

CLAIMS

What is claimed is:

1. A cold cathode ionization gauge comprising:
 - an anode;
 - a first cathode spaced from the anode by a first spacing sufficient to enable, at low pressures, formation of a plasma between the anode and the first cathode and a resultant ion current flow into the first cathode;
 - a second cathode electrically isolated from the first cathode and spaced from the anode by a second spacing less than the first spacing, the second spacing enabling electric discharge at pressures higher than the low pressures required for plasma formation in the first spacing;
 - a magnet applying a magnetic field through at least the first spacing to lengthen free electron paths to sustain the plasma;
 - an electric controller that applies voltage between the anode and each of the first and second cathodes to create ionization with plasma discharge at least between the anode and the first cathode at the low pressures and electric discharge between the anode and the second cathode at pressures higher than the low pressures, the controller determining pressure based on measured current flow to the first cathode and on measured current flow to the second cathode.
2. The cold cathode ionization gauge of Claim 1 wherein the controller determines first cathode impedance and second cathode impedance from the measured current flow to the first cathode, the measured current flow to the second cathode and measured anode voltage, and pressure is determined based on the first cathode impedance and the second cathode impedance.
3. The cold cathode ionization gauge of Claim 2 wherein pressure is determined based on the first cathode impedance and the second cathode impedance over respective ranges of pressure, including nonadjacent ranges of pressure in which the pressure is determined based on the first cathode impedance.
4. The cold cathode ionization gauge of Claim 1 wherein the first and second cathodes

surround the anode.

5. The cold cathode ionization gauge of Claim 4 wherein each cathode is cylindrical, the different spacings being determined by respective radii.
6. The cold cathode ionization gauge of Claim 5 comprising only two cylindrical cathodes.
7. The cold cathode ionization gauge of Claim 5 wherein the spacing between the anode and the first cathode is within a range of 5 to 15 millimeters and the first cathode has an effective length along the magnet in the range of 15 to 40 millimeters along the anode.
8. The cold cathode ionization gauge of Claim 7 wherein the spacing between the anode and the second cathode is in a range of 1 to 5 millimeters and the second cathode has a length in a range of 6 to 24 millimeters along the anode.
9. The cold cathode ionization gauge of Claim 8 wherein the second cathode comprises a feature directed toward the anode that establishes a narrow gap between the anode and the feature in a range of 0.3 to 1.0 millimeters to enable Paschen's Law discharge between the anode and the feature on the second cathode at high pressures approaching atmospheric pressure.
10. The cold cathode ionization gauge of Claim 9 wherein the electric controller includes impedance of at least a megaohm between the first cathode and a return to the power supply and an impedance between the second cathode and the return to the power supply that it is at least an order of magnitude larger than the impedance between the first cathode and return to the power supply.
11. The cold cathode ionization gauge of Claim 5 wherein the spacing between the anode and the second cathode is in a range of 1 to 5 millimeters and the second cathode has a length in a range of 6 to 24 millimeters along the anode.
12. The cold cathode ionization gauge of Claim 11 wherein the second cathode comprises a feature directed toward the anode that establishes a narrow gap between the anode

and the feature in a range of 0.3 to 1.0 millimeters to enable Paschen's Law discharge between the anode and the feature on the second cathode at high pressures approaching atmospheric pressure

13. The cold cathode ionization gauges of Claim 5 wherein the first and second cathodes are set in a polymer housing that electrically insulates the first and second cathodes.
14. The cold cathode ionization gauge of Claim 1 wherein the spacing between the anode and the second cathode is in a range of 1 to 5 millimeters and the second cathode has a length in a range of 6 to 24 millimeters along the anode.
15. The cold cathode ionization gauge of Claim 14 wherein the second cathode comprises a feature directed toward the anode that establishes a narrow gap between the anode and feature to enable Paschen's Law discharge between the anode and the feature.
16. The cold cathode ionization gauge of Claim 15 wherein the gap between the anode and the feature is in a range of 0.3 to 1.0 millimeters.
17. The cold cathode ionization gauge of Claim 15 wherein the feature is a disc and the gap is formed in a hole within the disc.
18. The cold cathode ionization gauge of Claim 15 wherein the feature is a disc and the gap is formed between the anode and a tip extending from the disc.
19. The cold cathode ionization gauge of Claim 15 wherein the feature is a pin.
20. The cold cathode ionization gauge of Claim 15 wherein the feature is a threaded pin.
21. The cold cathode ionization gauge of Claim 15 wherein the electric controller includes impedance of at least a megaohm between the first cathode and a return to the power supply and an impedance between the second cathode and the return to the power supply that it is at least an order of magnitude larger than the impedance between the first cathode and return to the power supply.

