

- 1 -

SCROLL-TYPE FLUID DISPLACEMENT MACHINEBACKGROUND AND SUMMARY

The present invention relates to fluid displacement apparatus and more particularly to a scroll-type machine especially adapted for compressing gaseous fluids and having improved (i.e. greater) volume/pressure ratio characteristics.

5 ~~A class of machines exists in the art generally known as "scroll" apparatus for the displacement of various types of fluids. Such apparatus may be configured as an expander, a displacement engine, a pump, a compressor, etc., and many features of the present invention are applicable to any one of these machines. For purposes of illustration,~~
10 ~~however, the disclosed embodiments are in the form of a gaseous fluid compressor.~~

Generally speaking, a scroll apparatus comprises two spiral scroll wraps of similar configuration each mounted on a separate end plate to define a scroll member. The two scroll members are interfitted together
15 with one of the scroll wraps being rotationally displaced 180 degrees

from the other. The apparatus operates by orbiting one scroll member (the "orbiting" scroll member) with respect to the other scroll member (the "fixed" scroll member) to make moving line contacts between the flanks of the respective wraps defining moving isolated crescent-shaped pockets or chambers of fluid. The spirals are commonly formed as involutes of a circle, and ideally there is no relative rotation between the scroll members during operation, i.e., the motion is purely curvilinear translation (i.e. no rotation of any line in the body). The fluid pockets carry the fluid to be handled from a first zone in the scroll apparatus where a fluid inlet is provided, to a second zone in the apparatus where a fluid outlet is provided. The volume of a sealed pocket progressively changes as it moves from the first zone to the second zone. At any one instant in time there will be at least one pair of sealed pockets, and when there are several pairs of sealed pockets at one time, each pair will have different volumes. In a compressor the second zone is at a higher pressure than the first zone and is physically located centrally in the apparatus, the first zone being located at the outer periphery of the apparatus.

Generally, the greater the arcuate length of the scroll wrap the greater the possible total reduction in the volume of a pocket as it moves to the second zone (i.e. the greater the possible volume ratio); and the greater the volume ratio the greater the pressure ratio of the machine.

Two types of contacts define the fluid pockets formed between the scroll members: axially extending tangential line contacts between the spiral faces of the wraps caused by radial forces ("flank sealing"), and area contacts caused by axial forces between the plane edge surfaces (the "tips") of each wrap and the opposite end plate ("tip sealing"). For high efficiency, good sealing must be achieved for both types of

contacts. In a conventional scroll compressor (i.e. one in which the wraps are involutes of a circle) good flank sealing requires that there be no relative rotation between the scrolls.

The concept of a scroll-type apparatus has been known for some time and has been recognized as having distinct advantages. For example, scroll machines have high isentropic and volumetric efficiency, and hence are relatively small and lightweight for a given capacity. They are quieter and more vibration free than many compressors because they do not use large reciprocating parts (e.g. pistons, connecting rods, etc.), and because all fluid flow is in one direction with simultaneous compression in plural opposed pockets there are less pressure-created vibrations. Such machines also tend to have high reliability and durability because of the relative few moving parts utilized, the relative low velocity of movement between the scrolls, and an inherent forgiveness to fluid contamination.

One of the important areas of design in a scroll machine concerns the technique used for preventing relative angular movement between the scrolls as they orbit with respect to one another. One of the more popular approaches resides in the use of an Oldham coupling operative between the orbiting scroll and a fixed portion of the apparatus. An Oldham coupling typically comprises an Oldham ring and two sets of key members or slider blocks. The Oldham ring is formed on one side thereof with grooves which are at right angles to a similar grooves formed on the other side thereof. One set of key members is connected to a surface of the orbiting scroll and is disposed in the grooves on one side of the Oldham ring, while the other set of key members is fixed to either the fixed scroll or the machine housing and is disposed in the grooves on the other side of the Oldham ring. The Oldham ring reciprocates in a motion parallel to the grooves containing the set of

22

key members fixed to the fixed scroll or housing. The Oldham coupling thus acts as a means for controlling (i.e. preventing) angular rotation of the orbiting scroll relative to the fixed scroll. U.S. Patent No. 4,121,438 shows a machine of this construction.

