the co-operating scroll wall surfaces of one of said pairs of at least one wrap are generally circular.



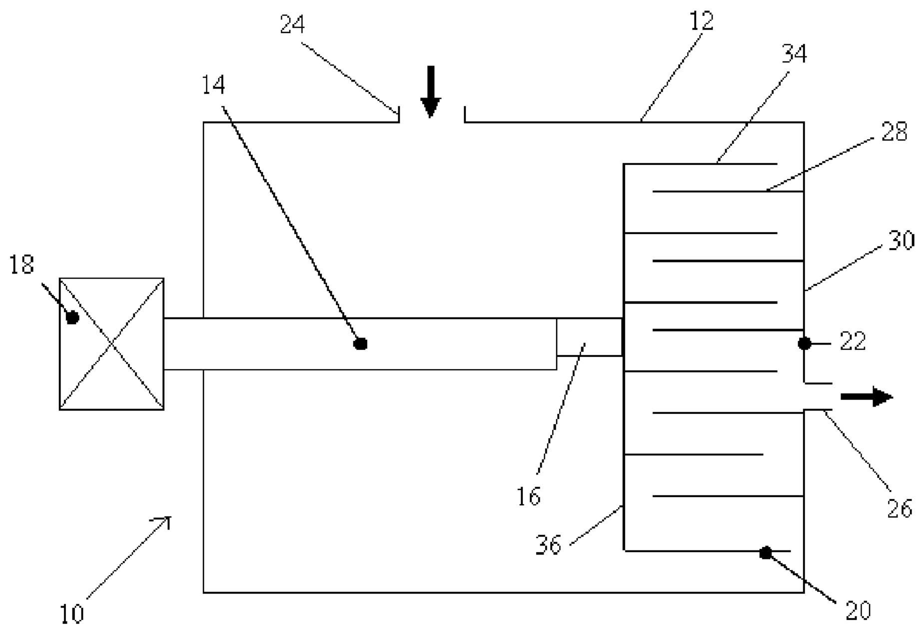


FIG. 1

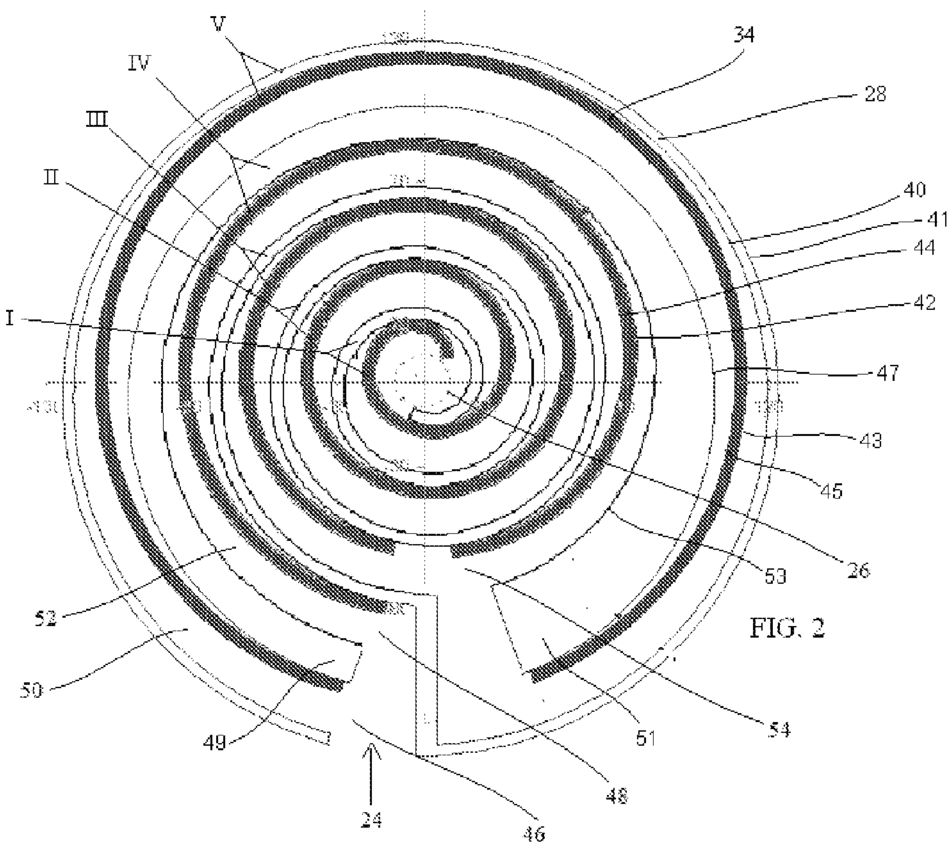


FIG. 2

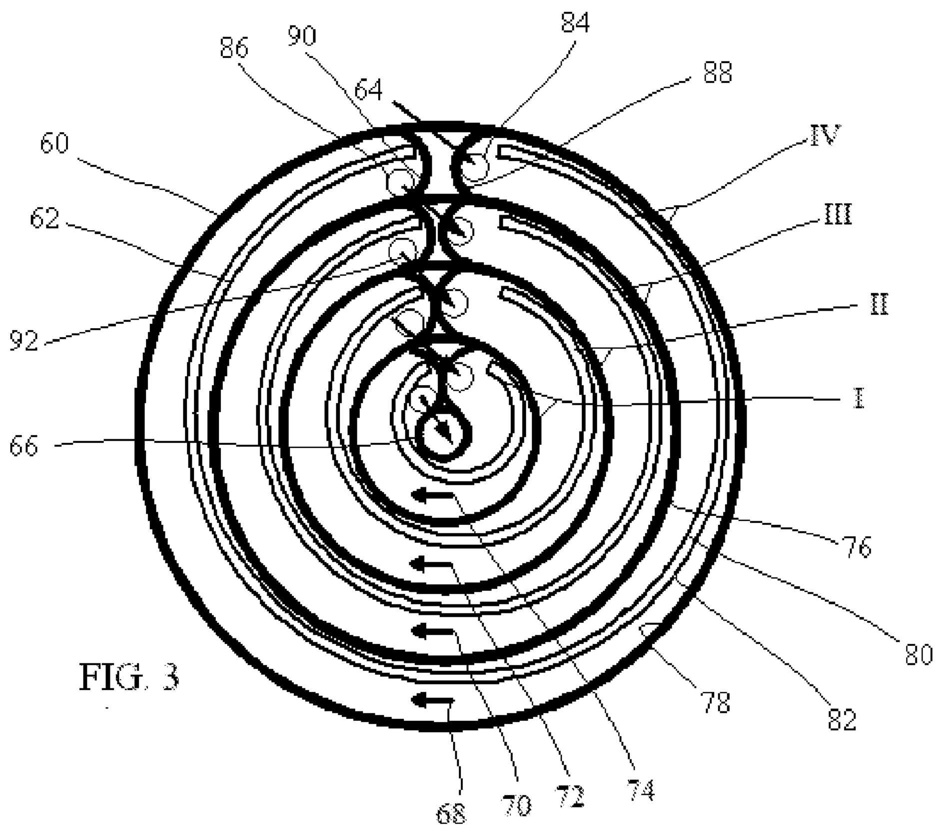


FIG. 3

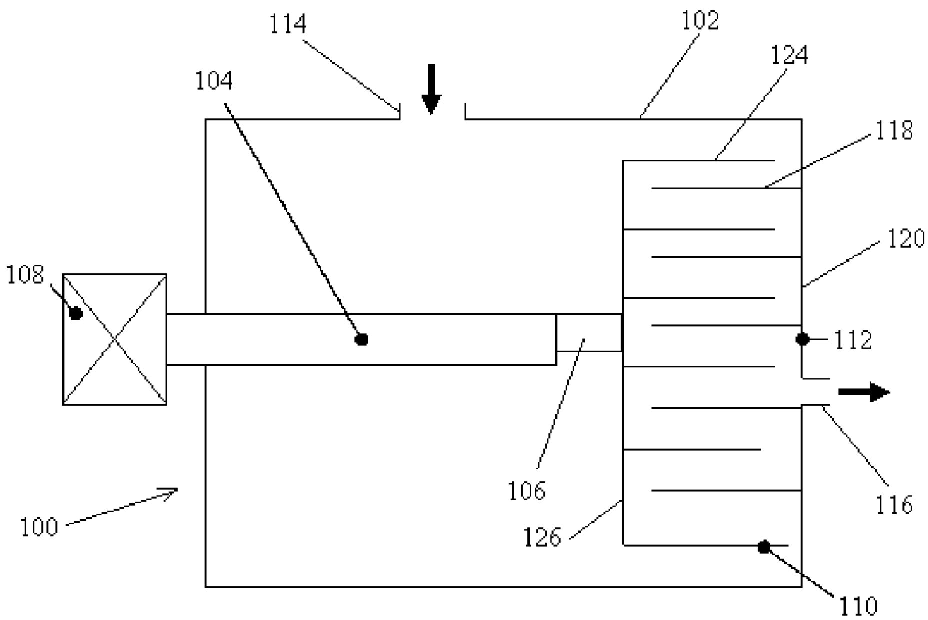


