CLAIMS

What is claimed is:

~~1. A vacuum pump, comprising:~~

~~a low pressure portion and a high pressure portion;~~

~~a partition separating the low pressure portion from the high pressure portion, wherein the partition is substantially gas impermeable and stationary;~~

~~a gas flow path for a gas to flow from the low pressure portion to the high pressure portion through the partition, wherein there is no seal to prevent the gas from leaking back from the high pressure portion to the low pressure portion through the gas flow path;~~

~~a rotatable surface in the high pressure portion adapted to be impinged on by molecules of the gas entering the high pressure portion via the gas flow path, wherein the rotatable surface has no protrusions that function as blades or vanes; and~~

~~a drive coupled to the rotatable surface and adapted to cause at least a portion of the rotatable surface to rotate with a tangential velocity in the range of approximately 1 to 6 times the most probable velocity of the molecules of the gas impinging on the rotatable surface to reduce the pressure in the low pressure portion down to at least approximately 0.5 atm before the molecules of the gas leaking back from the high pressure portion to the low pressure portion limits further reducing the pressure in the low pressure portion.~~

~~2. The vacuum pump of claim 1, wherein the drive is adapted to cause the at least a portion of the rotatable surface to rotate with a tangential velocity in the range of approximately 1 to 6 times the most probable velocity of the molecules of the gas impinging on the rotatable surface to reduce the pressure in the low pressure portion down to at least approximately 10^{-6} atm before the molecules of the gas leaking back from the high pressure portion to the low pressure portion limits further reducing the pressure in the low pressure portion.~~

~~3. The vacuum pump of claim 1, comprising an inlet in gaseous communication with the low pressure portion and an outlet in gaseous communication with the high pressure portion.~~

~~4. The vacuum pump of claim 1, wherein the partition has a substantially planar first surface that is exposed to the high pressure portion, wherein the rotatable surface comprises a~~

second surface that faces the first surface, and wherein the first surface and the second surface are separated by a gap with a dimension in the range of approximately 0.5 mm to approximately 100 mm.

5. The vacuum pump of claim 1, wherein:

the rotatable surface has an axis of rotation, a periphery, a peripheral surface portion around the periphery, and a first width between the axis of rotation and the periphery; and

the peripheral surface portion has a second width that is in the range of approximately 0.05 to approximately 1.0 times the first width.

6. The vacuum pump of claim 1, wherein the rotatable surface comprises a substantially circular ring with an interior open portion and a peripheral surface portion.

7. The vacuum pump of claim 1, comprising a plurality of substantially parallel rotatable surfaces arranged in a stacked configuration.

8. The vacuum pump of claim 7, wherein the plurality of substantially parallel rotatable surfaces are conical.

9. A vacuum pump, comprising:

an outer enclosure with a wall that is substantially gas impermeable and that defines a partially open interior space;

a rotatable surface in the interior space and adapted to be impinged on by molecules of a gas in the interior space, wherein the rotatable surface is arranged to separate the interior space into a low pressure portion and a high pressure portion, and wherein the rotatable surface has no protrusions that function as blades or vanes;

wherein the low pressure portion and the high pressure portion are in gaseous communication, and wherein there is no seal to prevent the gas from leaking back from the high pressure portion to the low pressure portion;

a drive coupled to the rotatable surface and adapted to cause at least a portion of the rotatable surface to rotate with a tangential velocity in the range of approximately 1 to 6 times the most probable velocity of the molecules of the gas impinging on the rotatable surface to reduce the pressure in the low pressure portion down to at least approximately 0.5 percent

before the molecules of the gas leaking back from the high pressure portion to the low pressure portion limits further reducing the pressure in the low pressure portion.

10. The vacuum pump of claim 9, wherein the drive is adapted to cause the at least a portion of the rotatable surface to rotate with a tangential velocity in the range of approximately 1 to 6 times the most probable velocity of the molecules of the gas impinging on the rotatable surface to reduce the pressure in the low pressure portion down to at least approximately 10^{-6} atm before the molecules of the gas leaking back from the high pressure portion to the low pressure portion limits further reducing the pressure in the low pressure portion.

11. The vacuum pump of claim 9, wherein the outer enclosure comprises an inlet in gaseous communication with the low pressure portion and an outlet in gaseous communication with the high pressure portion.

