United States Patent [19]

Herrmann et al.

[11] **3,916,201**

[45] **Oct. 28, 1975**

[54] **ELECTRON MICROSCOPE HAVING A PLURALITY OF COAXIAL CRYOGENICALLY COOLED LENSES**

[75] Inventors: **Karl-Heinz Herrmann**, Berlin; **Reinhard Weyl**, Assling; **Helmut Zerbst; Isolde Dietrich,** both of Munich, all of Germany

[73] Assignee: **Siemens Aktiengesellschaft,** Berlin & Munich, Germany

[22] Filed: **Feb. 7, 1974**

[21] Appl. No.: **440,332**

[30] **Foreign Application Priority Data**

Feb. 16, 1973 Germany............................ 2307822

[52] **U.S. Cl.**.................................. **250/396;** 250/311

[51] **Int. Cl.²**... **G21K 1/08**

[58] **Field of Search**........... 250/310, 311, 396, 397, 250/398, 399

[56] **References Cited**

UNITED STATES PATENTS

3,008,044	11/1961	Buchhold	250/396
3,351,754	11/1967	Dietrich et al.	250/396
3,587,013	6/1971	Dietrich et al.	250/396

Primary Examiner—Davis L. Willis
Attorney, Agent, or Firm—Hill, Gross, Simpson, Van Santen, Steadman, Chiara & Simpson

[57] **ABSTRACT**

The present invention relates to a lens system for particle radiation devices, particularly electron microscopes, which includes means for adjusting the particle beam, a plurality of superconducting cryogenically cooled magnetic lenses, a cryostat in which the lenses are received and a central supporting tube in the cryostat on which the lenses are mounted. An electron microscope produced according to the present invention is substantially free from thermal drift phenomena, is substantially insensitive to mechanical vibrations, can be readily protected against the influence of external magnetic fields, and can be assembled and disassembled conveniently for cleaning or exchanging parts.

