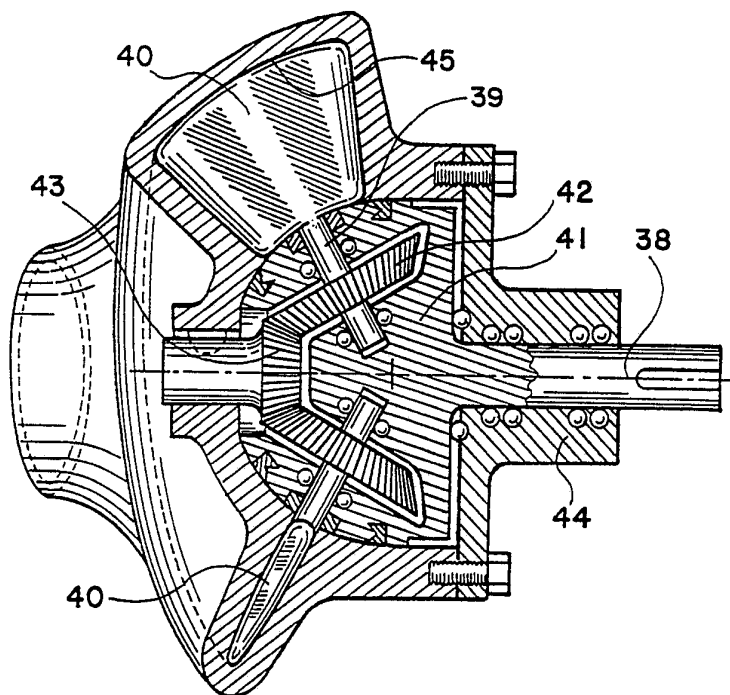




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(54) Title: REVOLTING-ROTATING VANE METER-MOTOR-PUMP



(57) Abstract

A positive displacement fluid handling apparatus comprises a closed loop cavity (45) with continuously varied cross-sectional areas between the maximum and minimum values respectively occurring at two diametrically opposite sections thereof, and a plurality of vanes (40) disposed within and traveling through the closed loop cavity (45) and rotatably supported by a rotor (41), wherein the revolving motion of the vanes (40) are coupled to the rotating motion of the rotor (41) by positively meshing gearing in such a way that the individual vane (40) revolves about its own axis (39) at one half of the rotary speed of the rotating motion of the rotor (41) about the rotor axis (38), and the cross-sectional areas of the closed loop cavity (45) are closely matched to the areas of sweep of the vanes (40) throughout the closed loop cavity (45).

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1 REVOLVING-ROTATING VANE METER-MOTOR-PUMP

2 This invention relates to a positive displacement fluid handling
3 apparatus that operates as a positive displacement flowmeter, a
4 hydraulic-pneumatic motor such as a windmill, a positive displacement
5 pump, or an internal combustion engine, which comprises a plurality of
6 vanes disposed within and traveling through a closed loop cavity (a
7 toroidal cavity), wherein the vanes revolvably supported by the rotor
8 of the apparatus are coupled to the rotating motion of the rotor in
9 such a way that the individual vane revolves about its own axis at one
10 half of the speed of rotation thereof about the axis of rotation of
11 the rotor. The cross section of the closed loop cavity accommodating
12 the vanes is continuously varied between the maximum and minimum values
13 respectively occurring at two diametrically opposite sections of the
14 closed loop cavity in such a way that the cross sectional areas of the
15 closed loop cavity are closely matched to the areas of sweep of the
16 vanes at all angular locations about the axis of rotation.

17

18 There are a number of inventions teaching the positive displacement
19 apparatus comprising a plurality of vanes operating under a compound
20 combination of the revolving motion and the rotating motion. An
21 Australian patent (643/31) shows a pseudo-positive displacement
22 apparatus that employs a plurality of revolving-rotating vanes, but the
23 cross section of the closed loop cavity accommodating the vanes are not
24 varied to match the cross sectional areas thereof to the areas of sweep
25 of the vanes. A U.S. patent (3,895,893) shows a similar apparatus
26 wherein the closed loop cavity is divided into two sections with two
27 different constant cross sectional areas, and the vanes are supported
28 by the rotor in a spring-biased arrangement whereby the individual vane
29 is forced to pivot about its own axis to conform with the cross
30 sectional geometry of the closed loop cavity. A Japanese patent
31 application (63-279598) shows one of the more intelligent versions of
32 the apparatus wherein the vanes are pivoted over angles significantly
33 less than 90 degrees during each cycle of rotation thereof instead of
34 continuously revolving about the vane axis. These prior arts amount to
35 an attempt to lasso a run-away train by throwing a rope. The positive
36 displacement fluid handling apparatus of the type under discussion,
37 whether they are applied as a flowmeter, a motor or engine, or a pump,
38 are subjected to a brutal loading by the fluid pressure and,

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1 consequently, the apparatus employing anything less than 100 percent
2 positive mechanical motion coupling means do not have a chance to
3 actually work in the real world. The above-mentioned prior arts
4 employing the vanes under pivoting movements manipulated by the
5 guiding surfaces such as the wall of the closed loop cavity or the
6 cam and cam follower combination are merely a few of many apparatus,
7 which lack the mechanical muscle and precision to be an actually
8 working positive displacement apparatus.

9

10 The primary object of the present invention is to provide a
11 positive displacement fluid handling apparatus comprising a plurality
12 of vanes disposed within and traveling through a closed loop cavity
13 (a toroidal cavity), wherein the individual vane revolves about its
14 own axis at one half of the rotating speed thereof about the axis of
15 rotation of the rotor revolvably supporting the vanes whereby the
16 individual vane completes one full revolution about its own axis for
17 every two full rotations about the axis of rotation of the rotor. The
18 cross section of the closed loop cavity accommodating the vanes is
19 varied in such a way that the cross sectional areas of the closed loop
20 cavity are closely matched to the areas of sweep of the vanes at all
21 angular locations about the axis of rotation.

22 Another object is to provide the apparatus described in the primary
23 object of the present invention, wherein the revolving motion of the
24 individual vane is coupled to the rotating motion thereof by a
25 positively meshing gearing.

26 A further object is to provide the apparatus described in the
27 primary object of the present invention, wherein the axes of revolution
28 of the vanes are disposed on a conical surface coaxial to the axis of
29 rotation of the rotor revolvably supporting the vanes.

30 Yet another object is to provide the apparatus described in the
31 primary object of the present invention, wherein the axes of revolution
32 of the vanes are disposed on a plane perpendicular to the axis of
33 rotation of the rotor revolvably supporting the vanes.