12. The vacuum pump of claim 9, comprising:

a second enclosure with a wall that is substantially gas impermeable in the high pressure portion, wherein the second enclosure defines an interior space with an opening, and wherein the interior space comprises a region of low pressure;

wherein the rotating surface comprises a first surface and a second surface opposite the first surface; and

wherein the first surface is exposed to low pressure portion and the second surface is exposed to the region of low pressure in the interior space of the inner enclosure through the opening.

13. The vacuum pump of claim 12, wherein the second surface of the rotatable surface has a periphery, wherein the second enclosure comprises a sloped wall that extends outwardly to the opening and an edge that extends around the opening, and wherein the edge is adjacent to and extends around the periphery of the second surface.

14. The vacuum pump of claim 9, wherein the rotatable surface comprises a first surface that is exposed to the low pressure portion and has a peripheral edge, wherein the wall of the outer enclosure comprises an interior surface, and wherein the wall extends around the rotatable surface with the interior surface adjacent to the peripheral edge and

~~separated from the peripheral edge by a gap that separates the low pressure portion and the high pressure portion.~~

~~15. The vacuum pump of claim 14, wherein the interior surface slopes away from the peripheral edge in relation to the first surface.~~

~~16. The vacuum pump of claim 9, wherein the wall of the outer enclosure has an interior surface, wherein the rotatable surface comprises a peripheral edge, and wherein the peripheral edge and the interior surface are separated by a gap with a dimension in the range of approximately 0.5 mm to approximately 100 mm.~~

~~17. The vacuum pump of claim 9, wherein:~~

~~the rotatable surface has an axis of rotation, a periphery, a peripheral surface portion around the periphery, and a first width between the axis of rotation and the periphery; and~~

~~the peripheral surface portion has a second width that is in the range of approximately 0.05 to approximately 1.0 times the first width.~~

~~18. The vacuum pump of claim 9, wherein the rotatable surface comprises a substantially circular ring with an interior open portion and a peripheral surface portion.~~

~~19. The vacuum pump of claim 9, comprising a plurality of substantially parallel planar rotatable surfaces arranged in a stacked configuration.~~

~~20. The vacuum pump of claim 19, wherein the plurality of substantially parallel rotatable surfaces are conical.~~

~~21~~1. A vacuum pump for pumping a gas, comprising:

an outer enclosure that is substantially gas impermeable, wherein the outer enclosure defines an interior space with an interior surface;

a rotatable ~~surface~~ disk or ring in the interior space, wherein the rotatable ~~surface~~ disk or ring has a first surface, a second surface opposite of the first surface, and a peripheral edge between the first surface and the second surface, and wherein the first surface and the second surface are substantially flat;

wherein the rotatable ~~surface~~ disk or ring is arranged to separate the interior space into a low pressure portion and a high pressure portion with the first surface facing the low pressure portion and the second surface facing the high pressure portion;

wherein the outer enclosure has a first apex that is spaced from the first surface and the interior surface slopes substantially continuously outward from at or near the first apex ~~outwardly~~ around substantially the entire peripheral edge of the rotatable ~~surface~~ disk or ring in the low pressure portion of the interior space;

wherein the peripheral edge of the rotatable ~~surface~~ disk or ring and the interior surface of the outer enclosure define a first gap, wherein the gas is able to flow ~~from~~ between the low pressure portion ~~to~~ and the high pressure portion through the first gap while the vacuum pump is pumping the gas, ~~wherein~~ and there is no seal to prevent the gas from ~~leaking back from~~flowing between the high pressure portion ~~to~~ and the low pressure portion through the first gap, wherein the first gap has a first dimension, ~~and wherein the first dimension is selected in relation~~that is related to the length of the mean free path of the gas at a predetermined target minimum pressure in the low pressure portion so that the ~~gas leaking back from the high pressure portion to the low pressure portion through the first gap does not prevent~~first gap is able to conduct a net outflow of the gas from the low pressure portion to the high pressure portion while the vacuum pump is pumping the gas until the pressure in the low pressure portion reaches the target minimum pressure;