24 Claims, 6 Drawing Figures

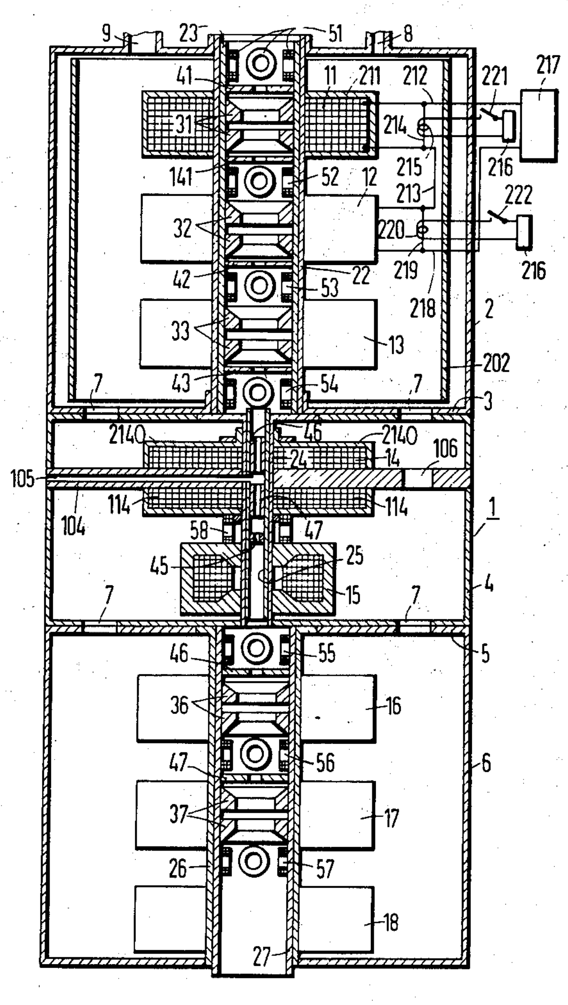


Fig. 1

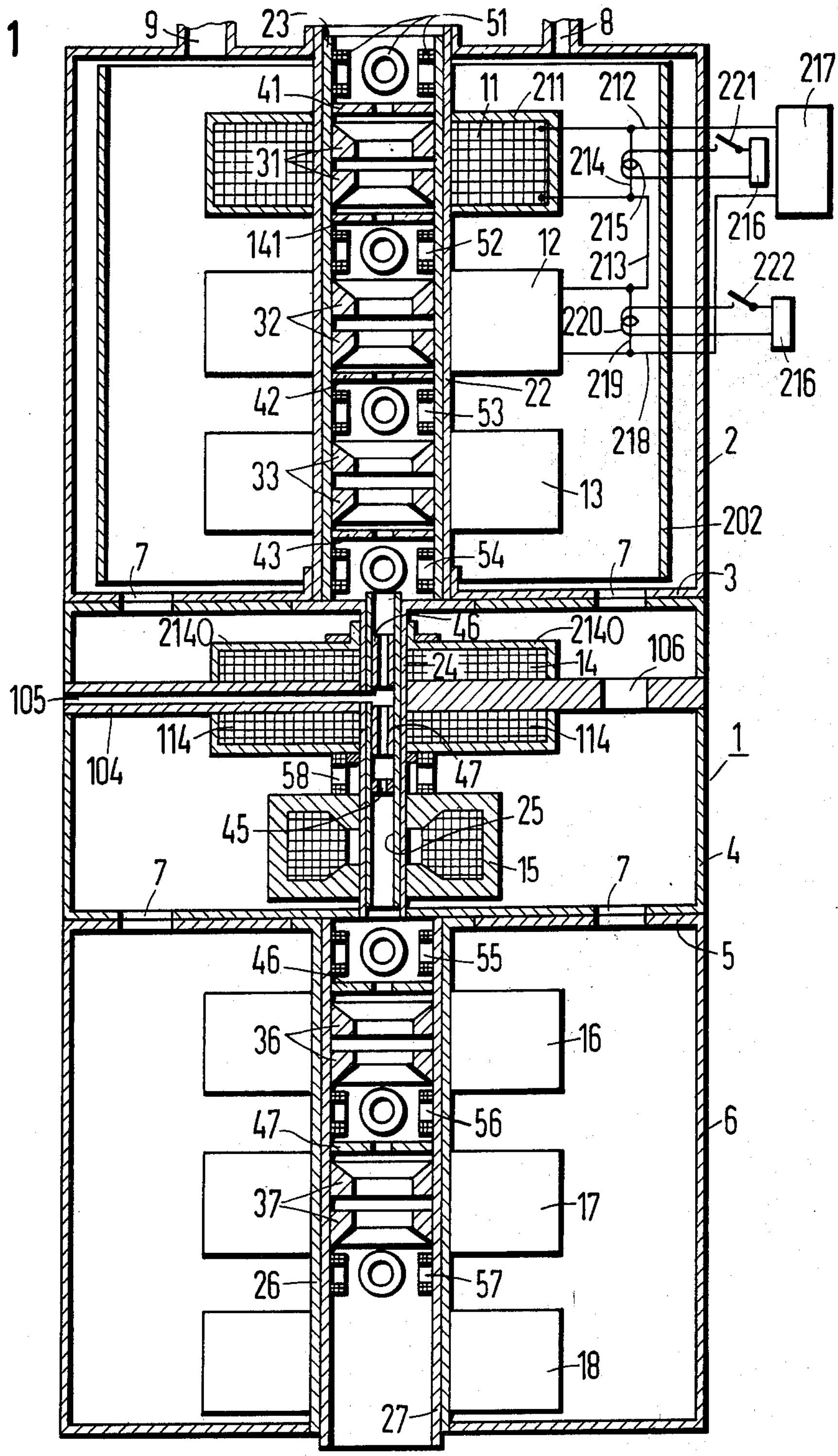

9
23
51
8
41
11
211
212
221
217
31
214
216
215
141
52
12
213
222
32
220
216
219
42
22
53
218
2
33
13
202
43
54
7
7
3
2140
46
2140
24
14
106
105
104
114
114
1
58
47
45
25
15
4
7
7
46
55
5
36
16
47
56
6
37
17
26
57
18
27