5 There are other known devices for controlling relative rotation of the scrolls, such as ~~the linkage mechanisms disclosed in co-pending applications Serial No. 471,742, filed March 3, 1983 and Serial No. 471,743, filed March 3, 1983;~~ the use of multiple drives rotating both scrolls about different centers; and like concepts. Rotation controlling
10 means, however, is not part of the present invention, and for exemplary purposes the scroll mechanism disclosed herein will be assumed to be controlled by an Oldham coupling or similar device which provides pure curvilinear relative motion between the scrolls. Furthermore, for simplicity of description the scroll wrap contours will be assumed to be
15 involutes of a circle.

The present invention resides in the provision of a unique scroll member design which is capable of providing substantially larger volume/pressure ratios for a given wrap length and number of wraps than those possible in a conventional scroll-type machine. This is very
20 advantageous because it results in a much more diametrically compact machine for a given volume/pressure ratio (usually the starting point of a machine design). Furthermore, because less wrap length is required for a given volume/pressure ratio it is possible to provide compressors with much larger discharge ports, thereby significantly improving
25 compressor efficiency. The present invention accomplishes this in an extremely simple manner by altering the wrap tip and end plate configurations to provide for an axial reduction in the volume of the sealed pockets as they move to the second zone, in addition to the conventional volume reduction in the radial direction.

Additional advantages and features of the present invention will become apparent from the subsequent description and the appended claims taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

5 Figure 1 is a exploded perspective view of the inside surfaces of a pair of scroll members embodying the principles of the present invention, the normally interengaging scroll members being separated in the same manner as a book is opened.

Figure 2 is a diagram of the geometry of the present invention.

10 Figures 3 through 9 are transverse sections through the wraps of a scroll-type machine embodying the principles of the present invention, illustrating the mechanism in a plurality of angular positions, respectively.

Figure 10 is a graph illustrating the volume of the sealed chambers
15 as a function of crank angle.

Figure 11 is a fragmentary sectional view of a second embodiment of the scroll members taken generally along a line equivalent to line x-x in Figure 1.

Figure 12 is a fragmentary sectional view of the second embodiment
20 of the scroll members taken generally along a line equivalent to line y-y in Figure 1.

Figure 13 is a fragmentary sectional view of the second embodiment of the scroll members taken generally along a line equivalent to line z-z in Figure 1.

25 Figure 14 is a fragmentary sectional view of a third embodiment of the scroll members taken generally along a line equivalent to line x-x in Figure 1.

Figure 15 is a fragmentary sectional view of the third embodiment of the scroll members taken generally along a line equivalent to line

y-y in Figure 1.

Figure 16 is a fragmentary sectional view of the third embodiment of the scroll members taken generally along a line equivalent to line x-x in Figure 1.

5 DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The principles of the present invention are applicable to almost all scroll-type machines and therefore because such machines are well known, only the scroll members themselves are illustrated in the present application. The way in which they are contoured, mounted, restrained
10 from rotation, driven, etc. may all be in accordance with known principles.

Referring to Figure 1, there is illustrated an orbiting scroll member 10 and a fixed scroll member 12. Normally the scroll members are intermeshed with one another but for purposes of illustration they are
15 shown in Figure 1 opened up as a book would be opened, in order to see the details of the configuration thereof.

Scroll member 10 includes a continuous spiral wrap 14 which extends outwardly from the central axis of the machine and has a roll angle of at least 1080 degrees, (i.e. 3 wraps). Only 2-1/2 wraps on
20 each of the inner and outer flank surfaces (900 roll angle degrees) are used, but 3 wraps are required because the outside flank of the outer one-half wrap and the inside flank of the inner one-half wrap are not functional. Wrap 14 is of uniform radial thickness with the radially outer flank thereof being uniformly radially spaced from the adjacent
25 opposed radially inner flank thereof which it faces.

An end plate 16 is disposed at the axially outer edge of wrap 14 for closing the open space between the opposed flanks thereof. End plate 16 has an outer end sealing surface 18 disposed between said

opposed flanks of wrap 14 for the outer arcuate portion thereof. An inner end sealing surface 20 (shown with shading) is disposed between the opposed flanks of wrap 14 for the inner arcuate portion thereof. Both of these end sealing surfaces are flat and perpendicular to the machine axis, with outer end sealing surface 18 being disposed axially outwardly from inner end sealing surface 20. Outer and inner end sealing surfaces 18 and 20 are interconnected by a circular cylindrical transition surface 22 formed about an axis of curvature parallel to the machine axis and having a radius equal to one-half the radial space between said adjacent opposed flanks of the wrap. This radius is also the orbital radius of the machine.