a drive coupled to the rotatable ~~surface~~disk or ring, wherein the drive is operable to rotate the rotatable ~~surface~~ disk or ring with at least a portion of the ~~rotatable~~ first surface and the second having tangential velocity in the range of approximately 1 to 6 times the most probable velocity of the molecules of the gas over a range of pressures in the low pressure portion from a starting pressure ~~of about 1 atm~~ to the target minimum pressure to cause the molecules of the gas impinging on the rotatable disk or ring to flow outwardly from the peripheral edge of the rotatable ~~surface~~ disk or ring through the first gap to reduce the pressure in the low pressure portion from the starting pressure to the predetermined target minimum pressure in a single pumping stage, wherein the target minimum pressure ~~is at least as low as approximately 10^{-4} atm~~in a single pumping stage;

a second enclosure in the high pressure portion, wherein the second enclosure is substantially gas impermeable, defines a second interior space ~~with an opening~~that is adjacent to the second surface of the rotatable ~~surface~~disk or ring, has a second apex that is spaced from the second surface, and has a surface that slopes outwardly from the second apex toward the peripheral edge of the rotatable ~~surface~~ disk or ring in the high pressure portion and

terminates just inwardly of the peripheral edge around substantially the entire peripheral edge;

wherein the peripheral edge of the rotatable ~~surface~~ disk or ring and the surface of the second enclosure define a second gap having a second dimension wherein the second interior space and the high pressure portion are in gaseous communication via the second gap;

wherein the second dimension of the second gap ~~is selected to be~~slightly less than the first dimension of the first gap to reduce a pressure differential between the first surface ~~of the rotatable surface~~ and the second surface ~~of the rotatable surface~~ while the pump is pumping the gas.

~~22~~2. The vacuum pump of claim ~~21~~1, wherein the starting pressure is about 1 atm and the target minimum pressure is in the range of approximately 10^{-4} to 10^{-6} atm.

~~23~~3. The vacuum pump of claim ~~21~~1, wherein the outer enclosure comprises an inlet in gaseous communication with the low pressure portion and an outlet in gaseous communication with the high pressure portion.

~~24~~4. The vacuum pump of claim ~~21~~1, wherein the first dimension of the first gap is in the range of approximately 0.5 mm to approximately 100 mm.

~~25~~5. The vacuum pump of claim ~~21~~1, wherein the rotatable ~~surface~~ ring comprises a substantially circular ring with a central opening, a radius dimension between the central opening and the peripheral edge, an interior open portion and a peripheral surface portion with a dimension in the range of approximately 0.05 to less than 0.5 times the radius dimension.

~~26~~6. The vacuum pump of claim ~~21~~1, comprising a plurality of substantially parallel planar rotatable ~~surfaces~~ disks or rings arranged in a stacked configuration.

~~27~~7. The vacuum pump of claim ~~21~~1, wherein the drive is operable to rotate the rotatable ~~surface~~ disk or ring with at least a portion of the first and second rotatable ~~surface~~ surfaces having a tangential velocity having a first velocity value when the pressure in the low pressure portion is approximately the starting pressure and having one or more second

velocity values that are progressively greater than the first velocity value as the pressure in the low pressure portion is reduced toward the target minimum pressure.

~~28~~8. A vacuum pump for pumping a gas, comprising:

an outer enclosure that is substantially gas impermeable, wherein the outer enclosure defines an interior space with an interior surface;

a rotatable surface in the interior space, wherein the rotatable surface has a first surface, a second surface opposite of the first surface, and a peripheral edge between the first surface and the second surface, and wherein the first surface and the second surface are substantially flat;

wherein the rotatable surface is arranged to separate the interior space into a low pressure portion and a high pressure portion with the first surface facing the low pressure portion and the second surface facing the high pressure portion;

wherein the outer enclosure has an apex that is spaced from the first surface and the interior surface slopes substantially continuously outward from at or near the first apex ~~outwardly~~ around the peripheral edge of the rotatable surface in the low pressure portion of the interior space;

wherein the peripheral edge of the rotatable surface and the interior surface of the outer enclosure define a first gap, wherein the gas is able to flow ~~from~~ between the low pressure portion ~~to~~ and the high pressure portion through the first gap while the vacuum pump is pumping the gas, ~~wherein~~ and there is no seal to prevent the gas from ~~leaking back from~~flowing between the high pressure portion ~~to~~ and the low pressure portion through the first gap, wherein the first gap has a first dimension~~, and wherein the first dimension is selected in relation~~ that is related to the length of the mean free path of the gas at a predetermined target minimum pressure in the low pressure portion so that the ~~gas leaking back from the high pressure portion to the low pressure portion through the first gap does not prevent~~first gap is able to conduct a net outflow of the gas from the low pressure portion to the high pressure portion while the vacuum pump is pumping the gas until the pressure in the low pressure portion reaches the target minimum pressure;