Fig. 2

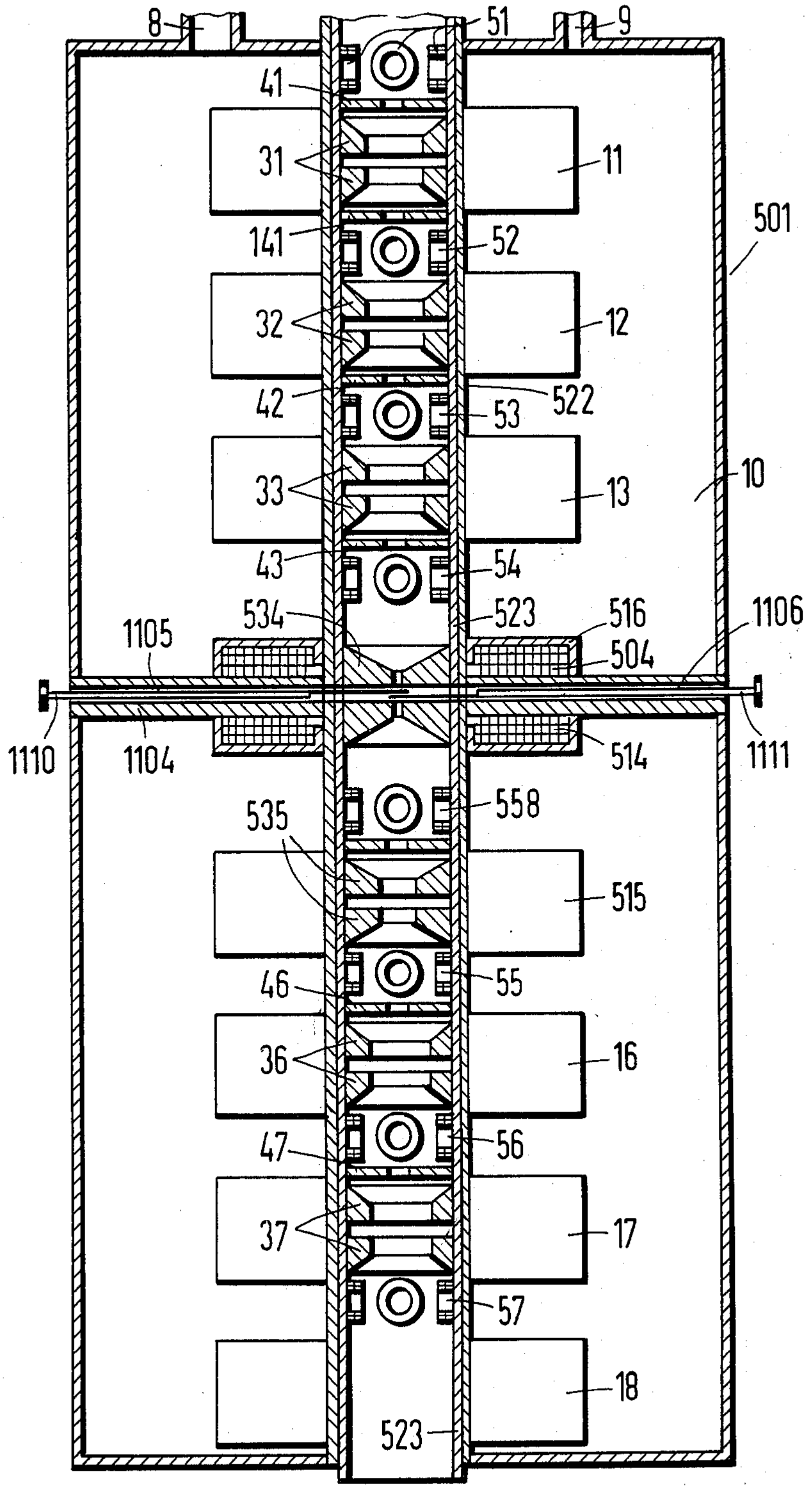

8
51
9
41
31
11
501
141
52
32
12
42
522
53
33
13
10
43
54
534
523
516
1106
1105
504
1110
1104
514
1111
558
535
515
46
55
36
16
47
56
37
17
57
18
523