FIG. 4

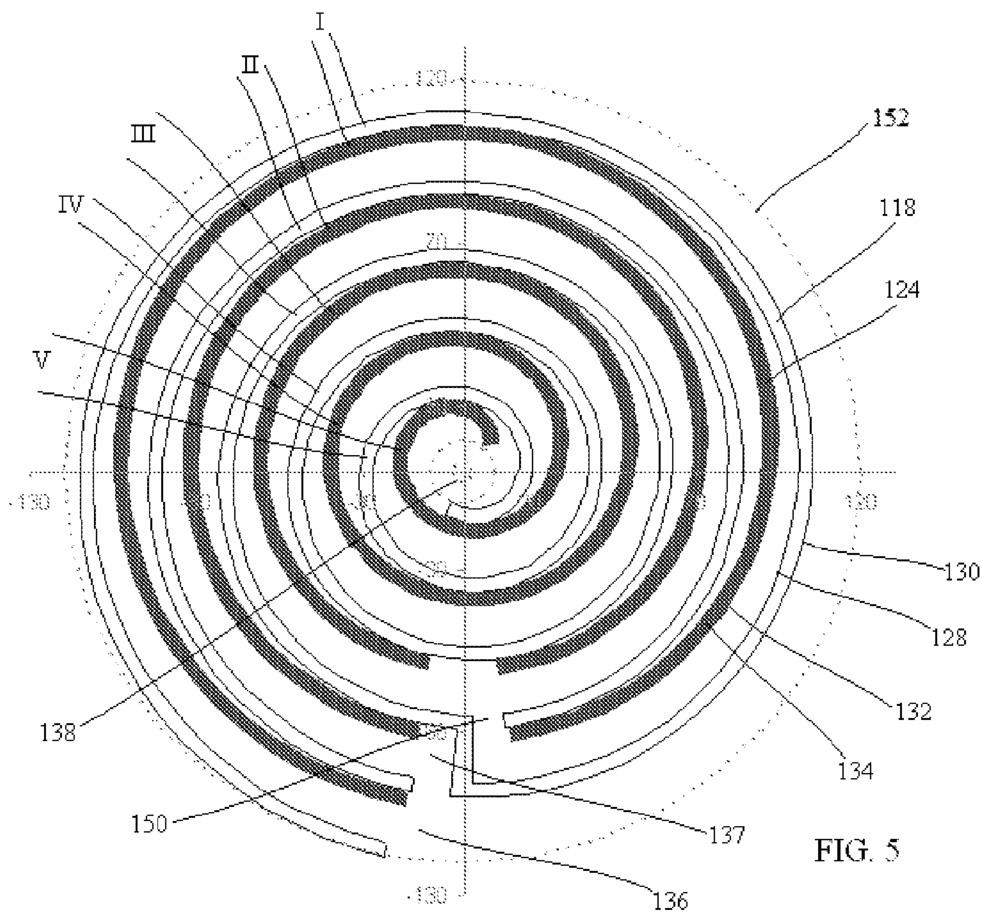

I
II
III
IV
V
152
118
124
130
128
132
134
138
150
137
136
120
70
-130
120
-130

FIG. 5

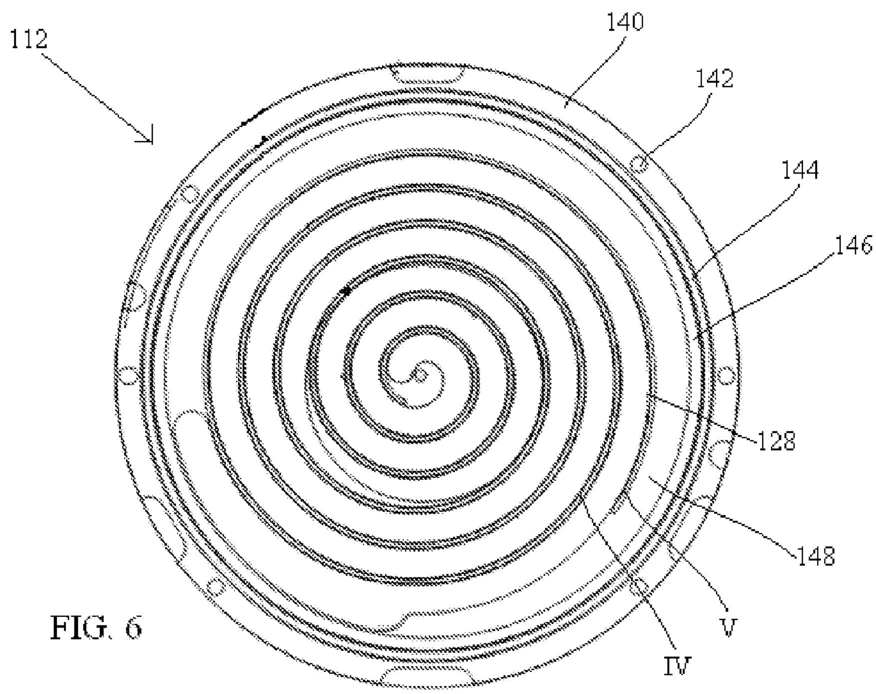


FIG. 6

SCROLL COMPRESSOR

[0001] This application is a national stage entry under 35 U.S.C. §371 of International Application No. PCT/GB2013/051517, filed Jun. 10, 2013, which claims the benefit of G.B. Application 1212026.7, filed Jul. 6, 2012. The entire contents of International Application No. PCT/GB2013/051517 and G.B. Application 1212026.7 are incorporated herein by reference.