a drive coupled to the rotatable surface, wherein the drive is operable while the pump is pumping gas to rotate the rotatable surface with at least a portion of the rotatable surface having a tangential velocity in the range of approximately 1 to 6 times the most probable velocity of the molecules of the gas over a range of pressures in the low pressure portion from a starting pressure of when the pump begins pumping the gas ~~about 1 atm~~ to the target

minimum pressure to cause the molecules of the gas impinging on the rotatable surface to flow outwardly from the peripheral edge of the rotatable surface through the first gap to reduce the pressure in the low pressure portion from the starting pressure to the predetermined target minimum pressure~~, wherein the target minimum pressure is at least as low as approximately 10^{-4} atm~~ in a single pumping stage.

~~29~~9. The vacuum pump of claim ~~28~~8, wherein the starting pressure is about 1 atm and the target minimum pressure is in the range of approximately 10^{-4} to 10^{-6} atm.

~~30~~10. The vacuum pump of claim ~~28~~8, wherein the first dimension of the first gap is in the range of approximately 0.5 mm to approximately 100 mm.

~~31~~11. The vacuum pump of claim ~~28~~8, wherein the rotatable surface comprises a substantially circular ring with a central opening, a radius dimension between the central opening and the peripheral edge, an interior open portion and a peripheral surface portion with a dimension in the range of approximately 0.05 to less than 0.5 times the radius dimension.

~~32~~12. The vacuum pump of claim ~~28~~8, comprising a plurality of substantially parallel planar rotatable surfaces arranged in a stacked configuration.

~~33~~13. The vacuum pump of claim ~~28~~8, wherein the drive is operable to rotate the rotatable surface with at least a portion of the rotatable surface having a tangential velocity having a first velocity value when the pressure in the low pressure portion is approximately the starting pressure and having one or more second velocity values that are progressively greater than the first velocity value as the pressure in the low pressure portion is reduced toward the target minimum pressure.

~~34~~14. A vacuum pump for pumping a gas, comprising:

an outer enclosure that is substantially gas impermeable, wherein the outer enclosure defines an interior space with an interior surface;

a plurality of rotatable rings arranged in a stack in the interior space, wherein the stack has a top ring and a bottom ring, wherein each ring of the plurality of rings is substantially circular and has an interior open portion, an axis of rotation, a peripheral edge, a first

peripheral surface around the peripheral edge, and a second peripheral surface around the peripheral edge opposite of the first peripheral surface, wherein the first peripheral surface and the second peripheral surface are substantially flat;

wherein the stack of rotatable rings separates the interior space into a low pressure portion and a high pressure portion with the first peripheral surface of the top ring facing the low pressure portion and the second peripheral surface of the bottom ring facing the high pressure portion;

wherein the outer enclosure has an apex that is spaced from the first surface of the top ring and the interior surface slopes substantially continuously outward from at or near the apex ~~outwardly~~ around the peripheral edges of the stack of rotatable rings in the low pressure portion of the interior space;

wherein the peripheral edge of the top ring and the interior surface of the outer enclosure define a first gap, wherein the gas is able to ~~flow~~ between from the low pressure portion ~~to~~ and the high pressure portion through the first gap while the vacuum pump is pumping the gas, ~~wherein~~ and there is no seal to prevent the gas from ~~leaking back from~~flowing between the high pressure portion ~~to~~ and the low pressure portion through the first gap, wherein the first gap has a first dimension, ~~and wherein the first dimension is determined by~~that is related to the length of the mean free path of the gas at a predetermined target minimum pressure in the low pressure portion ~~to prevent the gas leaking back from the high pressure portion to the low pressure portion from limiting~~so that the first gap is able to conduct a net outflow of the gas from the low pressure portion to the high pressure portion while the vacuum pump is pumping the gas until the pressure in the low pressure portion reaches the target minimum pressure;

a drive coupled to the stack of rotatable rings, wherein the drive is operable ~~when~~ while the vacuum pump is pumping the gas to rotate the stack of rotatable rings with at least a portion of the first peripheral surface and the second peripheral surface of ~~each~~ at least the top ring having a tangential velocity in the range of approximately 1 to 6 times the most probable velocity of the molecules of the gas to cause the molecules of the gas in the low pressure portion to flow outwardly through the first gap to reduce the pressure in the low pressure portion.