34 Yet a further object is to provide the apparatus described in the
35 primary object of the present invention, wherein the axes of revolution
36 of the vanes are disposed on a circular cylindrical surface coaxial to
37 the axis of rotation of the rotor revolvably supporting the vanes.

38 Still another object is to provide the apparatus described in the

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1 primary object of the present invention, that includes means for
2 injecting fuel into the closed loop cavity accommodating the vanes and
3 means for igniting the fuel-air mixture therein, whereby the apparatus
4 works as an internal combustion engine.

5 These and other objects of the present invention will become
6 clear as the description thereof progresses.

7

8 The present invention may be described with a greater clarity and
9 specificity by referring to the following figures :

10 Figure 1 illustrates a developed view of a plurality of vanes
11 disposed within and traveling through a closed loop cavity, which
12 shows the operating principles of the present invention.

13 Figure 2 illustrates a cross section of an embodiment of the
14 positive displacement apparatus of the present invention.

15 Figure 3 illustrates a cross section of another embodiment of
16 the positive displacement apparatus of the present invention.

17 Figure 4 illustrates another cross section of the embodiment
18 shown in Figure 2.

19 Figure 5 illustrates another cross section of the embodiment
20 shown in Figure 3.

21 Figure 6 illustrates a preferred embodiment of the gearing
22 coupling the revolving and rotating motions of the vanes to one
23 another.

24 Figure 7 illustrates a cross section of a further embodiment of
25 the positive displacement apparatus of the present invention.

26 Figure 8 illustrates an embodiment of gearing usable in
27 constructing the embodiment shown in Figure 7.

28 Figure 9 illustrates an internal combustion engine version of
29 the present invention.

30

31 In Figure 1 there is illustrated a developed view of the
32 plurality of vanes 1, 2, 3, 4, etc. disposed within and traveling
33 through a closed loop cavity (a toroidal cavity) 5. The plurality
34 of vanes are assembled into a rotor assembly of the positive
35 displacement apparatus of the present invention, which rotor
36 assembly of a construction axisymmetric about the axis of rotation
37 thereof forms the core region surrounded by the closed loop cavity
38 5, wherein the individual vane 1 is supported by the rotor

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1 revolvably about its own axis 6 (the axis of revolution) and
2 geared to the rotating motion of the rotor assembly about the axis
3 of rotation coinciding with the center axis of the closed loop cavity
4 5 in such a way that the individual vane revolves about its axis of
5 revolution at one half of the angular velocity of the rotation of
6 the rotor assembly about the axis of rotation, whereby each of the
7 plurality of vanes completes full 360 degree revolution about the
8 respective axes of revolution for every 720 degree rotation of the
9 rotor assembly about the axis of rotation. The cross section of the
10 closed loop cavity is varied between the maximum value at the 0
11 (360) degree section and the minimum value at the 180 degree section
12 in such a way that the cross sectional areas of the closed loop
13 cavity 5 are closely matched to the areas of sweep of the vanes at
14 all angular locations during the rotating motion. Two ports
15 providing a flow passage for the fluid media are respectively open to
16 the two opposite halves of the closed loop cavity 5 located on the
17 two opposite sides of the plane of symmetry passing through the 0
18 (360) and 180 degree sections of the closed loop cavity 5. It is
19 readily noticed that the volume between two adjacent vanes increases
20 in the first half of the closed loop cavity 5 that facilitates the
21 suction of the fluid media through the first port open to the first
22 half of the closed loop cavity 5, or the expansion of the gas in the
23 first half of the closed loop cavity 5 and discharge through the
24 first port, while the volume between two adjacent vanes decreases in
25 the second half of the closed loop cavity 5 that facilitates the
26 discharge of the fluid media through the second port open to the
27 second half of the closed loop cavity 5, or the compression of gas
28 entering through the second port into the second half of the closed
29 loop cavity 5.

30 In Figure 2 there is illustrated a cross section of an embodi-
31 ment of the positive displacement apparatus of the present invention,
32 wherein the axes of revolution of the plurality of vanes are disposed
33 on a plane perpendicular to the axis of rotation of the rotor
34 assembly. The plurality of vanes 7 disposed within and traveling
35 through the closed loop cavity 8 are respectively supported by a
36 plurality of stub shafts 9 which are revolvably supported by the
37 rotor 10. Of course, the central axis of each of the stub shafts 9
38 defines the axis of revolution of each of the vanes 7, while the axis

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1 of rotation of the vane assembly is defined by the central axis 11
2 of the rotor 10. The plurality of stub shafts 9 respectively
3 supporting the plurality of vanes 7 are disposed in a substantially
4 axisymmetrically radiating pattern from the axis 11 of rotation of
5 the rotor 10 and respectively include a plurality of bevel gears 12
6 at the inner extremity thereof. The closed loop cavity 8 has the outer
7 cylindrical wall and two opposite side walls provided by the housing
8 structure 13, and the inner cylindrical wall provided by the rotor 10.
9 The apparatus works best when the outer and inner cylindrical walls
10 respectively coincide with two spherical surfaces concentric to the
11 spherical center of the rotor assembly including the rotor 10 and the
12 vanes 7. The two opposite side walls of the closed loop cavity 8 are
13 curved in such a way that there is no or a little gap between the
14 surface of the vanes and the walls of the closed loop cavity 8 at all
15 angular locations about the axis of rotation 11. In the versions of
16 the apparatus applied as flowmeters, hydraulic or pneumatic motors or
17 pumps, two ports 14 and 15 are respectively open to the two opposite
18 halves of the closed loop cavity respectively located on the two
19 opposite sides of a plane of symmetry passing through the sections of
20 the maximum and the minimum cross sectional area of the closed loop
21 cavity 8. In order to work as a positive displacement apparatus,
22 the two ports 14 and 15 must be separated from one another by two
23 diametrically opposite unbroken sections of the closed
24 loop cavity 8, wherein each section thereof includes at least one
25 vane at all instances during the rotating motion of the vanes about
26 the axis 11 of rotation. The arrangement of the intake and discharge
27 ports in the internal combustion engine version of the apparatus is
28 shown in Figure 9.