TECHNICAL FIELD

[0002] The present invention relates to a scroll compressor.

BACKGROUND

[0003] A prior art scroll compressor, or pump, **100** is shown in FIG. **4**. The pump **100** comprises a pump housing **102** and a drive shaft **104** having an eccentric shaft portion **106**. The shaft **104** is driven by a motor **108** and the eccentric shaft portion is connected to an orbiting scroll **110** so that during use rotation of the shaft imparts an orbiting motion to the orbiting scroll relative to a fixed scroll **112** for pumping fluid along a fluid flow path between a pump inlet **114** and pump outlet **116** of the compressor.

[0004] The fixed scroll **112** comprises a scroll wall **118** which extends perpendicularly to a generally circular base plate **120**. The orbiting scroll **110** comprises a scroll wall **124** which extends perpendicularly to a generally circular base plate **126**. The orbiting scroll wall **124** co-operates, or meshes, with the fixed scroll wall **118** during orbiting movement of the orbiting scroll. Relative orbital movement of the scrolls causes a volume of gas to be trapped between the scrolls and pumped from the inlet to the outlet.

[0005] FIG. **5** shows the fixed scroll wall **118** and the orbiting scroll wall **124**. The fixed scroll wall has inner **128** and outer **130** scroll wall surfaces which co-operate with respective outer **132** and inner **134** scroll wall surfaces of the orbiting scroll wall. This arrangement provides two pairs **128**, **132**; **130**, **134** of co-operating scroll wall surfaces which, on relative orbiting motion of the scrolls, pump fluid from the inlet **136**, **137** to the outlet **138** of the arrangement. The scroll walls **118**, **124** have a respective plurality of wraps I, II, III, IV, V between the inlet and the outlet. The co-operating scroll wall surfaces **128**, **132**; **130**, **134** are involute from the inlet to the outlet.

[0006] The specific scroll arrangement shown in FIG. **5** is a so-called twin start arrangement having two inlets **136**, **137** which in this example are located at the same circumferential angle but at different radii. Two parallel pumping channels extend from the inlets and converge to a single pumping channel after approximately 360 degrees. A twin start arrangement is generally provided for increasing capacity.

[0007] FIG. **6** shows a more detailed view of the fixed scroll **112**. The fixed scroll comprises an annular flange **140** having a plurality of through holes **142** for fixing the fixed scroll to the remainder of the pump housing (not shown). An annular recess **144** receives an o-ring (not shown) for sealing between the fixed scroll and the pump housing. The annular recess is located between the flange **140** and an annular raised portion **146**. The outer wrap V of the fixed scroll has radially inner co-operating surface **128** which is an involute or spiral. The outer wrap V of the orbiting scroll wall fits between wraps IV and V of the fixed scroll wall. Therefore, the outer wrap V of the fixed scroll does not have an outer co-operating scroll wall surface.

[0008] As indicated above, in some applications it is desirable to increase a capacity of a scroll pump, and the arrangement shown in FIG. **5** increases capacity by adopting a twin-start inlet. However, invariably when capacity is increased, it is at the expense of compression or requires a larger pump. In a twin-start pump, there is one less wrap available for gradual compression from the inlet to the outlet and therefore a twin-start pump generally offers reduced compression. It should also be noted that a transitional point **150** (see FIG. **5**) where the two inlet channels converge to a single channel causes inefficiency in the arrangement since it is not possible to efficiently seal between wraps at the transitional point. Accordingly, performance of the pump is reduced.

SUMMARY

[0009] The present invention seeks to provide a scroll compressor having increased capacity and yet does not suffer, at least to the same extent, from one or more of the problems associated with prior art arrangements.

[0010] The present invention provides a scroll compressor comprising a scroll pumping arrangement comprising two scrolls each having a scroll wall with inner and outer scroll wall surfaces which co-operate with respective outer and inner scroll wall surfaces of the other scroll wall providing two pairs of co-operating surfaces which, on relative orbiting motion of the scrolls, pump fluid from an inlet to an outlet of the arrangement, the scroll walls having a respective plurality of wraps between the inlet and the outlet and wherein the co-operating scroll wall surfaces of one of said pairs of at least one wrap are generally circular.

[0011] The present invention also provides a scroll compressor comprising a scroll pumping arrangement comprising two scrolls each having a scroll wall with inner and outer scroll wall surfaces which co-operate with respective outer and inner scroll wall surfaces of the other scroll wall providing two pairs of co-operating surfaces which, on relative orbiting motion of the scrolls, pump fluid from an inlet to an outlet of the arrangement, the scroll walls having a respective plurality of wraps between the inlet and the outlet and wherein the co-operating scroll wall surfaces of one of said pairs of at least one wrap have a rate of change of radius with respect to the angle which is less than said rate of change of the other wraps so that the compression ratio of said one of said pairs is less than for the other wraps.