~~35~~15. The vacuum pump of claim ~~34~~14, wherein the target minimum pressure is at least as low as approximately ~~10~~$^{-4}$0.5 atm.

~~36~~16. The vacuum pump of claim ~~35~~15, wherein the drive is operable when the vacuum pump is pumping the gas to rotate the stack of rotatable rings with at least a portion of the first peripheral surface and the second peripheral surface of each ring having a tangential velocity in the range of approximately 1 to 6 times the most probable velocity of the molecules of the gas over a range of pressures in the low pressure portion from a starting pressure ~~of about 1 atm~~when the pump begins pumping the gas to the target minimum pressure.

~~37~~17. The vacuum pump of claim ~~34~~36, wherein the starting pressure is about 1 atm and the target minimum pressure is in the range of approximately 10^{-4} to 10^{-6} atm.

~~38. The vacuum pump of claim 35, wherein the drive is operable when the vacuum pump is pumping the gas to rotate the stack of rotatable rings with the first peripheral surface and the second peripheral surface of each ring having a tangential velocity in the range of approximately 1 to 6 times the most probable velocity of the molecules of the gas over a range of pressures in the low pressure portion from a starting pressure of about 1 atm to the target minimum pressure.~~

~~39~~18. The vacuum pump of claim ~~34~~14, wherein the drive is operable ~~when~~ while the vacuum pump is pumping the gas to rotate the stack of rotatable rings with at least a portion of the first peripheral surface and the second peripheral surface of each ring having a tangential velocity with a first velocity value when the pressure in the low pressure portion has a predetermined starting value and with one or more second velocity values that are progressively greater than the first velocity value as the pressure in the low pressure portion is reduced toward the target minimum pressure.

19. A vacuum pump for pumping a gas, comprising:

an outer enclosure that is substantially gas impermeable, wherein the outer enclosure defines an interior space with an interior surface;

a rotatable surface in the interior space, wherein the rotatable surface has a first surface, a second surface opposite of the first surface, and a peripheral edge between the first surface and the second surface, and wherein the first surface and the second surface are substantially flat and featureless;

wherein the rotatable surface is arranged to separate the interior space into a low pressure portion and a high pressure portion with the first surface facing the low pressure portion and the second surface facing the high pressure portion;

wherein the outer enclosure has an apex that is spaced from the first surface and the interior surface slopes substantially continuously from at or near the first apex toward the peripheral edge of the rotatable surface and extends around the peripheral edge;

wherein the peripheral edge and the interior surface define a first gap, wherein the gas is able to flow between the low pressure portion and the high pressure portion through the first gap while the vacuum pump is pumping the gas and there is no seal to prevent the gas from flowing between the high pressure portion and the low pressure portion through the first gap, wherein the first gap has a first dimension that is related to the length of the mean free path of the gas at a predetermined target minimum pressure in the low pressure portion so that the first gap is able to conduct a net outflow of the gas from the low pressure portion to the high pressure portion while the vacuum pump is pumping the gas until the pressure in the low pressure portion reaches the target minimum pressure; and

a drive coupled to the rotatable surface and operable to cause the rotatable surface to rotate with at least a portion of the surface having a tangential velocity that is sufficient to cause molecules of the gas in the space between the apex and the rotatable surface that impinge on the surface to be directed toward the peripheral edge and through the gap into the high pressure portion to reduce the pressure of the gas in the low pressure portion.

20. A method of operating the vacuum pump of claim 19, comprising:

introducing the gas into the space between the apex and the rotatable surface in the low pressure portion; and

operating the drive to rotate the rotatable surface with at least a portion of the rotatable surface having a tangential velocity in the range of approximately 1 to 6 times the most probable velocity of the molecules of the gas until the pressure of the gas in the low pressure portion is reduced from a starting pressure when the pump begins pumping the gas to the target minimum pressure in a single pumping stage.

21. The method of claim 19 wherein the starting pressure is about 1 atm and the minimum target pressure is at least as low as approximately .5 atm.

22. The method of claim 19 wherein the starting pressure is about 1 atm and the minimum target pressure is in a range of approximately 10^{-4} to 10^{-6} atm.