Fig. 3

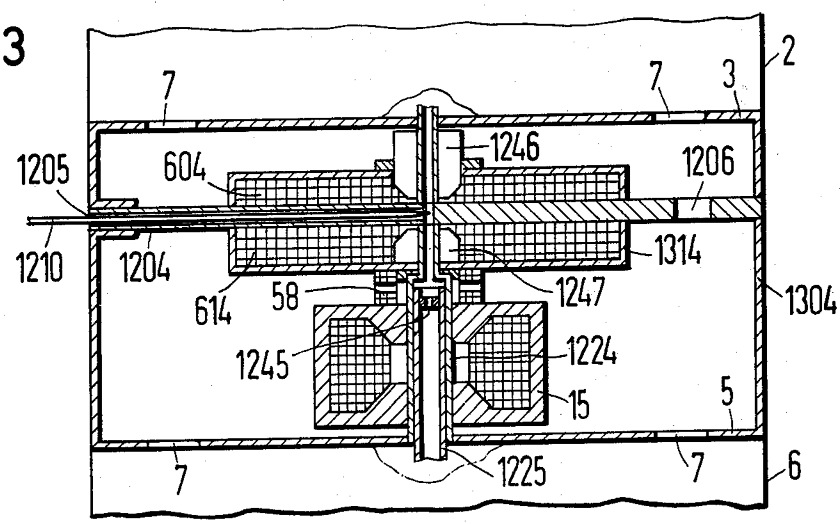

2
7
7
3
1246
1205
604
1206
1210
1204
1314
614
58
1247
1304
1245
1224
15
5
7
1225
7
6