[0012] Other preferred and/or optional aspects of the invention are defined in the accompanying claims.

BRIEF DESCRIPTION OF DRAWINGS

[0013] In order that the present invention may be well understood, an embodiment thereof, which is given by way of example only, will now be described with reference to the accompanying drawings, in which:

[0014] FIG. **1** shows schematically a scroll pump;

[0015] FIG. **2** shows a first scroll pumping arrangement for the pump shown in FIG. **1**,

[0016] FIG. **3** shows a second scroll pumping arrangement for the pump shown in FIG. **1**;

[0017] FIG. **4** shows a prior art scroll pump;

[0018] FIG. **5** shows a prior art scroll pumping arrangement of the pump shown in FIG. **4**; and

[0019] FIG. **6** shows a fixed scroll of a prior art pump in more detail.

DETAILED DESCRIPTION

[0020] A scroll compressor, or pump, **10** is shown in FIG. **1**. The pump **10** comprises a pump housing **12** and a drive shaft **14** having an eccentric shaft portion **16**. The shaft **14** is driven by a motor **18** and the eccentric shaft portion is connected to an orbiting scroll **20** so that during use rotation of the shaft imparts an orbiting motion to the orbiting scroll relative to a fixed scroll **22** for pumping fluid along a fluid flow path between a pump inlet **24** and pump outlet **26** of the compressor.

[0021] The fixed scroll **22** comprises a scroll wall **28** which extends perpendicularly to a generally circular base plate **30**. The orbiting scroll **20** comprises a scroll wall **34** which extends perpendicularly to a generally circular base plate **36**. The orbiting scroll wall **34** co-operates, or meshes, with the fixed scroll wall **28** during orbiting movement of the orbiting scroll. Relative orbital movement of the scrolls causes a volume of gas to be trapped between the scrolls and pumped from the inlet to the outlet.

[0022] As shown in FIG. **2**, the fixed scroll wall **28** has inner **38** and outer **40** scroll wall surfaces which co-operate with respective outer **42** and inner **44** scroll wall surfaces of the orbiting scroll wall **34** providing two pairs of co-operating surfaces **38**, **42**; **40**, **44**. On relative orbiting motion of the scrolls **20**, **22**, fluid is pumped from an inlet **46**, **48** to an outlet **50** of the arrangement. The scroll walls have a respective plurality of wraps I, II, III, IV, V between the inlet and the outlet. The co-operating scroll wall surfaces **38**, **42**; **40**, **44** of one of the pairs of at least one wrap are circular.

[0023] Typically, the co-operating scroll wall surfaces of a scroll pump are involute, or spiral. Since the volume of fluid trapped by each pair of co-operating surfaces reduces as the volume approaches the outlet **26** the pump compresses the fluid. As indicated above with reference to the prior art, many attempts have been made to increase pumping capacity, or the amount of fluid that can be pumped. These attempts have produced increased capacity but suffer from disadvantages such as reduced compression or increased back leakage. In the present invention, one pair of scroll wall surfaces is not involute but instead is substantially circular.

[0024] For Archimedean spirals and large angles of an involute, the geometry of a spiral in prior art pumps is such that the rate of change of the radius is generally constant with respect to the change in the angle. Where r is the radius and θ is the angle about the centre of the spiral, for an Archimedean spiral ($r=a\theta$), $dr/d\theta=a$, which is constant. For an involute, $dr/d\theta$ is not constant but changes a lot over the first ½ turn and then it tends to a single value. In other words, for large angles, it becomes reasonable constant. For a circle, $dr/d\theta=0$. That is, $dr/d\theta$ is a constant.

[0025] In the present invention, $dr/d\theta$ for at least one of the pairs of scroll surfaces **38**, **42**; **40**, **44** for at least one wrap I, II, II, IV, V is reduced such that the spiral tends towards a circular path and departs from a geometrical spiral or involute as defined above. That is, if $dr/d\theta$ equals 'a' for a spiral and 0 for a circle, then for embodiments of the invention $dr/d\theta$ equals a value between 'a' and 0, preferably approaching 0. In its most preferred example therefore, the scroll wall surfaces are circular, although benefits of the invention can be achieved by decreasing $dr/d\theta$ thereby increasing the trapped volume between the scroll wall surfaces. Therefore, decreasing $dr/d\theta$ increases pumping capacity and decreases compression. The circular or generally circular scroll wall surfaces may be located at any one of the wraps I, II, III, IV, V, or may be located at more than one wrap or at all of the wraps, the latter of which is shown in the example described in more detail below with reference to FIG. **3**.