29 In Figure 3 there is illustrated a cross section of another
30 embodiment of the positive displacement apparatus of the present
31 invention, wherein the axes of revolution of the plurality of vanes
32 are disposed on a circular cylindrical surface coaxial to the axis
33 16 of rotation of the rotor assembly including one or two supporting
34 flanges coaxial to the axis 16 of rotation and a plurality of vanes
35 17 disposed therebetween and respectively supported by a plurality of
36 shafts 18, which shafts are revolvably supported by one or two
37 supporting flanges forming a part of the rotor assembly. Of course
38 the axis of revolution of each of the plurality of vanes 17 is defined

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1 by the central axis of each of the plurality of shafts 18. A
2 plurality of tie-bars 19 disposed intermediate the two supporting
3 flanges in a parallel and axisymmetric pattern with respect to the
4 axis of rotation 16 structurally connect the two supporting flanges
5 to one another. Of course, a rotor assembly employing a single
6 supporting flange would not need these tie-bars 19. The closed
7 loop cavity 20 has the outer and inner cylindrical walls provided by
8 the housing 21, and two opposite side walls provided by the two
9 supporting flanges. Of course, in an embodiment employing a single
10 supporting flange, only one of the two opposite side walls of the
11 closed loop cavity 20 is provided by the supporting flange as the
12 other of the two opposite side walls is provided by the housing 21.
13 The outer and inner cylindrical wall of the closed loop cavity 20 are
14 spaced from one another in such a way that there is no or a little
15 gap between the surfaces of the vanes 17 and the walls of the closed
16 loop cavity 20 at all instances during the rotating motion of the vanes
17 17 about the axis 16 of the rotation. The pair of ports 22 and 23
18 are included in the manner described in conjunction with the embodi-
19 ment shown in Figure 2.

20 In Figure 4 there is illustrated another cross section of the
21 embodiment of the positive displacement apparatus shown in Figure 2,
22 which cross section is taken along plane 4-4 as shown in Figure 2.
23 The rotor assembly including the plurality of vanes 7 and the rotor
24 10 is supported by the rotor shaft 24, that is rotatably supported
25 by the housing 13. The bevel gear 12 nonrotatably mounted on the
26 vane shaft 8 engages a stationary pinion bevel gear 25 disposed
27 coaxially to the axis 11 of rotation and affixed to the housing
28 13, wherein a plurality of idler bevel gears 26 disposed in an
29 axisymmetric arrangement with respect to the axis 11 of rotation
30 and revolvably supported by the rotor 10 are employed in the gearing
31 engagement between the plurality of bevel gears 12 and the stationary
32 bevel gear 25. The ratio of the pitch diameters or the numbers of
33 gear teeth of the bevel gears 12, 25 and 26 are arranged in such a
34 way that the individual vane revolves about its axis of revolution
35 at one half of the speed of rotation of the rotor assembly about the
36 axis 11 of rotation whereby the individual vane completes one full
37 revolution about its own axis of revolution for every two full
38 rotations of the rotor assembly about the axis 11 of rotation, which

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1 requirement clearly explains why those idler bevel gears 26 have to
2 be employed. A vane motion detector 27 may be employed to measure
3 the speed of rotation of the rotor assembly as a measure of fluid
4 media passing through the apparatus. It is readily realized that
5 the shaft 24 does not need to extend through and out of the housing
6 13 when the apparatus is applied as a flowmeter only.

7 In Figure 5 there is illustrated another cross section of the
8 embodiment of the positive displacement apparatus shown in Figure 3,
9 which cross section is taken along plane 5-5 as shown in Figure 3.
10 The rotor assembly including the two supporting flanges 28 and 29,
11 and the plurality of vanes 17 is supported by the rotor shaft 30,
12 that is rotatably supported about the axis 16 of rotation by the
13 housing 21. The plurality of vane shafts 18 respectively include
14 a plurality of gears 31, which engage the stationary pinion gear 32
15 through a plurality of idler gears 33 rotatably supported by the
16 rotor flanges. The stationary pinion gear 32 is disposed coaxially
17 to the axis 16 of rotation and affixed to the housing 21. The gearing
18 ratio of the gears 31, 32 and 33 are selected in such a way that the
19 individual vane 17 revolves about its own axis of revolution at one
20 half of the rotating speed of the rotor assembly about the axis 16 of
21 rotation whereby the individual vane completes a full revolution about
22 its own axis of revolution for every two full rotations of the rotor
23 assembly about the axis 16 of rotation. Of course, in an alternative
24 design, the second flange 29 and the stub vane shafts extending
25 thereinto may be omitted and its place filled up by the housing
26 structure 21.

27 In Figure 6 there is illustrated a schematic diagram showing an
28 arrangement of gearing that couples the revolving motion of the vanes
29 to the rotating motion of the rotor assembly in an one to two rotary
30 speed ratio. Each adjacent pair 34 and 35 of the plurality of vane
31 gears share a common idler gear 36 in engaging the stationary pinion
32 gear 37 affixed to the housing structure of the apparatus. This
33 particular embodiment of the gearing arrangement can be employed in
34 constructing the embodiments of the positive displacement apparatus
35 shown in Figures 4 and 5.

36 In Figure 7 there is illustrated a cross section of a further
37 embodiment of the positive displacement apparatus of the present
38 invention, wherein the axes of revolution of the vanes are disposed

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1 on a conical surface coaxial to the axis 38 of rotation of the rotor
2 assembly. The plurality of stub shafts 39 respectively supporting
3 the plurality of vanes 40 are disposed on a conical surface coaxial to
4 the axis 38 of rotation in an axisymmetric arrangement and
5 revolvably supported by the rotor 41, wherein the plurality of bevel
6 gears 42 nonrotatably mounted on the plurality of stub shafts 39
7 engage a stationary pinion bevel gear 42 directly without any idler
8 gears, which stationary pinion bevel gear 42 is disposed coaxially to
9 the axis 38 of rotation and affixed to the housing 44. The closed
10 loop cavity 45 has the outer cylindrical wall and the two conical
11 side walls provided by the housing 44 and the inner cylindrical wall
12 provided by the rotor 41. The two conical walls of the closed loop
13 cavity 45 are arranged in such a way that there is no or a little
14 gap between the surfaces of the vanes 40 and the walls of the closed
15 loop cavity 45 at all angular positions about the axis 38 of rotation.
16 The apparatus works best when the outer and inner cylindrical walls of
17 the closed loop cavity 45 respectively coincide with two spherical
18 surfaces concentric to the point of convergence of the axes of
19 revolution of the plurality of vanes 40. The two ports disposed in
20 an arrangement as described in conjunction with Figure 2 may extend
21 through the outer cylindrical wall of the closed loop cavity 45 or
22 through one of the two conical walls thereof or through a combination
23 of the two walls. The embodiment shown in Figure 7 provides a
24 powerful advantage over those embodiments shown in Figures 4 and 5
25 in view that it does not employ any idler gears. Of course, the gear
26 ratio between the vane gears 42 and the stationary pinion gear 43 is
27 selected in such a way that the individual vane completes a full
28 revolution for every two full rotations of the rotor assembly.

