Dec. 11, 1951 E. G. LINDER 2,578,009

ELECTRONIC HIGH VACUUM APPARATUS

Filed Dec. 23, 1947

Fig. 1.

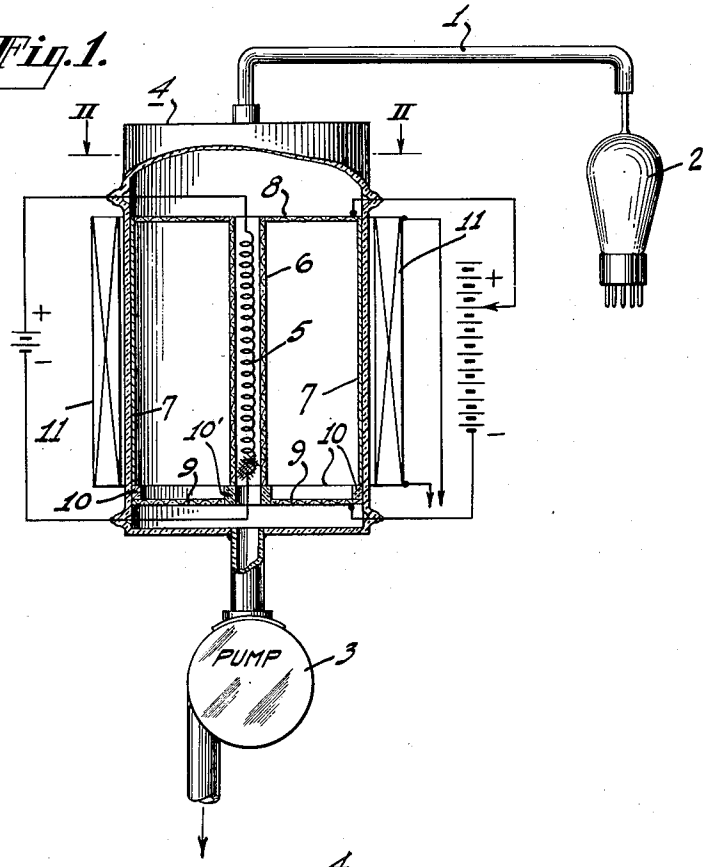
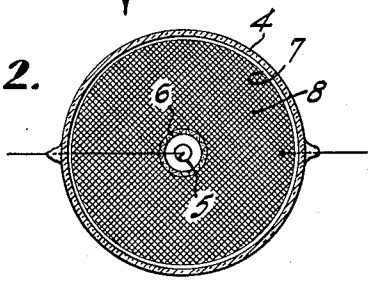


Fig. 2.



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ELECTRONIC HIGH VACUUM APPARATUS

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3 Claims. (Cl. 230—1)

1

My present invention relates to high-vacuum apparatus of the electronic type and has special reference to the provision of improvements in pumping systems for producing and gauging high vacua in bulbs and other evacuable chambers or compartments.

It has previously been proposed to provide vacuum pumping systems wherein electrical forces are employed to supplement the force of the pumping mechanism for the purpose: (*a*) of effecting the evacuation process or (*b*) producing pressure or (*c*) gauging sub-atmospheric pressures. As to this see, by way of example, Hansell 2,022,465, Hansell 2,063,250, Gaede 2,081,429 and Malter 2,131,897. All such systems depend for their operation upon ionization phenomena which involves, chiefly, a flow of gas ions and molecules in the direction of the exhaust and a flow of electrons (which are responsible for maintaining the glow discharge) in a different direction.

As taught by Gaede the efficiency of electronic pumping and gauging systems is greatly increased by the use of a magnetic field applied at an angle with respect to the conventional (cathode-anode) line of movement of the electrons. When subjected to such a field the electrons are caused to traverse curved (instead of "straight") paths in the gas. This increases the probability of the electrons striking and ionizing the discrete molecules of which the gas is composed and, therefore, greatly enhances the sensitivity of the system.

I have now discovered that the sensitivity and efficiency of electronic apparatus of the general character above described may be further increased by the provision in the system of what I designate as an "ion trap," i. e. an arrangement in which positive ions are trapped and allowed to accumulate so that diffusion or mechanical pumps may the more effectively operate to remove them.

