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ELECTRONIC PUMP

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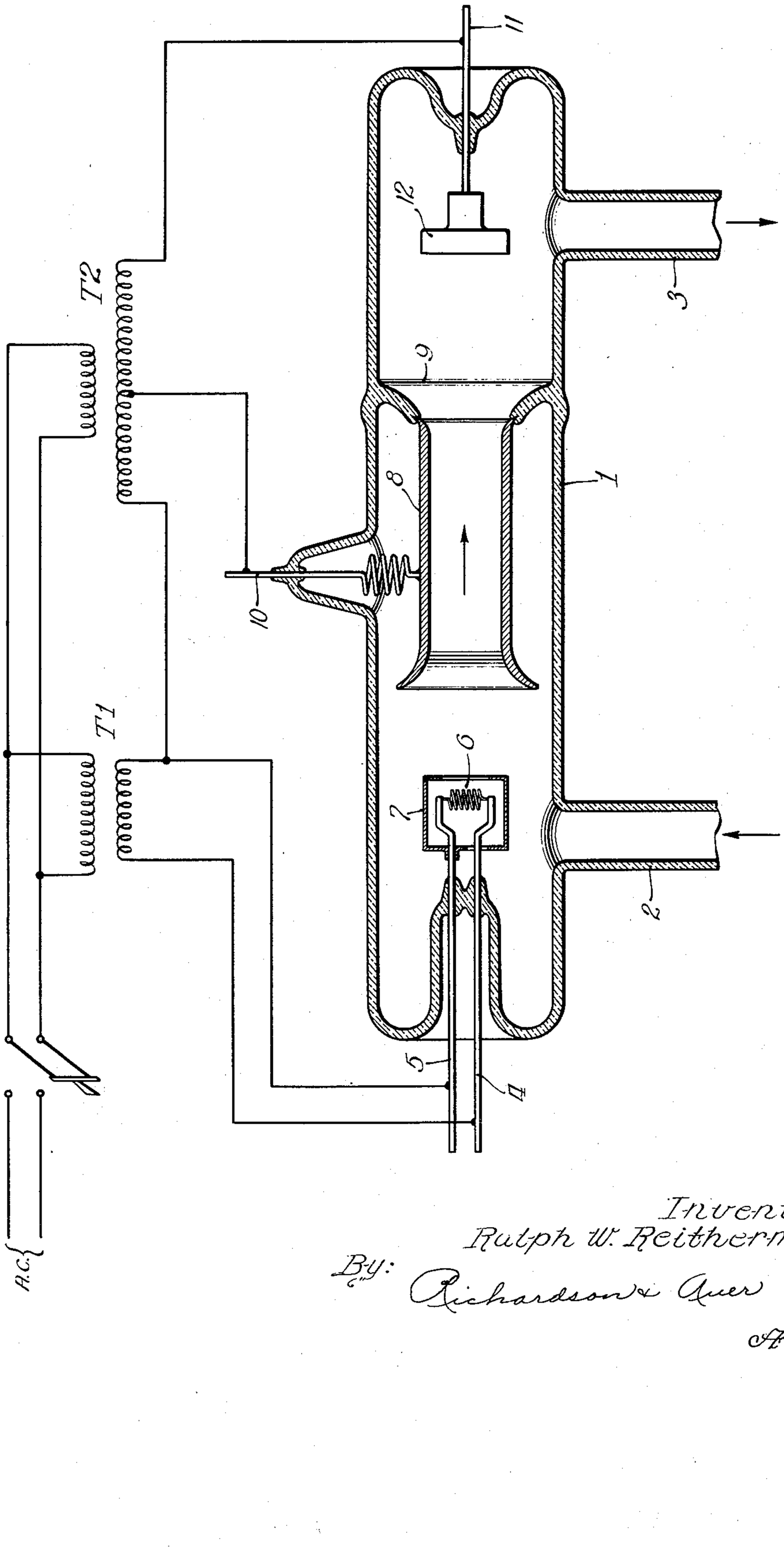

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ELECTRONIC PUMP

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1 Claim. (Cl. 230—69)

My invention relates in general to vacuum pumps; and the object of the invention is to produce a new and improved pump, operating on a principle which, insofar as I am aware, is also new, by means of which lower pressures can be obtained than with any pumps which have heretofore been available. In accomplishing this object, I employ an electronic stream, and the new pump therefore may be referred to as an electronic pump.