29 In Figure 8 there is illustrated a gearing arrangement that may
30 be employed in constructing a positive displacement apparatus of the
31 type shown in Figure 7, when the apparatus comprises relatively
32 many vanes and there is insufficient room to dispose all of the bevel
33 gears simultaneously engaging the stationary pinion bevel gear affixed
34 to the housing. In this particular arrangement of double layering of
35 gearing, every other vane gear 46 engages a first stationary pinion
36 gear 47, while the remaining vane gears 48 engage the second
37 stationary pinion gear 49 coaxially disposed to the first pinion gear
38 47. Of course, the gearing ratios for both sets of gearing are

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1 selected to attain the one to two rotary speed ratio between the
2 revolving motions of the vanes and the rotating motion of the rotor
3 assembly. It is readily recognized that the gearing arrangement may
4 employ a triple or quadruple layer design instead of the double layer
5 design shown and described.

6 In Figure 9 there is illustrated a cross section of an embodi-
7 ment of the internal combustion engine version of the positive
8 displacement apparatus of the present invention. An air intake port
9 50 to and an exhaust port 51 from the closed loop cavity 52 are
10 included in the first half of the closed loop cavity 52 including
11 the section with the maximum cross sectional area thereof in such a
12 way that the rotating vanes pass the exhaust port 51 and the intake
13 port 50 in that order, while the fuel injection nozzle 53 and the
14 ignition device 54 are included in the second half of the closed
15 loop cavity 52 including the section with the minimum cross sectional
16 area thereof in such a way that the rotating vanes pass the fuel
17 injection nozzle 53 and the ignition device 54 in that order. The
18 air entering through the intake port 50 may be precompressed by a
19 super- or turbo-charger of conventional design or a type employing one
20 of the embodiments shown in Figures 4, 5 and 7, and the exhaust gas
21 discharged through the exhaust port 51 may run through a pneumatic
22 motor of a conventional design such as a turbine or a type
23 employing one of the embodiments shown in Figures 4, 5 and 7. An
24 embodiment of the positive displacement apparatus of the present
25 invention applied as a compressor or pneumatic motor should have a
26 first port open to a first half of the closed loop cavity near the
27 section of the minimum cross sectional area of the closed loop
28 cavity, and the second port open to a second half of the closed
29 loop cavity near the section of the maximum cross sectional area
30 thereof.

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1 The embodiments of the invention, in which an exclusive
2 property or privilege is claimed, are defined as follows :

3 1. An apparatus for executing a function related to flow of
4 fluid comprising in combination :

5 a) a housing;

6 b) a rotor member with a shaft supported by the housing
7 rotatably about an axis of rotation coinciding with the
8 central axis of the shaft;

9 c) a closed loop cavity encircling the axis of rotation
10 wherein at least a portion of wall of the closed loop
11 cavity is provided by an annular surface encircling
12 the axis of rotation and belonging to the rotor member,
13 and the other portion of the wall of the closed loop
14 cavity is provided by the housing, wherein the closed
15 loop cavity has a cross sectional areas continuously
16 varying from a maximum value at a first cross section
17 substantially coinciding with a plane including the axis
18 of rotation to a minimum value at a second cross section
19 diametrically opposite to the first cross section across
20 the axis of rotation, and has a cross sectional
21 dimensions between two opposing portions of the wall of
22 the closed loop cavity provided by the housing varying
23 from a maximum value at said first cross section to a
24 minimum value at said second cross section, and further
25 has two ports respectively open to two opposite halves of
26 the closed loop cavity respectively located on two
27 opposite sides of said plane;

28 d) a plurality of vanes with width greater than thickness
29 thereof disposed within the closed loop cavity in a
30 distributed arrangement about the axis of rotation and
31 respectively supported by a plurality of stub shafts
32 disposed following said at least a portion of the wall
33 of the closed loop cavity provided by the rotor member
34 in a substantially axisymmetric arrangement about the
35 axis of rotation and revolvably supported by the rotor
36 member; and

37 e) a plurality of rotary members with positively meshing
38 teeth elements disposed coaxially to respective central

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1 axes thereof, each of said plurality of rotary members
2 nonrotatably mounted on each of the plurality of stub
3 shafts supporting the vanes, wherein each of the plurality
4 of rotary members positively engages a stationary round
5 member with positively meshing teeth elements disposed
6 coaxially to the axis of rotation and affixed to the
7 housing in such a way that each of the plurality of vanes
8 revolves about the central axis of each of the plurality
9 of stub shafts supporting the vanes at one half of the
10 angular speed of rotation of the rotor member about the
11 axis of rotation;

12 wherein cross sectional areas of the closed loop cavity is closely
13 matched to areas of sweep of the vanes throughout the orbiting motions
14 of the vanes about the axis of rotation in such a way that each of the
15 plurality of vanes substantially fills up cross section of the closed
16 loop cavity at all instances during orbiting motions of the vanes
17 about the axis of rotation.

18 2. An apparatus as defined in Claim 1 wherein the central axes of
19 said plurality of stub shafts supporting the vanes are disposed on a
20 plane perpendicular to the axis of rotation in a substantially
21 axisymmetrically radiating pattern from the axis of rotation.

22 3. An apparatus as defined in Claim 2 wherein said at least a
23 portion of the wall of the closed loop cavity provided by the rotor
24 member includes an annular portion of a spherical surface with center
25 coinciding with the point of convergence of the plurality of stub
26 shafts, wherein said annular portion of the spherical surface
27 constitutes inner circumferential portion of the wall of the closed
28 loop cavity.

29 4. An apparatus as defined in Claim 3 wherein outer circumferential
30 portion of the wall of the closed loop cavity includes an annular
31 portion of a second spherical surface concentric to said a spherical
32 surface.

33 5. An apparatus as defined in Claim 1 wherein the central axes of
34 said plurality of stub shafts supporting the vanes are disposed on a
35 circular cylindrical surface coaxial to the axis of rotation in a
36 parallel arrangement to the axis of rotation.

37 6. An apparatus as defined in Claim 5 wherein said at least a
38 portion of the wall of the closed loop cavity provided by the rotor

1 member includes a planar annular surface coaxial and perpendicular to
2 the axis of rotation, wherein said planar annular surface constitutes
3 one side portion of the wall of the closed loop cavity.

4 7. An apparatus as defined in Claim 6 wherein the other side
5 portion of the wall of the closed loop cavity opposite to said one
6 side portion thereof includes a planar annular surface coaxial and
7 perpendicular to the axis of rotation.

8 8. An apparatus as defined in Claim 7 wherein said the other side
9 portion of the wall of the closed loop cavity is also provided by the
10 rotor member.