Tip sealing surfaces are disposed on the axially inner edge of the wrap comprising an outer tip sealing surface 24 disposed along the outer arcuate portion of the wrap, and an inner tip sealing surface 26 disposed along the inner arcuate portion of the wrap, both of the tip sealing surfaces being flat and perpendicular to the machine axis, with outer tip sealing surface 24 being disposed axially inwardly from inner tip sealing surface 26. The outer and inner tip sealing surfaces are interconnected by a circular cylindrical transition surface 28 formed about an axis of curvature disposed parallel to the machine axis and having a radius equal to one-half the radial thickness of the wrap. The axes of curvature of transition surfaces 22 and 28 are disposed approximately 180 degrees from each other about the machine axis, and the surfaces are of equal axial height.

Scroll member 12 includes continuous spiral wrap 32 which is mirror image to wrap 14. An end plate 34 is disposed at the axially outer edge of wrap 32 for closing the open space between the opposed flanks thereof. End plate 34 has an outer end sealing surface 36 disposed between said opposed flanks of wrap 32 for the outer arcuate

26

portion thereof. An inner end sealing surface 38 (shown with shading) is disposed between the opposed flanks of wrap 32 for the inner arcuate portion thereof. Again, both of these end sealing surfaces are flat and perpendicular to the machine axis, with outer end sealing surface 5 being disposed axially outwardly from the inner end sealing surface. Outer and inner end sealing surfaces 36 and 38 are interconnected by a circular cylindrical transition surface 40 formed about an axis of curvature parallel to the machine axis and having a radius equal to one-half the radial space between said adjacent opposed flanks of the 10 wrap.

Tip sealing surfaces are disposed on the axially inner edge of wrap 32 comprising an outer tip sealing surface 42 disposed along the outer arcuate portion of the wrap, and an inner tip sealing surface 44 disposed along the inner arcuate portion of the wrap, both of the tip 15 sealing surfaces being flat and perpendicular to the machine axis, with the outer tip sealing surface being disposed axially inwardly from the inner tip sealing surface. The outer and inner tip sealing surfaces are interconnected by a circular cylindrical transition surface 46 formed about an axis of curvature disposed parallel to the machine axis 20 and having a radius equal to one-half the radial thickness of the wrap. As before, the axes of curvature of surfaces 40 and 46 are disposed approximately 180 degrees from each other about the machine axis.

Scroll member 34 is also provided with a centrally located relatively large discharge port 30 through which fluid compressed by the 25 compressor may be discharged. Scroll member 16 is provided with a centrally located recess 48 which is similar in shape to and aligns with discharge port 30 in order to facilitate the discharge of compressed fluid.

Orbiting scroll member 10 is mounted in the usual manner (not

shown) for circular orbital movement with respect to fixed scroll member 12, with wrap 14 intermeshing with wrap 32 so that (a) the radially outer flank of one of the wraps sealingly engages the radially inner flank of the other of the wraps, (b) outer tip sealing surface 24 sealingly engages outer end sealing surface 36, (c) inner tip sealing surface 26 sealingly engages inner end sealing surface 38, (d) outer tip sealing surface 42 sealingly engages outer end sealing surface 18, (e) inner tip sealing surface 44 sealingly engages inner end sealing surface 20, (f) cylindrical surface 28 sealingly engages cylindrical surface 40 during a portion of said orbital movement, and (g) cylindrical surface 46 sealingly engages cylindrical surface 22 during a portion of said orbital movement, whereby the relative orbital movement of said scroll members forms sealed fluid pockets of progressively changing volume therebetween.