[0026] In the first example as shown in FIG. **2**, the fixed scroll wall **28** of the outer wrap V has only one co-operating surface **40**, the other surface **41** being outside the pumped volume. The co-operating surface **40** is circular. The orbiting scroll wall **34** of the outer wrap V has two co-operating surfaces **43**, **45** both of which are circular. The outer surface **43** co-operates with the inner surface **40** of the fixed scroll wall, whilst the inner surface **45** co-operates with the outer surface **47** of wrap IV of the fixed scroll wall. The other radially inward wall surfaces of the pump in this example are involute. The transition between circular and involute surfaces is formed by the fixed scroll wall of wrap **4**. This scroll wall increases in radial thickness between a first portion **49** and a second portion **51** thereby defining an outer surface **47** which is circular and an inner surface **53** which is involute.

[0027] Typically, as shown in FIG. **6**, the fixed scroll casing **140**, **144**, **146 148** is generally circular so that the fixed scroll has a small overall volume and foot-print. However, the inner scroll wall surface **128** of the fixed scroll wall **118** is spiral. Therefore, referring to prior art FIG. **5**, a region between circle **152** and the outer wrap V of the fixed scroll is lost and not usefully available for pumping fluid. It is an advantageous feature of the present embodiment in FIG. **2** that the lost pumping region is brought within the pumping volume of the scrolls. In this regard, instead of having a transition between circular and spiral which is outside a pumping volume, the transition is brought within the pumping volume. Accordingly, as shown, the inner scroll surface **40** of the fixed scroll wall **28** is circular and the transition between the circular and spiral surfaces occurs at wrap IV of the fixed scroll. Therefore, the pumping capacity of the pump is increased without an increase in the overall volume or foot-print of the pump.

[0028] It will be appreciated that a single circular wrap does not achieve compression since the trapped volume between co-operating scroll wall surfaces is not reduced by pumping along a circular surface. However, capacity is increased because the circular scroll wall surfaces are inherently able to trap more volume than spiral surfaces at the same radius and hence greater capacity is achieved. Furthermore, if the co-operating surfaces of the outer scroll wrap are circular, a previously unused region of the pump is brought within the pumping volume.

[0029] Referring again to FIG. **2**, wraps Ito III are involute, wrap V is circular and wrap IV is transitional between circular and spiral. In the example shown, the fixed scroll wall of wrap IV has an outer scroll wall surface **47** which is circular and an inner scroll wall surface **53** which is spiral. The transition necessitates a relatively thick scroll wall and therefore it is advantageous that the transition takes place on the stationary fixed scroll, since a thicker orbiting scroll wall would increase the weight of the moving components of the pump. Alternatively the transition may take place on the orbiting scroll, and in this case the orbiting scroll may be hollow to reduce the amount of mass which must be moved during orbiting motion. In this regard, the outer wrap V of the orbiting scroll may have an outer scroll wall surface which is circular and an inner scroll wall surface which is spiral. In this arrangement, only the co-operating surfaces at the outer wrap of the scroll walls are circular. In other words, only an outer most pumping channel is circular.

[0030] It will be noted that the transition between circular and spiral pumping surfaces may take place on any of the wraps of the orbiting scroll or any of the wraps of the fixed scroll (except the outer wrap of the fixed scroll).

[0031] The inlet **24** to the scroll pumping arrangement shown in FIG. **2** is sub-divided into inlets **46**, **48** to respective pumping channels **50**, **52**. Typically, as described above in relation to the prior art, a two-start or multi-start arrangement is often used to increase pumping capacity. The example shown comprises two inlets **46**, **48** on different radii, although in other examples, the inlets may be provided on the same radius at different circumferential positions. The present invention encompasses all such examples.

[0032] A problem that exists with multi-start arrangements occurs where the pumping channels converge as shown by **150** in FIG. **5**. In more detail, the scroll wall is not continuous at the convergence between multiple and single channels and therefore there is a gap in the tip seals which resist back-leakage. Accordingly, back-leakage is increased thereby reducing the pumping efficiency.

[0033] In the embodiment of the invention, the pumping channels **50**, **52** converge at **54** and the convergence is a source of some pumping inefficiency as the tip seals are discontinuous thereby reducing the capacity of the pump. However, the increased pumping capacity produced by the circular pumping channel **50** at least partially and preferably fully compensates for the back-leakage at the convergence **54**. In this regard, pumping channel **50** has two pairs of co-operating surfaces formed on both sides of the outer wrap V of the orbiting scroll wall **34**. Accordingly, the embodiment provides a multi-start scroll pumping arrangement which does not suffer from reduced efficiency.

[0034] Whilst a multi-start arrangement is shown in FIG. **2**, the present invention applies equally to single start arrangements. That is, the fixed scroll wall may define one pumping channel between successive wraps (as in a single start arrangement) or more than one pumping channel between successive wraps of the scroll wall which may converge.