Fig. 4

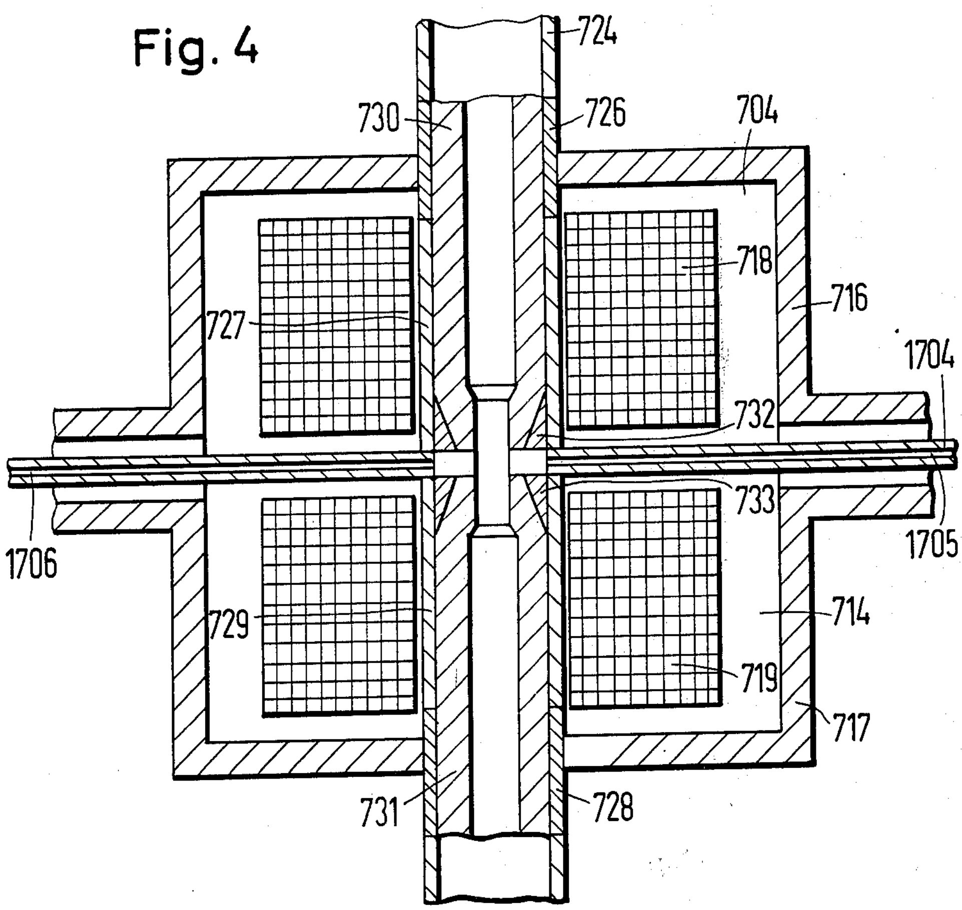

724
730
726
704
718
716
727
1704
732
733
1706
1705
729
714
719
717
731
728

Fig. 5

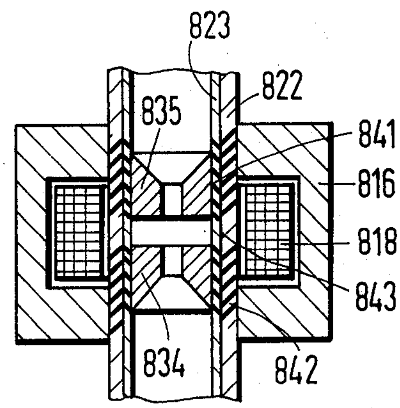
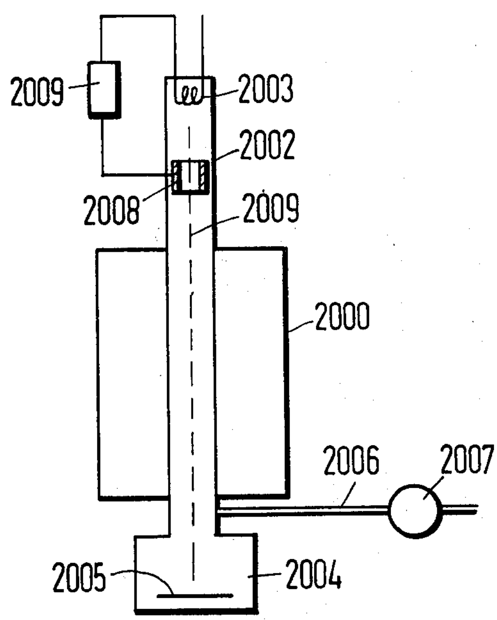

823
822
835
841
816
818
843
834
842

Fig. 6


2009
2003
2002
2008
2009
2000
2006
2007
2005
2004

ELECTRON MICROSCOPE HAVING A PLURALITY OF COAXIAL CRYOGENICALLY COOLED LENSES

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention is in the field of lens systems for particle radiation applications, particularly electron microscopes involving the use of cryogenically cooled magnetic lenses which are received in a cryostat and are supported on a central support tube located in the cryostat.

2. Description of the Prior Art

The prior art has described columns for an electron microscope with superconducting lenses, including a plurality of condenser lenses, intermediate lenses, an objective lens and a projective lens. Each individual superconducting lens is arranged in a helium cryostat which can be displaced horizontally on a platform in order to enable alignment of individual lenses in relation to the column axis and the objective lens. This prior art arrangement is not only relatively elaborate but is also sensitive to thermal drift phenomena. It is also difficult to dismantle. Dismantling of this type of column is necessary if the internal components such as the pole pieces and the diaphragms are to be cleaned or replaced.

SUMMARY OF THE INVENTION

The present invention provides a column for an electron microscope or the like using superconducting lenses, the structure being such that it is substantially free of thermal drift phenomena, is largely insensitive to mechanical vibrations, can readily be protected against the influence of external magnetic fields such as alternating current fields, and whose individual components which are located in proximity to the electron beam can be readily cleaned and/or exchanged in relatively simple fashion. The present invention also provides a structure which is substantially more compact than prior art structures.

The lens system of the present invention utilizes a plurality of superconducting magnetic lenses with means for magnetic adjustment of the particle beam. The lenses of the new system are arranged in a cryostat and are assembled on a central supporting tube located in the cryostat. In the simplest device, the system consists of the objective lens and an intermediate lens which is used for secondary magnification. In the preferred form of the invention, two or more lens systems designed in accordance with the present invention are provided which form component parts of an overall lens system, namely, the overall electron microscope. Inside the support tube, there are diaphragms and/or pairs of pole pieces and/or adjusting systems for adjusting the axis of the particle beam.