Illustrated in Figure 2 is the basic geometry of a typical scroll in accordance with the present invention, wherein 100 is the base generating circle of the involute which defines the wrap profile, 102 is the involute of circle 100 which defines the outer flank surface of the wrap and 104 is the involute of circle 100 which defines the inner flank surface of the wrap. Assuming the diagram illustrates the orbiting scroll member, circular cylindrical transition surfaces 22 and 28 are shown. In order to obtain uniform compression in the pockets of each pair of pockets the centers of curvature of the transition surfaces should be located on parallel lines which are tangent to the base generating circle. Thus, the axis 105 of curvature of transition surface 22 is disposed on a tangent 106 to base circle 100, and the axis 107 of curvature of transition surface 28 is disposed on tangent 108 of base circle 100. Tangents 106 and 108 must be parallel to one another, but may be disposed at any point in the wrap, provided that the first

transition surface center (between the end sealing surfaces) is at least 360 degrees from the outer active end of the wrap. As will be seen, this is necessary to insure that a full charge of fluid will be input during the suction portion of the cycle. The second transition surface center (between the tip sealing surfaces) will therefore be approximately 180 degrees further from the end of the wrap. Axis 105 is disposed midway between the adjacent opposed flanks of the wrap, and axis 107 is disposed in the middle of the wrap. The transition surfaces have no points of inflection and the edges thereof are tangent to the wrap flank surfaces they intersect. In order to achieve good sealing, and hence efficiency, it is essential that the scroll members be the mirror image of one another, rotated 180 degrees about the machine axis for proper intermeshing.

Operation of the scroll machine of the present invention may be best understood by referring to Figures 3 through 9, with additional reference to Figure 10. It must be visualized that the scrolls are interengaged in the manner illustrated with the orbiting scroll member moving in a clockwise (as shown) circular orbit with respect to the fixed scroll member, the orbit having a diameter equal to the distance between the opposed flanks of a wrap. With reference to Figures 3-9, orbiting wrap 14 is orbiting in a clockwise circular motion with respect to fixed wrap 32. Figure 3 shows the compressor after completing the first 360 degrees of crank rotation, i.e. a full 360 degrees of orbital movement of the orbiting scroll with respect to the fixed scroll. During this period, the outer wraps have moved from a seal-off position (similar to that shown in Figure 3) to a fully open position (similar to that shown in Figure 4) and then back to the seal-off position actually shown in Figure 3, and in so doing have input two full charges of suction gas, indicated at 200 and 202. At this point, all of the

29
suction gas is in the "tall" chambers, i.e. the chambers axially disposed between outer end sealing surfaces 18 and 36.

During the next 180 degrees of rotation, charges 200 and 202 move to the positions shown in Figure 4, wherein part of each charge is in the tall chamber and another part of each charge is in the "short" chamber, i.e. the chamber disposed axially between inner end sealing surfaces 20 and 38. The portion of the charge in the short chambers is shown in the drawings with a greater shading density than it is in the tall chambers. Another 180 degrees of crank rotation takes the apparatus to the position shown in Figure 5, and yet another 180 degrees to the position shown in Figure 6, at 900 degrees. At this point in time the entirety of charges 200 and 202 is in the short chambers. They have, therefore, been compressed not only radially in the normal manner, but also axially by virtue of the fact that the short chambers have less height in the axial direction than do the tall chambers (all other things being equal. There is thus a volume reduction achieved which is greater than that which would have been achieved if the chambers were all of equal axial height.

The 900 degree position shown in Figure 6 is the earliest point at which the discharge cycle can begin. In the apparatus illustrated, however, the configuration is such that discharge does not take place until 45 degrees later, at the position shown in Figure 7. Discharge begins at the last position in which the inner tips of the wraps sealingly engage one another. As the crank rotates further, the chambers are opened to discharge port 30, such as shown 180 degrees later at 1125 degrees in Figure 8, and discharge continues an additional 180 degrees until the 1305 degree position shown in Figure 9, when the inner tips of wraps again seal one another.

An apparatus constructed in accordance with the principles of the

30

present invention will have proper sealing throughout its full cycle of operation. The adjacent flanks of the respective scroll members sealingly engage one another in the conventional manner, as do the mating tip and end sealing surfaces, and the respective transition surfaces engage one another in the manner which can be visualized from the drawings. For example, during the first 360 degrees of rotation only suction takes place until there is full suction seal-off. Therefore, during that portion of the cycle the sealing of the transition surfaces is not significant to the initial change.

10 Thereafter, starting at 360 degrees and continuing up until 900 degrees, there is a compression of the fluid charge from a relatively large tall chamber to a relatively small short chamber, as best seen in Figures 4, 5 and 6. The respective transition surfaces sealingly engage one another from the Figure 3 (360 degree) position to the Figure 4 (540

15 degree) position. Between 540 degrees and 720 degrees (Figures 4 and 5, respectively) there is no sealing engagement of the respective transition surfaces, but during that particular portion of the cycle leakage across the transition area is merely leakage between two identically sized charges that are being compressed at the same rate.