The invention and the operation thereof will be described hereinafter with reference to the accompanying drawing, which is in diagrammatic form, showing the new electronic pump in cross section and the necessary circuit connections.

Referring to the drawing, the reference character 1 indicates a container, which may be made of glass substantially in the form shown. The container is sealed except for the inlet 2 and the outlet 3, which are also of glass and are joined to the container at the points shown in the drawing.

At the left-hand end, the two conductors 4 and 5 are sealed into the container in known manner, and support the cathode 6, which is suspended between them. Surrounding the cathode is a cylindrical metallic shield 7. This shield may be secured to the conductor 5, as shown, and is provided with a small opening through which the conductor 4 passes. There is also a somewhat larger opening in front of the cathode to permit egress of the electronic emission.

About the center of the container there is located an accelerating anode 8, which may be a cylinder of copper flared at one end, as shown. At the other end the cylinder is shaved down thin and is sealed around a central opening in the partition 9. This is a type of metal-to-glass seal in common use and known as a housekeeper seal. Adjacent the cylinder or accelerating anode there is a lead-in conductor 10, which is sealed in the side of the container and secured to the accelerating anode, as shown.

Near the right-hand end of the container there is provided an anode 12, which is supported on the lead-in conductor 11. The anode 12 is preferably of carbon.

The circuit arrangements include a transformer T1 for supplying a low voltage current to heat the cathode 6, and a transformer T2 for supplying potentials to the anodes 8 and 12. The transformer T2 is a step-up transformer and may be wound for a primary voltage of 110 volts and a secondary voltage of about 15,000 volts. The secondary winding of the transformer T2 is connected between the cathode 6 and the anode 12, by means of the lead-in conductors 5 and 11. There is also a center tap which is connected to the accelerating anode 8 by means of the lead-in conductor 10. The maximum cathode-anode voltage therefore will be about 15,000 volts, and the maximum voltage between the cathode and the accelerating anode will be about 7,500 volts. Higher voltages may be used, however. A switch S may be provided for connecting the primary windings of both transformers to a commercial 110-volt A. C. power source.

The electronic pump is set up for use by connecting the inlet 2 in suitable manner to the vessel to be evacuated. The connecting tube may have a side tube fitted to it and leading to an ionization gauge (not shown). The outlet 3 is connected to the inlet of a known type of pump, such as a mercury vapor pump, which is adapted to produce a very low pressure; and ahead of the mercury vapor pump may be inserted a fore pump, such as an oil pump, which is adapted to exhaust into the atmosphere. Mercury vapor pumps and oil pumps of many varieties are well known and hence are not shown herein. For a description of such pumps reference may be made to the book entitled "Vacuum Practice" by Dunoyer, and published by D. Van Nostrand Company, New York.

The fore pump and the mercury vapor pump, the latter functioning as a second fore pump, are first started up and gas is exhausted from the electronic pump and from the vessel to be evacuated. The flow of gas is from the vessel, through the inlet 2, into the low pressure side of the electronic pump, through the accelerating anode 8 into the high pressure side, and thence out through the outlet 3 to the mercury vapor pump. This operation is continued until a low pressure is reached, on the order of 10^{-7} mm. Hg, which is about the limit that can be reached by the mercury vapor pump.

At this point the electronic pump is started up by closing the switch S, which extends the 110-volt supply circuit through to the primary windings of transformers T1 and T2. The first of these transformers supplies a low voltage A. C. current to heat the cathode 6, which is thus placed in emitting condition. The second transformer T2 supplies high voltage alternating potentials to the two anodes 8 and 12. At every half cycle, therefore, the anodes go positive with respect to the cathode, and emission takes place from the cathode in large volume. Thus an intermittent stream of electrons is produced, passing from the cathode 6 toward the accelerating anode 8. The

latter intercepts a part of the stream, but the main portion of the stream passes along straight lines through the accelerating anode 8 to the anode 12. There is, therefore, during each half cycle, when the anodes are positive, a stream of electrons moving at high velocity from the cathode to the anode 12 and filling the space inside the accelerating anode 8. The effect of this intermittent stream of electrons is to produce a difference in gas pressure between the two ends of the pump; that is, gas is transferred from the low pressure inlet side to the high pressure side to the right of the partition 9, whence it is removed by the mercury vapor pump through the outlet 3.