It is a relatively simple matter to clean a lens system in accordance with the present invention or to exchange parts inside the system, particularly in that form of the invention in which there is a sleeve of electrically conductive material provided inside the support tube, the sleeve being designed to be removable from the support tube but fitting relatively closely inside the tube. Components which are arranged inside the support tube are located inside the sleeve for ready removability.

BRIEF DESCRIPTION OF THE DRAWINGS

Other objects, features and advantages of the invention will be readily apparent from the following description of certain preferred embodiments thereof, taken in conjunction with the accompanying drawings, although variations and modifications may be effected without departing from the spirit and scope of the novel concepts of the disclosure, and in which:

FIG. 1 is a view partly in elevation and partly in cross-section of an electron microscope assembly according to the present invention;

FIG. 2 is a similar view of a modified form of the present invention;

FIG. 3 is a fragmentary cross-sectional view of a still further modified form;

FIG. 4 is a fragmentary cross-sectional view of a further embodiment of the invention;

FIG. 5 is a fragmentary cross-sectional view of a still further modified form; and

FIG. 6 is a schematic representation of an electron microscope with a lens system in accordance with the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. 1 illustrates a column 1 of an electron microscope employing superconducting lenses. A cryostat housing is provided in which the lens system components, to be described subsequently, are located and into which liquid helium is introduced in order to cool the components. Housing sections **2, 4** and **6** are superimposed together to form a closed cryostat housing with an opening **8** for the introducion of liquid helium and with an opening **9** for gaseous helium and for the passage of electrical leads into the interior of the cryostat housing. Reference numerals **3** and **5** have been applied to flanges through which the sections **2, 4** and **6** are held together. The flanges **3** and **5** contain bores **7** for the passage of liquid helium through the complete cryostat housing.

Reference numeral **104** has been applied to a plate which contains a bore **105** sealed in vacuum tight relationship for the introduction of the specimen. The bore **105**, as seen in FIG. **1**, is horizontally disposed. The plate **104** further contains bores which are vertically disposed, one of which has been shown at reference numeral **106**, serving for the passage of the helium through the interior of the cryostat housing.

Condenser lenses have been identified at numerals **11, 12** and **13**, and the intermediate lenses at numerals **15, 16** and **17**. The objective lens because of the presence of the plate **104** is split into two parts **14** and **114** located respectively above and below the plate **104** and together forming a lens. In the embodiment of FIG. **1**, this lens is a lens of superconductive material, also known as a shielding lens.

Inside section **2** of the cryostat housing, there is centrally located a support tube **22** on which the lenses **11**, 12 and 13 are arranged. In like manner, in section **4** of the housing, there is a support tube **24** to which the lens portions **14** and **114** and the parts of the first intermediate lens **15** are attached. Inside section **6** of the housing there is a support tube **26** upon which the lenses **16, 17** and **18** are arranged, lens **18** being a projective lens.

In accordance with the preferred embodiment of the present invention, the support tubes **22, 24** and **26** have individual sleeves **23, 25** and **27** fitted into them. These sleeves are provided without any substantial clearance between the outer diameter of the sleeve and the inner diameter of the tube, but the sleeves are nevertheless conveniently removable from the support tubes.

Inside the sleeve **23,** for each of the lenses **11, 12** and **13,** a pair of pole pieces **31, 32,** and **33,** respectively, are provided, the pole pieces being made of ferromagnetic material. Preferably, these pairs of pole pieces are arranged to be removable from the interior of the sleeves so that they can be individually cleaned. In addition to the pairs of pole pieces, there are a number of diaphragms **41, 141, 42** and **43** inside the sleeve **23** which are used to stop out the electron beam. These diaphragms, in addition, are preferably made to be removable. The attachment and centering of the diaphragms and pole pieces can be effected by means of adjuster mechanisms which are operated following removal. Pole pieces can also be arranged inside the tube, in the manner shown with respect to the lens **15.**

Inside the sleeve **27** in the support tube **26,** there are pairs of pole pieces **36** and **37** as well as diaphragms **46** and **47.** Inside the sleeve **25** which is inside the support tube **24** of the housing, there is a further diaphragm **45** and screening elements **46** and **47** composed of superconductive material. These screening elements are used to shape the magnetic focusing field of the screening lens operating as the objective lens.