22. The cold cathode ionization gauge of Claim 1 wherein the electric controller includes an impedance of at least a megaohm between each cathode and a return to a power supply.
23. The cold cathode ionization gauge of Claim 22 wherein the impedance from the second cathode is at least an order of magnitude larger than the impedance from the first cathode.
24. The cold cathode ionization gauge of Claim 22 wherein at least one of the impedances is provided by a variable resistance.
25. The cold cathode ionization gauge of Claim 22 wherein the electric controller selects one of plural algorithms to provide pressure output based on electrical measurements, the electric controller selecting the algorithm based on impedance measurements between the anode and each cathode.
26. The cold cathode ionization gauge of Claim 25 wherein the algorithms are processed using precomputed data stored in lookup tables.
27. The cold cathode ionization gauge of Claim 1 wherein pressure is determined based on electrical outputs from each of the first and second cathodes over distinct ranges of pressure including nonadjacent ranges of pressure in which the pressure is determined based on the first cathode output.
28. The cold cathode ionization gauge of Claim 27 wherein the pressure is based on an output of the first cathode for a first low pressure range, based on an output of the second cathode over a second pressure range higher than the first pressure range, based on an output of the first cathode over a third pressure range higher than the first and second pressure ranges, and based on an output of the second cathode over a fourth pressure range higher than the first, second and third pressure ranges.
29. The cold cathode ionization gauge of Claim 1 wherein at least a Townsend plasma discharge is supported between the anode and the first cathode at low pressures, and

at least a breakdown discharge is supported between the anode and the second cathode at pressures higher than the low pressures.

30. The cold cathode ionization gauge of Claim 29 wherein the Townsend discharge is also supported between the anode and the second cathode at pressures higher than the low pressures.
31. The cold cathode ionization gauge of Claim 29 wherein the breakdown discharge is supported at a feature of the second cathode.
32. The cold cathode ionization gauge of claim 29 wherein the breakdown discharge is supported at a feature of one of the second cathode and the anode that reduces the spacing between the second cathode and anode.
33. The cold cathode ionization gauge of Claim 1 wherein at least a Townsend plasma discharge is supported between the anode and the first cathode at low pressures, and at least a Townsend discharge is supported between the anode and the second cathode at pressures higher than the low pressures.
34. A cold cathode ionization gauge of Claim 1 wherein each cathode is cylindrical, surrounding the anode, the different spacings being determined by respective radii, at least one of the cathodes being tapered in inner surface diameter.
35. The cold cathode ionization gauge of Claim 1 wherein the second cathode comprises a feature directed toward the anode that establishes a narrow gap between the anode and feature to enable Paschen's Law discharge between the anode and the feature.
36. The cold cathode ionization gauge of Claim 35 wherein the feature is displaced from the end of the second cathode adjacent to the first cathode.
37. A method of measuring pressure comprising:
 - applying a magnetic field to a first space between an anode and a first cathode;
 - at low pressures, releasing electrons into the first space to create a plasma

discharge in the first space and ion flow to the first cathode;

at pressures higher than the low pressures, creating electric discharge between a second cathode and the anode to create a current flow to the second cathode; and

determining pressure based on measured current flow to the first cathode and on measured current flow to the second cathode.

38. A cold cathode ionization gauge comprising:

an anode;

a first cathode spaced from the anode by a first spacing sufficient to enable formation of a plasma between the anode and the first cathode and a resultant ion current flow into the first cathodes, a current flow response with respect to pressure of the first cathode having a first discontinuity;

a second cathode electrically isolated from the first cathode and spaced from the anode by second spacing less than the first spacing, the second spacing sufficient to enable formation of a plasma between the anode and the second cathode and a resultant ion current flow into the first cathode, a current flow response with respect to pressure of the second cathode having a second continuity;

a magnet applying a magnetic field through the first and second spacings to lengthen free electron paths to sustain the plasma;

an electric controller that applies voltage between the anode and each of the first and second cathodes to create ionization with plasma discharge between the anode and each of the first cathode and the second cathode, the controller determining pressure based on measured current flow to the first cathode through pressures that include the second discontinuity and determining pressure based on measured current flow to the second cathode through pressures that include the first discontinuity.

39. A method of measuring pressure comprising:

applying a magnetic field to a first space between an anode and a first cathode;

applying a magnetic field to a second space between the anode and a second cathode;

releasing electrons into the first space to create a plasma discharge in the first space and ion flow to the first cathode, a current flow response with respect pressure

of the first cathode having a first discontinuity;

releasing electrons into the second space to create a plasma discharge in the second space and ion flow to the second cathode, a current flow response with respect to pressure of the second cathode having a second discontinuity;

determining pressure based on measured current flow to the first cathode and on measured current flow to the second cathode, pressure being based on measured current flow to the first cathode through pressures that include the second discontinuity and being based on measured current flow to the second cathode through pressures that include the first discontinuity.

40. A cold cathode ionization gauge comprising:

an anode;

a first cathode spaced from the anode by a first spacing sufficient to enable the formation of a plasma between the anode and the first cathode and the resultant ion current flow into the first cathode;

a second cathode electrically isolated from the first cathode and spaced from the anode by second spacing less than the first spacing sufficient to enable formation of a plasma between the anode and the second cathode and a resultant ion current flow into the second cathode;

a magnet applying a magnetic field through the first and second spacings to lengthen free electrons paths to sustain the plasma; and

an electric controller that applies voltage between the anode and each of the first and second cathodes to create ionization with plasma discharge between the anode and the first cathode and the second cathode over respective pressure ranges, the controller determining pressure based on measured current flow to the first cathode and on measured current flow to the second cathode

41. The cold cathode ionization gauge of Claim 40 wherein the controller determines first cathode impedance and second cathode impedance from the measured current flow to the first cathode, the measured current flow to the second cathode and measured anode voltage, and pressure is determined based on the first cathode impedance and the second cathode impedance.