My invention may be said further to reside in the features of construction and operation which are hereinafter described in connection with the accompanying drawing, wherein: Fig. 1 is a partly schematic sectional view of an electronic pumping system including an "ion trap" and constructed and operated in accordance with the principle of my invention, and Fig. 2 is a top sectional view taken on the line II—II of Fig. 1.,

In the embodiment of my invention which I have selected for illustration 1 designates, generally, an exhaust line which is connected at one end to the bulb 2 or other device to be evacuated and, at the other end to a pump 3 of any convenient type capable of removing most of the gas from the device 2. An enlarged section or glass chamber 4 in the exhaust line intermediate the evacuable device 2 and the pump 3 supports and contains the ionization system or "trap" which I have devised for facilitating the removal of the gas molecules which remain in the device 2 after it has been "rough pumped". This chamber 4 contains a source of electrons which, in the instant case, comprises a pure tungsten coil or wire 5 (but which may take the form of a non-thermionic emitter) and, about the emitter as an axis, a grid 6 and anode 7 are arranged in cylindrical symmetry. The anode 7 is a non-perforate cylinder of a diameter approximately that of the inner diameter of the glass chamber 4 and may in fact comprise an adherent metallic coat or film applied to the inner surface thereof. The ends of the concentric grid and anode cylinders 6 and 7 which lie adjacent to the inlet or "top" of the chamber 4 are connected by an annular metal screen 8 and hence are adapted to be maintained at the same potential, though they may be separated, electrically, if desired. The other ends of the grid and anode cylinders 6 and 7 are closed by a similar metal screen 9, but this lower screen 9 is separated electrically from the grid 6 and anode 7, and hence from the upper screen 8, as by two annular inserts 10, 10' of insulating material so that a difference in potential may be established between the upper and lower screen ends of the trap. The only other element of the trap is a magnet coil 11, which is disposed on the exterior of the glass chamber 4 and supplies magnetic flux for influencing the trajectories of the electrons within the trap. It is apparent that the direction of the lines of force of the magnetic field from the coil 11 is substantially parallel to the axis of the cathode 5.

In operating the system of my invention the anode 7 and hence the top screen 8 and the grid 6 which are connected thereto are maintained at a potential of several hundred volts positive with respect to the electron source or cathode 5. Hence electrons from the source 5 will shoot through the mesh 5 of the grid 6 into the trap where they produce positive ions by impact with the gas molecules. As previously indicated and as taught by Gaede, Gerdien (U. S. P. 1,004,012), Malter and others the effect of the crossed electric and magnetic field upon the electrons is to cause them to travel in spiral or other non-straight paths in the grid-anode space and thereby augment the probability of their striking and ionizing the discrete molecules of which the rare-

fied gas is composed. The insulated annular screen 9 comprising the bottom surface of the trap is maintained at a potential of several hundred volts negative with respect to the upper screen 8.

The positive ions produced within the grid-anode space are unable to pass upwardly (cf. Malter 2,131,897) through the top screen 8 or radially through the sides, since the said screen, grid and anode are positively charged. The ions are thus confined within the trap until they are drawn downwardly and through the negatively charged screen 9. Thus there is a constant flow of gas through the trap. In passing through the negatively charged lower screen 9 the ions give up their positive charge, thus preventing the accumulation of an electrical charge in any part of the pumping system. If necessary or expedient more than one such negatively charged lower screen may be employed for the said purpose. Or, for the same purpose, the base of the pump may comprise a grounded metal plate.

The grid through which the electrons from the source 5 are drawn into the trap is shown as comprising a tubular wire screen 6. This form of grid prevents the positively charged ions from bombarding the cathode and possibly destroying it. It also augments the trapping action of the cage. However, when the cathode comprises a very fine wire the grid 6 may be omitted, if desired, since the cathode would then comprise only a very small target for the ions.

It will now be apparent that I have provided an improved pumping system wherein the force of the pumping mechanism is supplemented by electrical forces, and one wherein a novel "ion trap" operates to increase the efficiency of the system by providing a constant flow of rarefied gas.

I claim as my invention:

1. In vacuum apparatus, a metal cage defining a space through which a rarefied gas may pass, a source of electrons exterior of said cage, means for projecting electrons from said source into said cage, a source of magnetic energy adjacent to said cage for directing said electrons in non-linear paths among the molecules of which said rarefied gas is composed whereby to cause said electrons to impinge upon said molecules and to ionize the same, and means for subjecting said ionized gas molecules to an electric field of an intensity and direction calculated to project them out of said cage in a predetermined direction.

2. The invention as set forth in claim 1 and wherein said cage comprises a perforate cylinder presented to the interior of a coaxial outer cylinder and wherein said source of electrons is contained within said perforate inner cylinder.

3. In the gas-exhaust line of a vacuum pumping system, a cathode, a perforate grid and an anode arranged concentrically with each other and with said line, means including said electrodes for generating positively charged ions in gas flowing through said line in the vicinity of said electrodes, and a plurality of perforate electrically-conductive members mounted adjacent to opposite ends of said concentrically arranged electrodes and extending across the path of said gas for accelerating the passage of said positively charged ions through said exhaust line and for neutralizing the positive charges thereon.

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