Because the sleeves **23** and **27** can be quite readily removed, the sleeve **25** which is located inside the support tube **24** of the section **4** can also be readily extracted from the overall lens system. In the focusing zone of the objective lens **14, 114,** that is, in the neighborhood of the screening elements **46** and **47,** it is important to insure that the walls are free of any contaminating foreign bodies which could develop electrical charges and thus give rise to an unwanted superimposition of an electric field.

The structure of the lens systems using support tubes in accordance with the present invention, and particularly in the matter of removable sleeves, also facilitates the exchange of individual parts which for electrooptical reasons are subjected to modification or wear, for example, the consequence of electron impact.

Non-mechanical adjusting systems can be provided in the column to correct errors which may arise. In FIG. **1,** reference numerals **51, 52, 53, 54, 55, 56** and **57** are applied to adjusting systems of this kind arranged between the individual lenses and constituting deflection systems by means of which the electron beam can be deflected laterally in any direction, and/or stigmators by means of which deviations on the part of the lens fields from rotational symmetry can be corrected.

The adjusting systems **51, 52, 53** and **54** are located inside the support tube **22** and inside the slide-in sleeve **23.** Each individual adjusting system can consist, for example, of four individual coils arranged in one plane at right angles. Using the four coils, three of which are shown in the figure, a magnetic deflecting field can be generated by means of which an electron beam which is deviating from the axis can be deflected back to the system axis.

The deflection systems referred to previously can, as mentioned, be arranged inside the support tube or the sleeve or outside the support tube. The latter arrangement has been illustrated with respect to the adjusting system **58** in the direct vicinity of the objective lens. Adjusting systems can readily be positioned outside the support tube if the tube has a relatively small diameter. A small internal diameter is convenient particularly for the support tube **24** of the lens system, consisting of the objective lens **14, 114,** and the first secondary magnification lens **15,** because the geometric dimensions of the objective lens in the neighborhood of the specimen are involved in the imaging properties. Because of the small internal diameter of the tube **24,** the pairs of pole pieces of the intermediate lens **15** are also outside the tube.

Using the structure of the present invention, a column with a large number of condenser lenses and a large number of additional secondary magnification lenses can be produced. Because of the low installed height and the large refractive power of superconducting lenses, the installed length of the column in accordance with the invention can be kept very short, that is, a very precise, stable and vibration resistant structure is provided.

Using the principals of the present invention, it is possible to build a column for a beam voltage of **3** megavolts, which has at least two condenser lenses and three intermediate lenses, giving a magnification of about **1,000,000** times, the length of the column being less than **1** meter. Comparable known systems with non-superconducting lenses, on the other hand, have lengths up to **5** meters.

To shield the individual lens systems and therefore the overall lens system against external magnetic fields, in particular, alternating current fields, it is advisable to provide superconducting shielding cylinders inside the cryostat housing. A shielding cylinder **202** of this kind has been shown in FIG. **1** located in housing section **2.** Corresponding shielding cylinders can also be arranged in the other housing sections. They are located in the liquid helium and are therefore superconducting.

In connection with lenses **11** and **12,** there has been shown an arrangement for introducing the electric current flowing through the magnetic winding of the lens. The other lenses can be electrically connected in a similar fashion. A single current supply unit can be employed to energize different lenses or correcting systems, successively. Leads **212** and **218** can be taken out of the interior of the cryostat through an opening such as the opening **9.** Also inside the cryostat is a superconducting short-circuiting line **214** or **219** which produces short circuits, respectively, between the lines **212** and **213** or **213** and **218,** respectively. However, this short circuit is absent as long as the flow of current through the winding **215** surrounding the line **214** or the winding **220** surrounding the line **219** produces sufficient heat for the line **214** or **219** to retain a normally conducting condition. A controllable generator **216** is provided for generating current and by operation of switches **221** and **222,** the current flow is either through the winding **215** or through the winding **220.** While the short circuit **214** is inoperative as a consequence of the heat developed in the winding **215** with normal conduction occurring, the generator **217** feeds current into the winding of the lens **11** independently of the load. The coil of lens **12** is not energized because the current flow is through the short circuit line **219.** As soon as the current in the lens **11** has built up, the current in the winding **215** is interrupted and the short circuit **214** becomes operative so that a permanent superconduction current flows in the winding of the lens 11. Subsequently, in the same fashion, the current can be introduced into the coil 12.