20 Consequently, even though there is mixing there is no loss of efficiency. Thereafter, starting with 720 degrees (Figure 5), the transition surfaces are in sealing engagement for the next 180 degrees until the apparatus reaches the 900 degree position shown in Figure 6. At that position the entirety of both charges is in the short chambers

25 (as shown), and the transition surfaces therefore have no bearing on the charges being considered.

Figure 10 graphically illustrates what is happening in the apparatus. In that Figure the ordinate represents chamber volume and the abscissa represents crank angle. For the first 360 degrees (one

revolution) of rotation of the crank, from point a to point c, the suction cycle takes place until complete suction seal-off is reached at point c. There should be no transition zones during the first 360 degrees of active wrap. Thereafter, continued rotation results in compression. As shown in Figure 10, if the end plates were perfectly flat and coplanar with the tall chamber end sealing surfaces the compression line would be from point c to point g. On the other hand, if the compressor had originally been designed with flat end plates coplanar with the short chamber end sealing surfaces, compression would take place along the line from point b to point d (but the total volume of intake fluid would only be the volume at b). Although it can start later in the cycle if desired (such as at point c'), in the present embodiment compression from the tall chamber to the short chamber starts at point c and continues for 1-1/2 revolutions to point d, at 900 degrees. Although this cycle is shown, for exemplary purposes, as a straight line in Figure 10, in an actual machine it would probably be slightly curved. At that point it is possible to begin discharge because there has been a complete compression and seal-off with all of the fluid being transferred to the short chamber. On the other hand, if desired, continued compression is possible. In the present embodiment, there is another 45 degrees of radial compression from d to e, at 945 degrees, which is the point at which the inner ends of the wraps move out of sealing engagement and the discharge cycle begins. Discharge continues from the end of compression at e for one revolution to point f.

The improvement in the volume ratio and hence pressure ratio of the present machine is very evident from Figure 10, wherein can be seen that a conventional machine having minimum wrap length would, after the same number of degrees of crank rotation, end up with a chamber volume

32

having a point g value, whereas a machine incorporating the present invention would have a final volume much smaller, i. e. the value at point d; yet in both machines the same original mass of fluid would have been taken into the machine. Obviously, the axial height of the transition surface can be varied in accordance with known mathematical principles to establish whatever pressure ratio is desired for the application under consideration. Furthermore, it is possible to have a plurality of steps or transition zones to permit even greater or more gradual increases in the volume/pressure ratios, as will be readily appreciated by those skilled in the art.

A machine constructed in accordance with the principles of the present invention will have a minimum operative crank angle of 1260 degrees, consisting of one revolution of suction, one and one-half revolutions of compression, and one revolution of discharge. To accomplish this, as noted earlier, it is necessary to have a minimum of 2-1/2 active wraps (which is 3 wraps total). The illustrative machine shown in the drawings has an additional 45 degrees of compression and therefore has a total angular crank displacement of 1305 degrees. The wrap is therefore also 45 degrees longer.

As used herein, the "roll angle" between two points on a wrap is the angle between a line tangent to the base generating circle and passing through the first point, and a line tangent to the base generating circle and passing through the second point.

Although the invention has been disclosed in exemplary form in connection with a scroll-type machine utilizing an Oldham coupling or like device for giving true curvilinear motion, and wraps having profiles which are the involutes of a circle, it will be readily appreciated by those skilled in the art that the invention is readily capable of modification for use with other types of scroll-type devices.

For example, devices incorporating the linkage mechanisms and modified scroll profiles of the aforementioned copending applications are also suitable for adaptation of the present invention. The same criteria that are discussed above in connection with this embodiment are utilized 5 to apply the invention to other types of machines.