11 9. An apparatus as defined in Claim 1 wherein the central axes
12 of said plurality of stub shafts supporting the vanes are disposed on
13 a conical surface coaxial to the axis of rotation.

14 10. An apparatus as defined in Claim 9 wherein said at least a
15 portion of the wall of the closed loop cavity provided by the rotor
16 member includes an annular portion of a spherical surface with center
17 coinciding with the point of convergence of the plurality of stub
18 shafts, wherein said annular portion of the spherical surface
19 constitutes inner circumferential portion of the wall of the closed
20 loop cavity.

21 11. An apparatus as defined in Claim 10 wherein outer
22 circumferential portion of the wall of the closed loop cavity includes
23 an annular portion of a second spherical surface concentric to said
24 a spherical surface.

25 12. An internal combustion engine comprising in combination :

26 a) a housing;

27 b) a rotor member supported by the housing rotatably about
28 an axis of rotation and including a power output shaft
29 extending therefrom coaxially to the axis of rotation;

30 c) a closed loop cavity encircling the axis of rotation
31 wherein at least a portion of wall of the closed loop
32 cavity is provided by an annular surface encircling the
33 axis of rotation and belonging to the rotor member, and
34 the other portion of the wall of the closed loop cavity
35 is provided by the housing, wherein the closed loop
36 cavity has cross sectional areas continuously varying
37 from a maximum value at a first cross section
38 substantially coinciding with a plane including the axis

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- 1 of rotation to a minimum value at a second cross section
2 diametrically opposite to the first cross section across
3 the axis of rotation, and has cross sectional dimensions
4 between two opposing portions of the wall of the closed
5 loop cavity provided by the housing varying from a maximum
6 value at said first cross section to a minimum value at
7 said second cross section, and further has an exhaust port
8 and intake port open to a first half of the closed loop
9 cavity including the section of the maximum cross sectional
10 area in such a way that the vanes orbiting about the axis
11 of rotation pass the exhaust port and the intake port in
12 that order;
- 13 d) a plurality of vanes with width greater than thickness
14 thereof disposed within the closed loop cavity in a
15 distributed arrangement about the axis of rotation and
16 respectively supported by a plurality of stub shafts
17 disposed following said at least a portion of the wall of
18 the closed loop cavity provided by the rotor member in a
19 substantially axisymmetric arrangement about the axis of
20 rotation and revolvably supported by the rotor member;
- 21 e) a plurality of rotary members with positively meshing
22 teeth elements disposed coaxially to respective central
23 axes thereof, each of said plurality of rotary members
24 nonrotatably mounted on each of the plurality of stub
25 shafts supporting the vanes, wherein each of the plurality
26 of rotary members positively engages a stationary round
27 member with positively meshing teeth elements disposed
28 coaxially to the axis of rotation and affixed to the
29 housing in such a way that each of the plurality of vanes
30 revolves about the central axis of each of the plurality
31 of stub shafts supporting the vanes at one half of the
32 angular speed of rotation of the rotor member about the
33 axis of rotation; and
- 34 f) means for injecting fuel into the closed loop cavity and
35 means for igniting fuel-air mixture contained in the
36 closed loop cavity included in a second half of the closed
37 loop cavity including the section of minimum cross
38 sectional area in such a way that the vanes orbiting about

- 14 -

1 the axis of rotation pass said means for injecting fuel
2 and said means for igniting fuel-air mixture in that
3 order;
4 wherein cross sectional areas of the closed loop cavity are closely
5 matched to areas of sweep of the vanes throughout orbiting motions of
6 the vanes about the axis of rotation in such a way that each of the
7 plurality of vanes substantially fills up cross section of the closed
8 loop cavity at all instances during orbiting motions of the vanes
9 about the axis of rotation, and expanding volume of combusting fuel-air
10 mixture rotates the combination of the plurality of vanes and the rotor
11 member about the axis of rotation.

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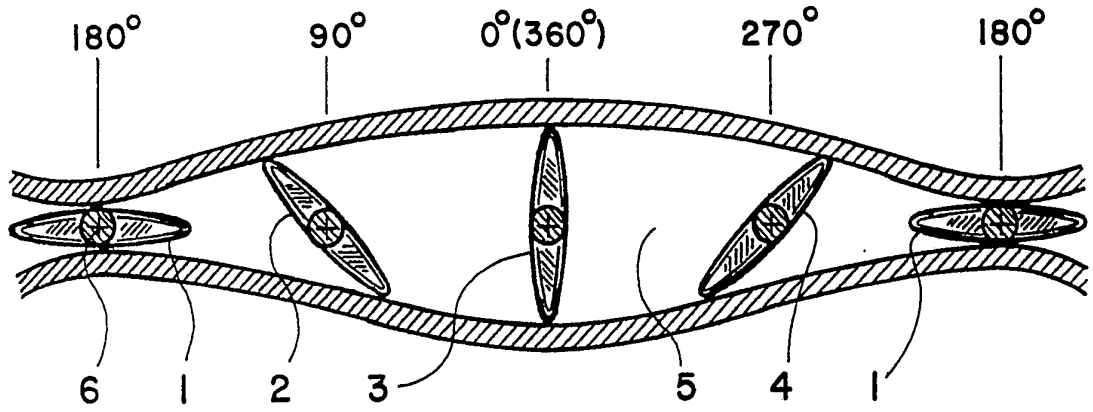


