PUBLISHED

MAY 25, 1943.

BY A. P. C.

B. VON BORRIES ET AL

ELECTROSTATIC LENSES FOR CORPUSCULAR RAY APPARATUS

Filed Sept. 11, 1940

Serial No. 356,260

Fig. 1

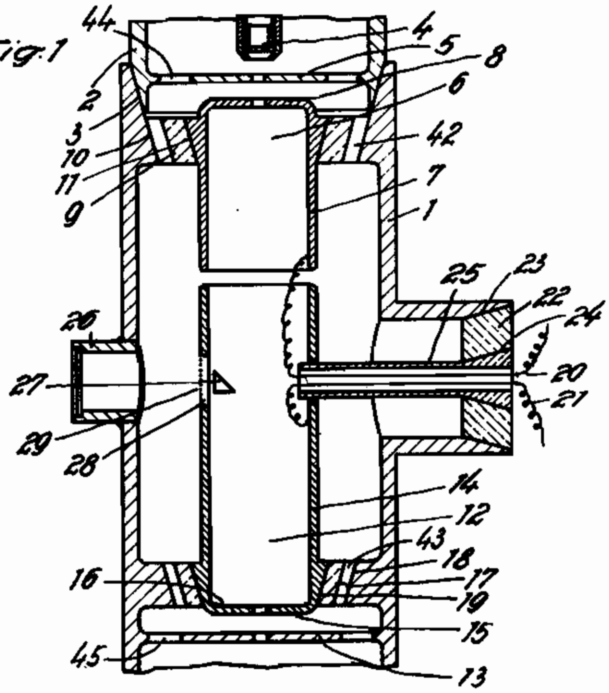
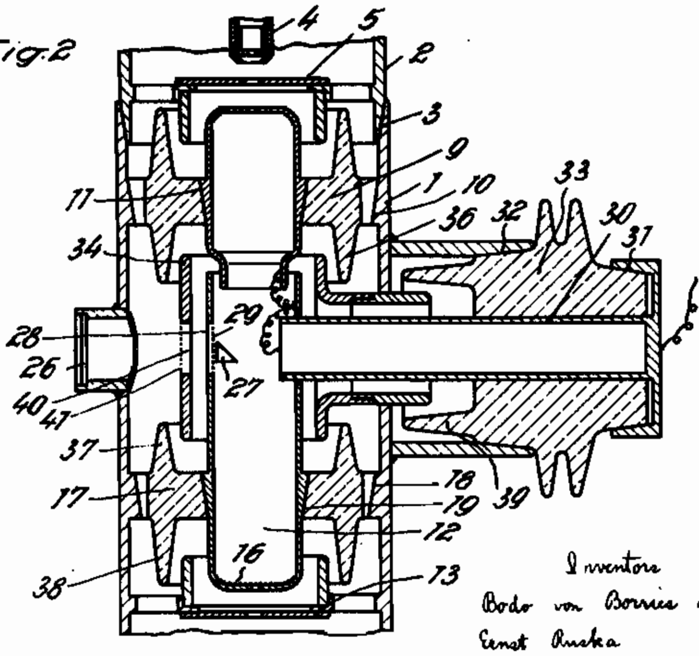


Fig. 2



Inventors
Bodo von Borries and
Ernst Ruska
by Knight Bros.
Attorneys

Published May 25, 1943 Serial No. 356,260

ALIEN PROPERTY CUSTODIAN

ELECTROSTATIC LENSES FOR CORPUSCULAR RAY APPARATUS

Bodo von Borries and Ernst Ruska, Berlin-Spandau, Germany; vested in the Alien Property Custodian

Application filed September 11, 1940

This invention relates to electrostatic lenses for corpuscular ray apparatus, particularly for electronic microscopes.

It is known in the art to employ in corpuscular ray apparatus, for instance, in electronic microscopes electrostatic or magnetic lenses for influencing the rays emitting from the ray producing source. The invention relates to electrostatic lenses for the above purpose. These lenses consist, as a rule, of two electrodes between which a potential difference is maintained to produce the desired effect. To obtain a symmetrical form of the electric fields, which is the first prerequisite of a faultless lens, it is necessary to center the two lens electrodes very accurately with respect to each other. According to the invention the two electrodes of such an electrostatic lens provided with conical contact surfaces are arranged in an insulator. In this manner a properly centered mechanically fixed electrostatic lens is obtained. The arrangement may be so designed that the lenses withstand a high voltage and that electrodes of any shape may be alternately replaced. By the use of conical contact surfaces for securing both electrodes to the insulator the electrodes may be brought again into alignment at all times when replacing the same. The arrangement is, for instance, so designed that the one electrode is integral with the outer wall of the apparatus and is impressed with earth potential and that high voltage is supplied to the other electrode by a particular bushing. Also this bushing is then so designed that an insulator which is secured to the bushings through conical contact surfaces as well as to the outer wall is arranged between the current carrying parts of the bushing and the grounded outer wall of the apparatus.

The conical contact surfaces of the lens insulator are arranged according to the invention preferably concentrically to the center line of the ray. A very simple lens construction is obtained by providing the outer grounded tubular part of the apparatus carrying the lens with an inner cone in which fits a corresponding outer cone of the insulator. In this case this insulator is provided with a conical bore in which fits a corresponding outer cone of the lens electrode impressed with a high voltage. The electrodes themselves may, for instance, consist of a tubular part provided with a central opening and lying symmetrically to the center line of the ray as well as of a part also provided with a central opening and lying perpendicularly to the center line of the ray. If such lenses which are operated at very high voltages are employed, the insulators are preferably given according to the invention such a form that the insulators project into the space free of electrostatic fields formed between the outer wall of the apparatus and the electrode impressed with the same potential. In this manner such a form of the electric acceleration field is attained that no electric lines of force pass from one electrode to the other which run tangentially to the surface of the insulator without passing through the latter. Discharges which otherwise occur at high voltages are thus avoided.