The mating parts at the transition zones must have complimentary shapes in all parallel planes disposed perpendicularly to the machine axis so that they touch (and seal) for 180 degrees of each orbit. They should also be tangent to the adjacent wrap flanks in all such parallel 10 planes. If the scroll orbit is circular and there is no relative rotation between the scroll members than this is the shape of the profile of each transition surface (i.e. of constant radius) in all such planes (e.g. a circular cylinder); however, it need not be of the same radius in each such plane. For example, the transition surfaces could 15 be conical in configuration, such as shown in Figures 11, 12 and 13, or generally cylindrical with a rounded chamfer or fillet, such as shown in Figures 14, 15 and 16. Other configurations are equally possible. If the orbit is not circular or there is limited relative rotation between the scroll members, then this shape must be calculated 20 mathematically so that the parts touch (and seal) for 180 degrees of each orbit. The proper shape for a given machine, however, need not be of the same magnitude in each of the aforesaid parallel planes (just like a cone can substitute for a circular cylinder).

Although the discharge port is shown as being circular, it can be 25 of any desired shape based on conventional criteria; however, because of the geometry of the present invention it can be made much larger than those possible in conventional scroll-type machines for a given pressure ratio.

~~Thus there is described and shown in the above description and in~~



34

- 16 -

CLAIMS

1. An orbiting scroll compressor having first and second intermeshed scroll members in which a fluid is compressed by displacement in a direction parallel to a plane perpendicular to the axis of orbital movement, means
5 being provided in said compressor for causing concurrent additional compression of said fluid by displacing it in a direction parallel to said axis.
2. An orbiting scroll compressor as claimed in claim 1, wherein said first scroll member comprises:
10 (A) an end plate;
(B) a spiral wrap extending outwardly from a first axis generally perpendicular to said end plate, said wrap being attached to said end plate;
(C) means on said end plate defining a generally
15 flat first surface disposed between the flanks of said wrap for a first portion of the arcuate length thereof; and
(D) means on said end plate defining a generally flat second surface disposed between the flanks of said wrap for a second portion of the arcuate length thereof;
20 (E) said first and second surfaces respectively lying in spaced parallel planes disposed perpendicularly to said first axis.
3. A compressor as claimed in claim 2, wherein said spiral wrap has flanks which are configured as the
25 involute of a circle.
4. A compressor as claimed in claim 2, wherein said first and second surfaces are joined by an intermediate transition surface.
5. A compressor as claimed in claim 4, wherein
30 the profile of said transition surface has a constant radius of curvature in planes perpendicular to said first axis.
6. A compressor as claimed in claim 5, wherein
35 said transition surface has a configuration which is



- 17 -

5 cylindrical about an axis disposed parallel to said first axis.

7. A compressor as claimed in claim 5, wherein said transition surface is conical in configuration.

5 8. A compressor as claimed in claim 5, further comprising a rounded fillet at the intersection of said transition surface and one of said first or second surfaces.

10 9. A compressor as claimed in claim 8, wherein said fillet is disposed at the intersection of said transition surface and the most outwardly disposed of said first or second surfaces.

15 10. A compressor as claimed in claim 5, wherein said last-mentioned axis is located at least approximately 360 degrees along the angular extent of the wrap from the outer end of said wrap.

11. A compressor as claimed in claim 2, wherein said wrap has an active length of at least 900 degrees roll angle.

20 12. A compressor as claimed in claim 2, wherein said second surface is disposed radially inwardly of said first surface.

25 13. A compressor as claimed in claim 12, wherein said second surface is disposed further away from the general plane of said end plate than is said first surface.

14. A compressor as claimed in claim 2, further comprising means defining a discharge port centrally through said end plate.

30 15. A compressor as claimed in claim 2, further comprising means defining a recess centrally of said end plate in one of said surfaces.

16. A compressor as claimed in claim 2, wherein said first and second surfaces are joined by an intermediate concave transition surface.

35 17. A compressor as claimed in claim 2, wherein



36

- 18 -

said first and second surfaces are joined by an intermediate conical transition surface.

18. A compressor as claimed in claim 17, wherein the center axis of said conical surface is parallel to said first axis.

19. A compressor as claimed in claim 2, wherein said first and second surfaces are joined by an intermediate cylindrical transition surface, the intersection of said transition surface with said first and second surfaces having a radius in cross-section.

20. A compressor as claimed in claim 19, wherein the axis of said cylindrical portion of said transition surface is parallel to said first axis.