Due to lack of knowledge of conditions in the space around the anode 12, and the difficulty of investigating them, the precise manner in which the electronic pump operates is but imperfectly understood, but the operation is thought to be mainly mechanical in nature, although electrical phenomena are believed to play some part.

If we consider the pump at the instant a spurt of electronic emission starts, or at the beginning of a positive half cycle, it will be clear that the gas molecules in the space between the cathode 6 and the end of the accelerating anode, also those further on in the path of the stream, will be subject to collision by electrons moving at high velocity in the direction of the anodes 8 and 12. The electrons have a relatively small mass, but in view of their high velocity they have considerable energy. When a collision takes place, therefore, movement is imparted to the gas molecule. This movement may be at an angle to the direction of movement of the electron, but in many cases it will be substantially in the same direction; and in view of the large number of collisions taking place, a considerable number of gas molecules will be driven through the anode 8 into the high pressure side of the pump, whence they are extracted through the outlet 3, as previously stated.

As regards the electrical phenomena that take place, it is known, of course, that with the very low pressures attained, positive ions are produced by the collisions, and it appears probable, therefore, that the major portion of the gas which passes through the anode 8 under impact of the electronic stream is ionized. The positive charge on the anode 8 merely tends to concentrate the flow, but the charge on the anode 12 opposes it with increasing force as the ions approach the anode. However, when the anode 12 becomes negative, the positive ions are attracted and flow toward the anode 12 is resumed or accelerated, as the case may be, depending on the condition of the individual ions at the moment of the reversal of potential.

It is thought, therefore, that a nearly continuous movement of gas takes place through the anode 8. During each positive half cycle the space is filled with a high velocity stream of electrons, a large number of collisions take place, and many positive ions are produced which are given a substantial, although diminishing, velocity in the general direction of the anode 12. The operation as regards movement of the gas during the positive half cycle is therefore mechanical. During each negative half cycle the electronic emission ceases, and the mechanical effect likewise, but the positive ions produced on the preceding half cycle are instantly placed under the influence of the negative potential on the anode 12, which also tends to produce a movement in the direction of the anode. There is therefore an electrical effect during each negative half cycle which tends to produce the same direction of gas movement as the mechanical effect. Such positive ions as actually reach the anode during each negative half cycle are of course discharged or neutralized.

The foregoing explanation is necessarily somewhat incomplete; but it is the most reasonable hypothesis it is possible to formulate at the present time, and should suffice to give a general idea at least of the working principles of the device.

Whatever happens in the pump to bring about the desired result, it is certain that gas is transferred as described, from the low pressure side to the high pressure side, and extremely low pressures can be reached. How low, it is impossible to say, for no means of measuring it is available. The ionization gauge, which can measure pressures considerably lower than can be attained by the mercury vapor pump, gives no indication at all after the electronic pump has been in operation for about fifteen minutes, exhausting air from a vessel of 200 cc. capacity.

It will be appreciated, therefore, that a very desirable form of vacuum pump has been devised, capable of producing a very high degree of evacuation. The invention is obviously of great utility, as it not only lends itself to the production of more efficient devices of known character which depend for their operation on a high vacuum, but also opens up new fields of investigation by affording to the scientist a means of attaining a much higher vacuum than it has been possible to produce before.

While a certain specific form of the invention has been shown and described, it will be understood that modifications may be made, and I do not therefore wish to be restricted to the exact disclosure; but desire to include and have protected by Letters Patent all forms and modifications of my invention which come within the scope of the appended claim.

I claim:

An electronic pump comprising a tubular structure having an inlet near one end and an outlet near the other end, a cathode at the inlet end, an anode at the outlet end, a tubular accelerating anode between and in alignment with said cathode and anode, a partition joining the outside wall of said accelerating anode to the inner wall of said tubular structure, means for heating said cathode, and means for supplying potentials to said anodes comprising a transformer with a tapped secondary winding, the opposite ends of said winding being connected to said cathode and anode, respectively, and the tap being connected to said accelerating anode.

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