[0035] In an alternative arrangement, a multi-start or single start scroll arrangement comprises one or more circular pumping channels and one or more involute pumping channels and the circular pumping channels are deeper than the involute pumping channels. The transition from deep to shallow channels in prior art pumps can often be a cause of inefficiency because the tip seals are not continuous. In this example of the invention however, the circular nature of the deeper pumping channels compensates for the back-leakage caused at the transition.

[0036] In a further scroll pumping arrangement, there are one or more circular pumping channels and one or more involute pumping channels, and a flow intersection between the circular pumping channels and the involute pumping channels is in flow communication with a blow-off valve for releasing over pressure from the scroll arrangement. The intersection is a suitable location for the blow-off valve as it is located at the transition between a high capacity region and a low capacity region and when running at high inlet pressures substantial over-pressure may occur.

[0037] A still further scroll arrangement is shown in FIG. **3**. The fixed scroll **22** comprises a scroll wall **60** having four discrete generally circular sections. The orbiting scroll **20** comprises a scroll wall **62** having four discrete generally circular sections. The orbiting scroll wall **62** co-operates, or meshes, with the fixed scroll wall **60** during orbiting movement of the orbiting scroll. Relative orbital movement of the scrolls causes a volume of gas to be trapped between the scrolls and pumped from the inlet **64** to the outlet **66**.

[0038] As shown in FIG. **3**, the fixed scroll wall and the orbiting scroll wall each have four wraps I, II, II, IV which in this example are formed by four circular wall sections. The fixed scroll wall sections of successive wraps form therebetween four circular pumping channels **68**, **70**, **72**, **74**. For example, the fixed scroll wall sections of wraps III and IV form pumping channel **68**. The four sections of the orbiting scroll wall are located within respective pumping channels.

[0039] With regard to the outer pumping channel **68**, the fixed scroll wall sections of wraps III and IV form outer **76** and inner **78** scroll wall surfaces respectively. The orbiting scroll wall section of wrap IV forms inner **80** and outer **82** scroll wall surfaces which co-operate with respective outer **76** and inner **78** of the fixed scroll wall surfaces forming two pairs of co-operating surfaces **76**, **80**; **78**, **82** in pumping channel **68**. On relative orbiting motion of the scrolls, fluid in the outer pumping channel **68** is trapped between both pairs of co-operating surfaces and pumped from a channel inlet **84** to a channel outlet **86**.

[0040] Each pumping channel extends through less than 360° (although not substantially less than 360°, e.g. about 350°) so that the pumping channel forms an incomplete circle. The ends of each pumping channel are closed by one or more wall closures **88**, **90** thereby separating the inlet from the outlet in a pumping channel. The closures are arcuate so that an end of an orbiting scroll wall section sweeps across its face during orbiting motion. This arrangement allows fluid to be trapped efficiently by the orbiting scroll wall.

[0041] The outlet **86** of each channel is connected by a duct (shown by arrows **92**) to an inlet **84** of the next inward pumping channel. Trapped fluid in channel **68** is forced along a duct **92** entering channel **70** and so on until fluid is forced through the outlet of the most inward channel **74** to the outlet **66** of the pumping arrangement. As fluid is pumped from one channel to the next it becomes compressed because the trapped volume becomes progressively smaller. Accordingly, compression occurs even though all the pumping channels, and co-operating surfaces are circular.

[0042] Circular wall profiles are easier to design, manufacture and inspect. The simple profile allows better tolerances to be achieved. Having all the wraps as circular avoids over compression between any of the stages, which maximises pumping efficiency.

[0043] In FIG. **2**, an outer pumping channel is circular and the remaining pumping channels are spiral. This arrangement reduces dead space in the pump and thereby increases capacity. A circular pumping channel achieves increased capacity without compression. In FIG. **3**, all the pumping channels are circular. The invention also encompasses any arrangement between these two examples, such as where one, two or three wraps or pumping channels are circular. Therefore, the invention covers arrangements in which only one pair of co-operating scroll wall surfaces are circular or at least generally circular, and in which all of the co-operating surfaces are circular and all possibilities in between.

[0044] In a multi-start pump, one pumping channel at a first start may be circular, a plurality of pumping channels at more than one start may be circular or all of the pumping channels at all of the starts may be circular.

1. A scroll compressor comprising:
a scroll pumping arrangement comprising two scrolls, each scroll of the two scrolls including a respective scroll wall including a respective inner scroll wall surface and a respective outer scroll wall surface which co-operate with respective outer and inner scroll wall surfaces of the other scroll wall providing two pairs of co-operating scroll wall surfaces which, on relative orbiting motion of the scrolls, pump fluid from an inlet to an outlet of the arrangement, wherein each scroll wall of the respective scroll walls includes a respective plurality of wraps between the inlet and the outlet, and wherein the co-operating scroll wall surfaces of one pair of the two pairs of co-operating scroll wall surfaces of at least one wrap are generally circular.