Fig. 1

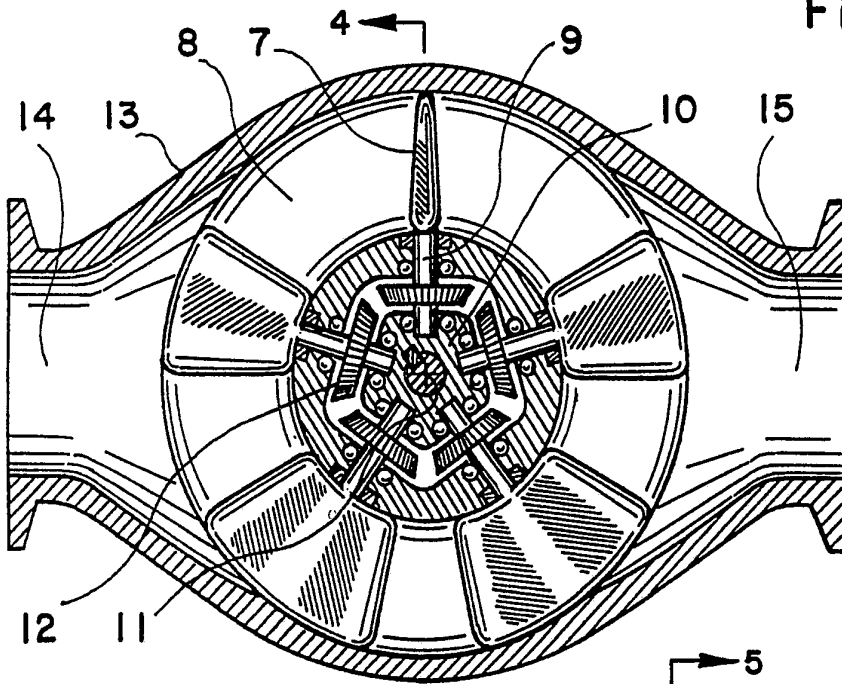


Fig. 2

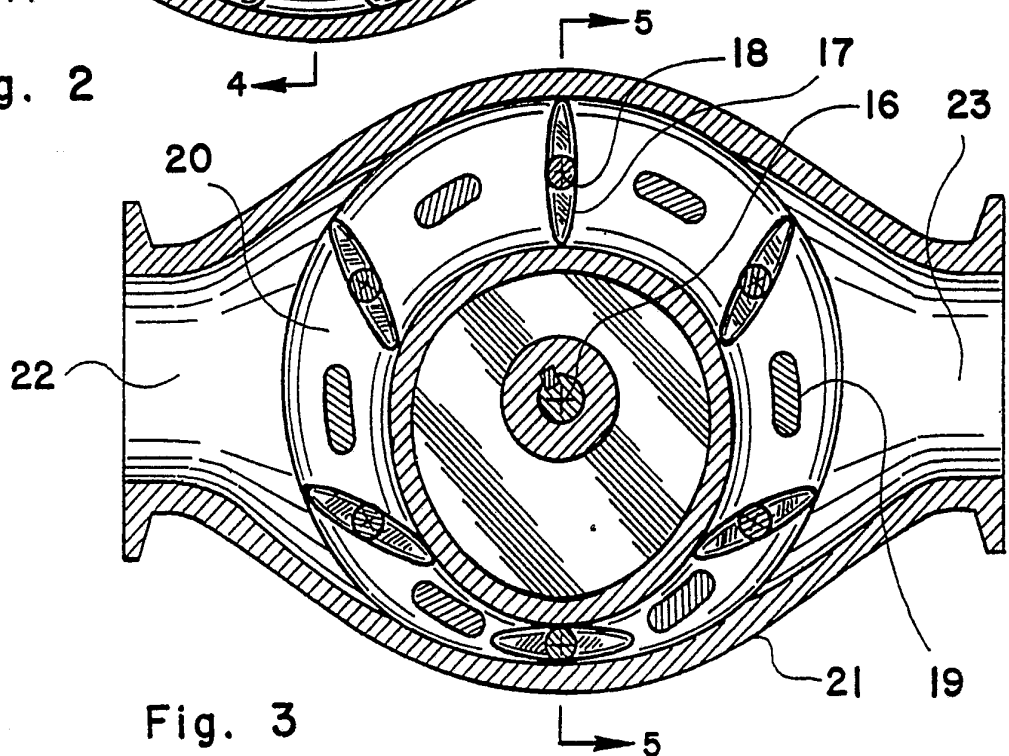


Fig. 3

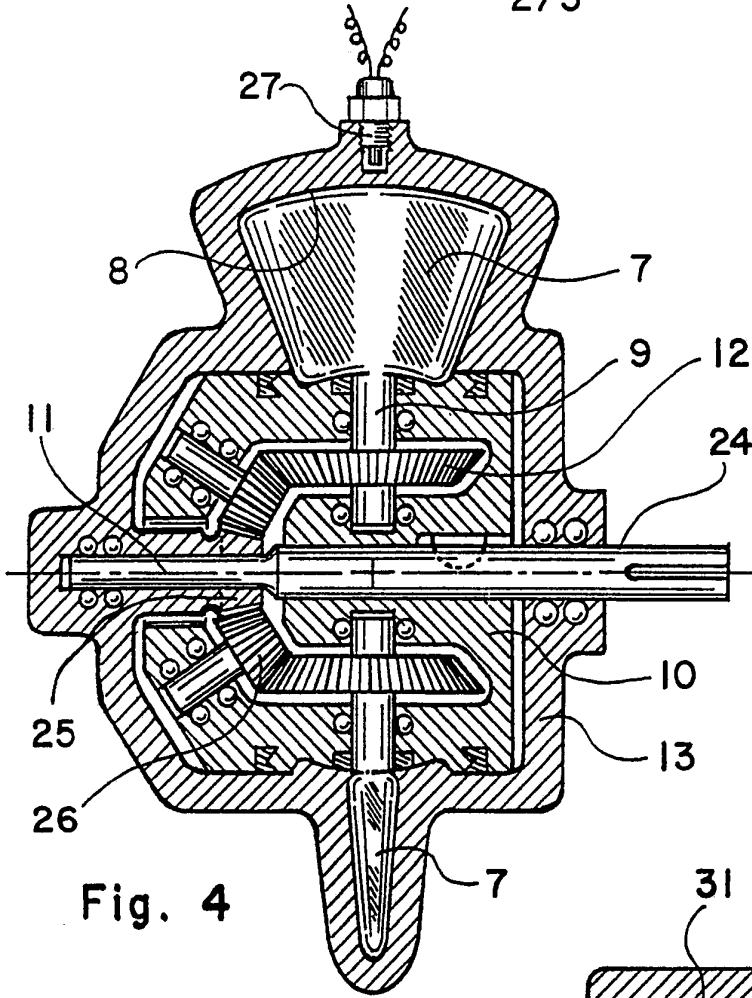


Fig. 4

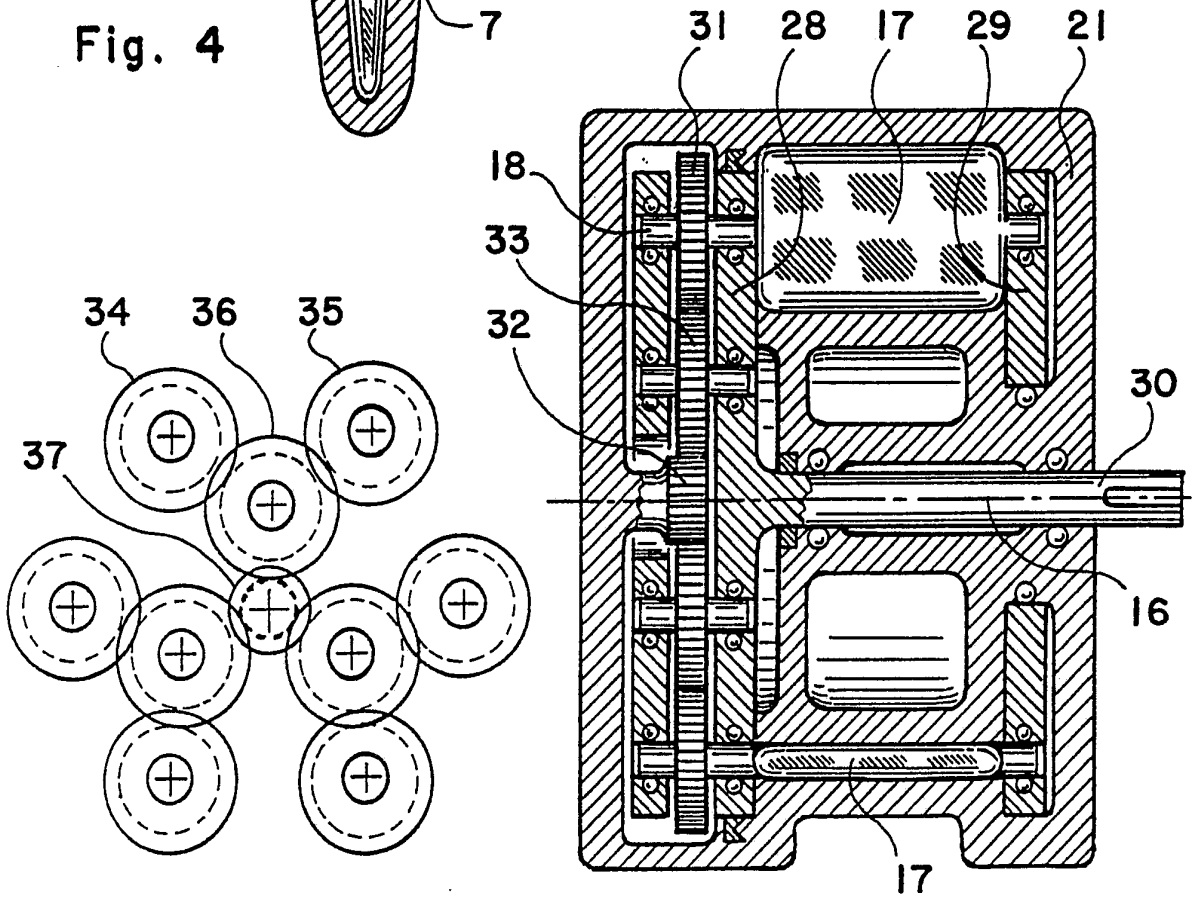


Fig. 5

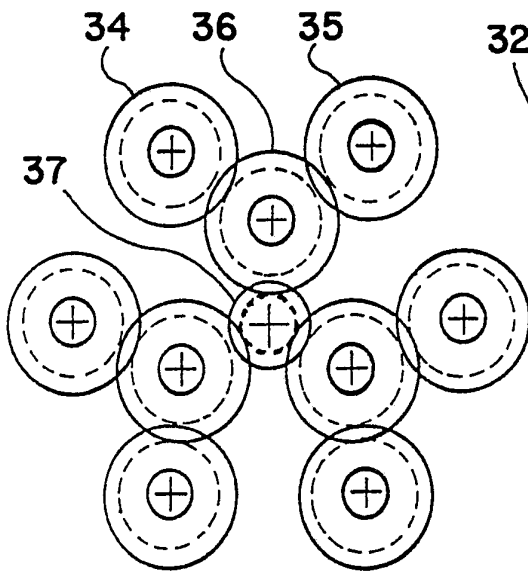


Fig. 6

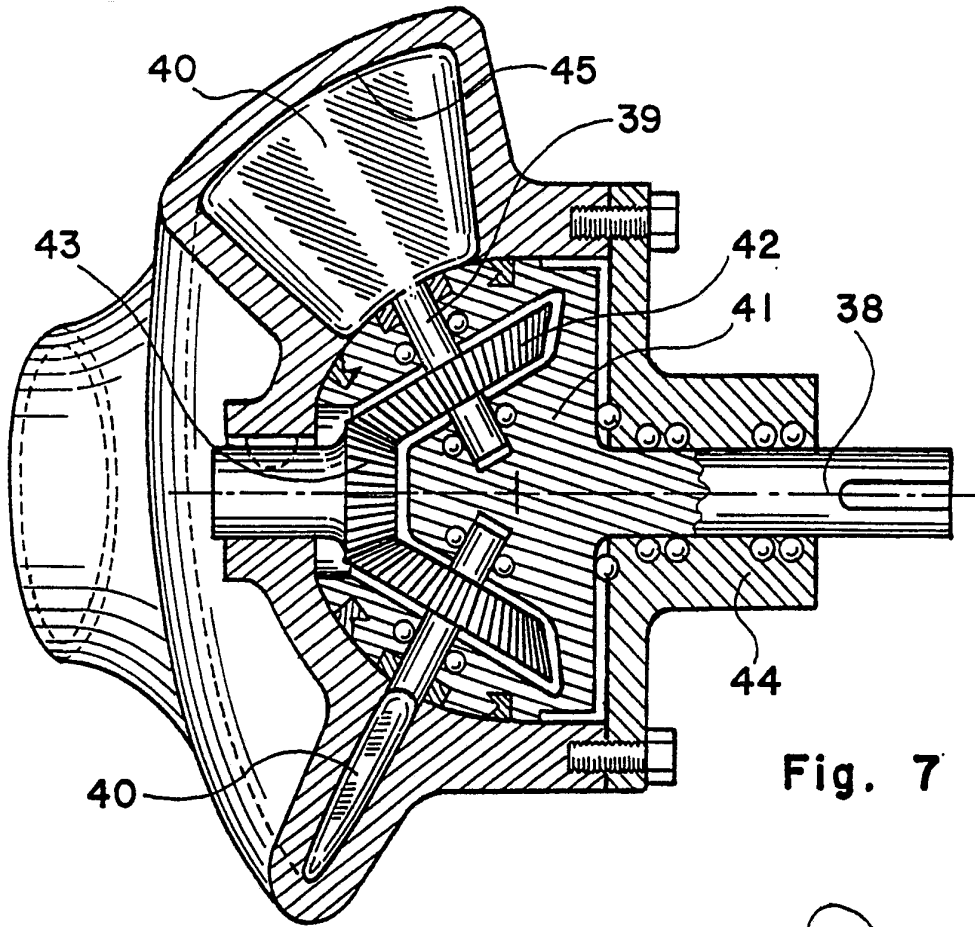


Fig. 7

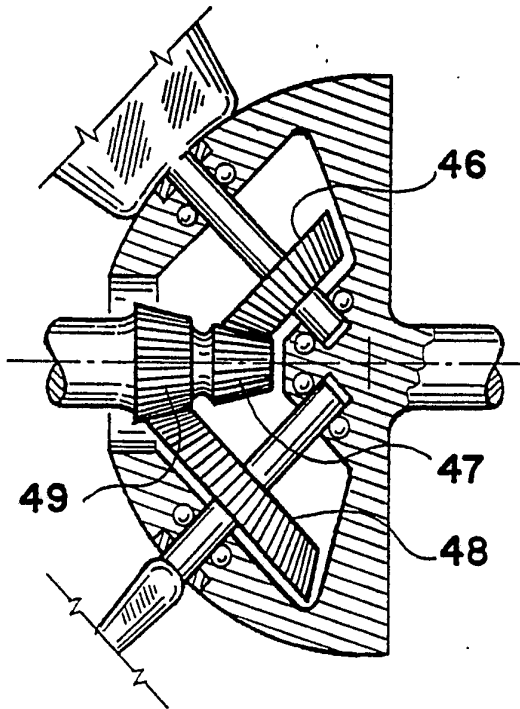


Fig. 8

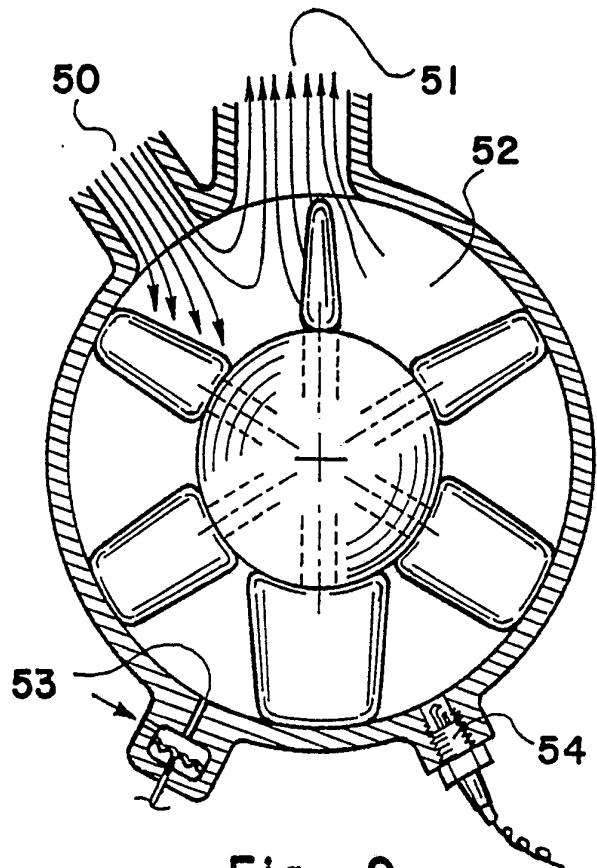


Fig. 9

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US92/03659

<p>A. CLASSIFICATION OF SUBJECT MATTER IPC(5) :F01C 1/00, 17/02; F02B 53/00 US CL :418/226, 227, 233, 234;123/243; 73/253 According to International Patent Classification (IPC) or to both national classification and IPC</p>																				
<p>B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) U.S. : 418/226, 227, 233, 234;123/243; 73/253</p> <p>Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched</p> <p>Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)</p>																				
<p>C. DOCUMENTS CONSIDERED TO BE RELEVANT</p> <table border="1"> <thead> <tr> <th>Category*</th> <th>Citation of document, with indication, where appropriate, of the relevant passages</th> <th>Relevant to claim No.</th> </tr> </thead> <tbody> <tr> <td>A</td> <td>US,A, 1,136,976 (Reaugh), 27 April 1915, see figures 1-6.</td> <td></td> </tr> <tr> <td>A</td> <td>US,A, 3,491,728 (Ahlsten), 27 January 1970, note figures 1-4.</td> <td></td> </tr> <tr> <td>A</td> <td>AU,A, 643/31, (Hughes), 11 June 1931, see figures 1-3.