The invention may particularly be employed for the objective lens and projection lens of an electronic microscope. In this case the arrangement may be simplified considerably by employing for the two lenses one and the same high-voltage bushing. The parts of both lenses impressed with a high voltage may then be so designed as to face each other. In order to assemble the electronic microscope in a simple manner and to replace the individual lens parts as quickly as possible the individual electrodes and the insulator are preferably so dimensioned that the entire lens system may be placed in the vacuum tube from one side, for instance, from the side of the ray producing source. In this case, this vacuum tube itself is made of two pieces which are assembled, for instance, at the point where the objective lens is arranged, the conical surfaces of the two parts being in engagement with each other.

Further details of the invention will be apparent from the following description taken in connection with the accompanying drawings.

Fig. 1 shows a cross-sectional view of a part of an electronic microscope provided with two electric lenses serving to magnify the object. 1 denotes the middle portion of the outer vacuum wall of the electronic microscope. The cathode (not shown) and the object sluice (not shown) are firmly secured to the part 2. The stream of electrons coming from above strikes the object cartridge 4 which serves as a carrier for the object to be magnified. The objective lens consists of the two electrodes 5 and 6. The electrode 5 is impressed with earth potential and is integral with the vacuum wall 2. The electrode 6 has a tubular part 7 lying concentrically with respect to the center line of the ray as well as a part 8 lying perpendicularly to the center line of the ray. To support the electrode 6 against the vacuum wall 1 an insulator 9 is employed. 10 and 11 denote the conical surfaces of the vacuum wall 1 and the insulator 9, of the insulator 9 and electrode 7 respectively.

The projection lens consists of the electrode 12 impressed with a high voltage and of the electrode 13 connected to earth. The electrode 13 is integral with the vacuum wall 1. The electrode 12 is also provided with a tubular part 14 lying concentrically to the center line of the ray and with a part 15 lying perpendicularly to the center line of the ray. This part is designed on the inner side in the form of a luminous screen 16 on which appears the intermediate image. To support the electrode 12 against the vacuum wall 1 an insulator 17 is employed having corresponding conical contact surfaces 18 and 19. The insulators 9 and 17 are provided at their outer periphery with recesses 42 and 43 respectively opposite to which are arranged openings 44 and 45 respectively provided in the parts 5 and 13. In this manner a flow of the air to be exhausted is made possible.

The high voltage is supplied to the electrodes 6 and 12 by a bushing. In the embodiment shown it is assumed that the electrodes 6 and 12 are impressed with different voltages. The current is supplied to the electrode 6 and electrode 12 by the conductors 20 and 21 respectively. In this embodiment it is possible to control both lenses independently of one another. In this case, the voltage which the electrodes 6 and 12 must have with respect to each other is small as compared to the voltages which the electrodes 6 and 12 have with respect to the tube 1. 22 denotes an insulating piece whose conical contact surfaces 23 and 24 are in engagement with the outer wall 1 and the insert 25 of the bushing.

An inspection window 26 arranged in the vacuum wall 1 as well as a prism 27 arranged inside the electrode 12 serve to observe the intermediate image. In order that the image of the field is not impaired a wire net 29 is arranged in front of the opening 28 provided in the part 14 of the electrode 12.

The assembly of the arrangement is effected in the following manner: The insulator 17 is first placed in the vacuum wall 1, and the electrode 12, the parts 22 and 25, the insulator 9 and the electrode 6 are then positioned in the microscope. The upper part 2 of the electronic microscope is hereafter placed on the upper end of the vacuum tube 1. In order to enable the assembly of the above parts, the outer and inner dimensions of the insulators 17 and 9 and of the electrodes 12 and 6 are correspondingly dimensioned.

While the arrangement shown in Fig. 1 lends itself above all to such microscopes whose lens voltages are not too high, it is advisable to employ for very high voltages other forms of insulators. An embodiment for electronic microscopes of this character is shown in Fig. 2, in which the same characters denote corresponding parts of Fig. 1. In Fig. 2, 33 denotes an insulator which serves to insulate the high-voltage bushing 30 against the grounded outer jacket 1 of the apparatus. The conical contact surfaces 31 and 32 serve to support the insulator and the bushing 30. In this embodiment it is assumed that the two electrodes 6 and 12 of both lenses are impressed with the same voltage. To attain a uniform distribution of the electric field a body 34 impressed with earth potential is arranged within the apparatus. The insulators 9 and 17 are provided with corresponding annular extensions 35, 36, 37, 38 which are given such a shape that the insulator extends in the space free of electrostatic fields formed between the grounded outer wall of the apparatus and the electrode impressed with the same voltage. In this manner discharges are prevented from occurring. Also the insulator 33 for the high-voltage bushing is provided with a corresponding annular extension 39. In the body 34 is arranged an inspection opening 26 provided with a wire net 41. Also in this embodiment the dimensions of the insulating parts (insulators, electrons and other inserts) are so chosen that the parts may be mounted in the apparatus one after the other before placing the upper part 2 of the microscope on the vacuum tube 1.

The electrodes 5 and 13 impressed with earth potential are slidably arranged in the embodiment shown in Fig. 2. Consequently, they may be subsequently centered in an accurate manner. The devices (not shown) for adjusting these electrodes may be so designed that the adjustment can also be effected during the operation. This is advisable particularly in the case of the electrode 5 facing the object to be magnified.

BODO VON BORRIES.
ERNST RUSKA.