2. The scroll compressor of claim **1**, wherein the respective scroll walls have an outer wrap adjacent the inlet and wherein the co-operating scroll wall surfaces of one pair of the two pairs of co-operating scroll wall surfaces of the outer wrap are circular.

3. The scroll compressor of claim **2**, wherein the respective scrolls comprise a fixed scroll wall and an orbiting scroll wall which is configured to move relative to the fixed scroll wall for pumping fluid from the inlet to the outlet, and wherein a radially inner co-operating scroll wall surface of the outer wrap of the fixed scroll wall and a radially outer co-operating scroll wall surface of the outer wrap of the orbiting wall are circular.

4. The scroll compressor of claim **1**, wherein one scroll wall of the respective scroll walls includes a radially inner co-operating surface which is involute and a radially outer co-operating surface which is circular.

5. The scroll compressor of claim **3**, wherein the fixed scroll wall defines one or more pumping channels between successive wraps thereof.

6. The compressor of claim **5**, wherein the scroll pumping arrangement includes a plurality of inlets through which fluid can be pumped along respective pumping channels, and an outer pumping channel is circular.

7. The scroll compressor of claim **5**, wherein one or more of the respective pumping channels are circular and converge to form a single involute pumping channel.

8. The scroll compressor of claim **5**, wherein the scroll pumping arrangement comprises one or more circular pumping channels and one or more involute pumping channels, and wherein the one or more circular pumping channels are deeper than the one or more involute pumping channels.

9. The scroll compressor of claim **1**, wherein the scroll pumping arrangement comprises one or more circular pumping channels and one or more involute pumping channels, and a flow intersection between the circular pumping channels and the involute pumping channels is in flow communication with a blow-off valve for releasing over pressure from the scroll pumping arrangement.

10. A scroll compressor comprising:
a scroll pumping arrangement comprising two scrolls each respective scroll of the two scrolls including a respective scroll wall including a respective inner scroll wall surface and a respective outer scroll wall surface which co-operate with respective outer and inner scroll wall surfaces of the other respective scroll wall providing two pairs of co-operating surfaces which, on relative orbiting motion of the two scrolls, pump fluid from an inlet to an outlet of the scroll pumping arrangement, wherein the respective scroll walls each includes a respective plurality of wraps between the inlet and the outlet and wherein the co-operating scroll wall surfaces of one pair of the two pairs of co-operating surfaces of at least one wrap have a rate of change of radius with respect to the angle which is less than the rate of change of the other wraps so that the compression ratio of the one pair of the two pairs of co-operating surfaces is less than for the other wraps.

11. The scroll compressor of claim **6**, wherein one or more of the respective pumping channels are circular and converge to form a single involute pumping channel.

12. The scroll compressor of claim **6**, wherein the scroll pumping arrangement comprises one or more circular pumping channels and one or more involute pumping channels, and wherein the one or more circular pumping channels are deeper than the one or more involute pumping channels.

13. The scroll compressor of claim **7**, wherein the scroll pumping arrangement comprises one or more circular pumping channels and one or more involute pumping channels, and wherein the one or more circular pumping channels are deeper than the one or more involute pumping channels.

14. The scroll compressor of claim **2**, wherein one scroll wall of the respective scroll walls includes a radially inner co-operating surface which is involute and a radially outer co-operating surface which is circular.

15. The scroll compressor of claim **3**, wherein one scroll wall of the respective scroll walls includes a radially inner co-operating surface which is involute and a radially outer co-operating surface which is circular.

16. The scroll compressor of claim **2**, wherein the scroll pumping arrangement comprises one or more circular pumping channels and one or more involute pumping channels, and a flow intersection between the circular pumping channels and the involute pumping channels is in flow communication with a blow-off valve for releasing over pressure from the scroll pumping arrangement.

17. The scroll compressor of claim **3**, wherein the scroll pumping arrangement comprises one or more circular pumping channels and one or more involute pumping channels, and a flow intersection between the circular pumping channels and the involute pumping channels is in flow communication with a blow-off valve for releasing over pressure from the scroll pumping arrangement.

18. The scroll compressor of claim **4**, wherein the scroll pumping arrangement comprises one or more circular pumping channels and one or more involute pumping channels, and a flow intersection between the circular pumping channels and the involute pumping channels is in flow communication with a blow-off valve for releasing over pressure from the scroll pumping arrangement.

19. The scroll compressor of claim **5**, wherein the scroll pumping arrangement comprises one or more circular pumping channels and one or more involute pumping channels, and a flow intersection between the circular pumping channels and the involute pumping channels is in flow communication with a blow-off valve for releasing over pressure from the scroll pumping arrangement.

20. The scroll compressor of claim **6**, wherein the scroll pumping arrangement comprises one or more circular pumping channels and one or more involute pumping channels, and a flow intersection between the circular pumping channels

and the involute pumping channels is in flow communication with a blow-off valve for releasing over pressure from the scroll pumping arrangement.

* * * * *