</td> <td></td> </tr> <tr> <td>A</td> <td>FR,A, 596,888 (Dufresne), 17 August 1925, see figures 1 and 5.</td> <td></td> </tr> <tr> <td>A</td> <td>GB,A, 874,045 (Rohsmann), 02 August 1961, note figures 1 and 3-6.</td> <td></td> </tr> </tbody> </table>			Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.	A	US,A, 1,136,976 (Reaugh), 27 April 1915, see figures 1-6.		A	US,A, 3,491,728 (Ahlsten), 27 January 1970, note figures 1-4.		A	AU,A, 643/31, (Hughes), 11 June 1931, see figures 1-3.		A	FR,A, 596,888 (Dufresne), 17 August 1925, see figures 1 and 5.		A	GB,A, 874,045 (Rohsmann), 02 August 1961, note figures 1 and 3-6.	
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<p><input type="checkbox"/> Further documents are listed in the continuation of Box C. <input type="checkbox"/> See patent family annex.</p>																				
<table border="0"> <tr> <td>* Special categories of cited documents:</td> <td>"T"</td> <td>later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</td> </tr> <tr> <td>"A" document defining the general state of the art which is not considered to be part of particular relevance</td> <td>"X"</td> <td>document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone</td> </tr> <tr> <td>"E" earlier document published on or after the international filing date</td> <td>"Y"</td> <td>document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art</td> </tr> <tr> <td>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</td> <td>"&"</td> <td>document member of the same patent family</td> </tr> <tr> <td>"O" document referring to an oral disclosure, use, exhibition or other means</td> <td></td> <td></td> </tr> <tr> <td>"P" document published prior to the international filing date but later than the priority date claimed</td> <td></td> <td></td> </tr> </table>			* Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention	"A" document defining the general state of the art which is not considered to be part of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone	"E" earlier document published on or after the international filing date	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art	"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&"	document member of the same patent family	"O" document referring to an oral disclosure, use, exhibition or other means			"P" document published prior to the international filing date but later than the priority date claimed		
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<p>Date of the actual completion of the international search 28 JULY 1992</p>		<p>Date of mailing of the international search report 29 SEP 1992</p>																		
<p>Name and mailing address of the ISA/ Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. NOT APPLICABLE</p>		<p>Authorized officer <i>John Vrablik</i> JOHN VRABLIK Telephone No. (703) 308-2629</p>																		