21. A compressor as claimed in claim 1 or 2, wherein said second scroll member comprises:

- (A) a generally flat end plate;
- (B) a spiral wrap extending outwardly from a first axis generally perpendicular to said end plate, said wrap being attached along one axial edge to said end plate;
- (C) means on the axially opposite edge of said wrap defining a first tip surface extending for a first portion of the arcuate length of said wrap; and
- (D) means on said axially opposite edge of said wrap defining a second tip surface extending for a second portion of the arcuate length of said wrap;
- (E) said first and second tip surfaces respectively lying in spaced parallel planes disposed perpendicularly to said first axis.

22. A compressor as claimed in claim 21, wherein said spiral wrap of the second scroll member has flanks which are configured as the involute of a circle.

23. A compressor as claimed in claim 21 or 22, wherein said first and second tip surfaces are joined by an intermediate transition surface.

24. A compressor as claimed in claim 23, wherein



- 19 -

the profile of said transition surface has a constant radius of curvature in planes perpendicular to said first axis.

25. A compressor as claimed in claim 24, wherein
5 said transition surface has a configuration which is cylindrical about an axis disposed parallel to said first axis.

26. A compressor as claimed in claim 24, wherein said transition surface is conical in configuration.

10 27. A compressor as claimed in claim 24, further comprising a rounded fillet at the intersection of said transition surface and one of said first or second tip surfaces.

28. A compressor as claimed in claim 27, wherein
15 said fillet is disposed at the intersection of said transition surface and the most inwardly disposed of said first or second tip surfaces.

29. A compressor as claimed in any one of claims 21 to 28, wherein said last-mentioned axis is located at
20 least approximately 360 degrees along the angular extent of the wrap from the outer end of said wrap.

30. A compressor as claimed in any one of claims 21 to 29, wherein said wrap of the second scroll member has an active length of at least 900 degrees roll angle.

25 31. A compressor as claimed in any one of claims 21 to 30, wherein said second tip surface is disposed radially inwardly of said first tip surface.

32. A compressor as claimed in claim 31, wherein said second tip surface is disposed nearer to the general
30 plane of said end plate than is said first tip surface.

33. A compressor as claimed in any one of claims 21 to 32, further comprising means defining a discharge port centrally through said end plate.

34. A compressor as claimed in claim 21, wherein
35 said first and second tip surfaces are joined by an



38

- 20 -

intermediate concave transition surface.

35. A compressor as claimed in claim 21, wherein said first and second tip surfaces are joined by an intermediate conical transition surface.

5 36. A compressor as claimed in claim 35, wherein the center axis of said conical surface is parallel to said first axis.

37. A compressor as claimed in claim 21, wherein said first and second tip surfaces are joined by an intermediate cylindrical transition surface, the intersection of said transition surface with said first and second surfaces having a radius in cross-section.

10 38. A compressor as claimed in claim 37, wherein the axis of said transition surface is parallel to said first axis.

15 39. A compressor as claimed in claim 1, wherein said first scroll member comprises a spiral wrap disposed on an end plate; said second scroll member also comprising a spiral wrap disposed on an end plate, said scroll members intermeshing with one another and being movable orbitally with respect to one another about an axis, said end plates being disposed substantially parallel to one another and substantially perpendicular to said axis, said spiral wraps being configured so that at least one moving sealed chamber of progressively changing volume is formed between said wraps, said change in volume being caused by the orbital movement of said wraps with respect to one another; and further comprising volume ratio enhancing means on at least one of said end plates reducing the axial distance between said plates in an area where said moving chamber is disposed for a portion of the displacement cycle, thereby causing a further volume change in said moving chamber in addition to that otherwise caused by the movement of said wraps relative to one another.

20 25 30 35 40. A compressor as claimed in claim 39, wherein



- 21 -

said spiral wraps on said first and second scroll members are mirror images one of the other.

41. A compressor as claimed in claim 39, wherein each of said wraps has an active length of at least 900
5 degrees roll angle.

42. A compressor as claimed in claim 39, wherein both of said end plates are provided with said volume ratio enhancing means.

43. A compressor as claimed in claim 39, wherein
10 said volume ratio enhancing means is not operative during the initial portion of said displacement cycle.

44. A compressor as claimed in claim 39, wherein said volume ratio enhancing means is not operative for the first 360 degrees of relative orbital movement of said
15 scroll members in each displacement cycle.

45. An orbiting scroll compressor constructed and arranged to operate substantially as hereinbefore described with reference to and as illustrated in the accompanying drawings.