A support tube used in accordance with the present invention can be made up in sections of different material. The material of the support tube may be superconducting, ferromagnetic or neither superconducting nor ferromagnetic in a given section. If a sleeve is provided inside a support tube, the same applies to the sleeve. Which material is used at which point in the support tube and in the sleeve depends upon whether, at the particular location, ferromagnetic directing of magnetic lines of force or screening of a magnetic field using the phenomenon of superconduction is required, is acceptable or has to be avoided. For example, in the case of pole pieces which are arranged inside the support tube or the sleeve, it is necessary that between the pole pieces and the magnetic surround of the lens, for example, between **31** and **211**, the magnetic lines of force should close. Consequently, the portions of the support tube **22** and the sleeve **23** in proximity to the ferromagnetic surround **211** on the lens **11** are ferromagnetic in nature so that the lines of force passing through **211** can cross to the pole piece **31** without substantial difficulty. On the other hand, the support tube and sleeve at the location of the gap between the pole pieces of the pair **31** should be non-ferromagnetic because otherwise there would be more or less a short circuit in respect to the particular magnetic field designed to develop between the pole pieces of the pair **31** in the neighborhood of the axis of the lens system. In the neighborhood of the objective lens **14, 114,** the support tube **24** and the sleeve **25** must be superconducting in the region of the screening elements **46, 47.** This superconducting condition is necessary so that no gap is created of the kind through which the lines of force could penetrate between the superconducting screen **2140** of the lens **14** and the screening element **46.** On the other hand, in the lens gap between the section **14** and the section **114,** the magnetic field must enter the center of the lens in order to exert a focusing action there. The support tube and sleeve cannot therefore be superconducting or ferromagnetic in this zone. In the superconducting shielding lens **14, 114,** the shielding elements **46** and **47** act as far as focusing is concerned in the manner comparable with the way the pairs of pole pieces act. In the neighborhood of the pole pieces of the lens **15,** the support tube and sleeve must be ferromagnetic. However, between the pole pieces of the lens **15,** the support tube and sleeve must be free of ferromagnetic or superconducting properties. The support tube and sleeve can, however, be superconducting in some cases in the neighborhood of the pole pieces of the lens **15.**

In the embodiment shown in FIG. **1,** as mentioned, adjusting systems are provided inside and outside the sleeve and support tube. Insofar as these adjusting systems, which consist of field coils, are located internally, the sleeves and/or support tubes should be ferromagnetic in order to produce an external annular pattern of closing of the lines of force for the individual coils, for example, the adjusting system **51.** When the adjusting system is arranged outside the support tube as, for example, at **58,** the support tube and sleeve must be neither ferromagnetic nor superconducting at this location so that the magnetic field of the individual coils of the system **58** can, in fact, operate in the neighborhood of the axis of the column. It is convenient in the case of external adjusting systems such as system **58** to provide for magnetic return externally around the adjusting system, although this has not been shown in FIG. **1.** If required, it is also possible to use a ferromagnetic casing **211** of the lens as a return means.

The support tube and the sleeve are provided with bores as necessary or expedient. For example, in the support tube **24** and the sleeve **25** there are bores arranged in continuation of the bore **105** in the plate **104.** Through the bore **105** and the associated bores in the support tube and sleeve, the specimen is introduced into the object plane of the objective lens **14, 114.**

FIG. **2** illustrates an embodiment of the invention in which a support tube **522** passes centrally through the complete column. Inside the support tube **522** there is a through sleeve **523.** Inside the sleeve **523,** the lens structures of the type shown in FIG. **1** have been employed, and correspondingly numbered. In the same way as plate **104,** a plate **1104** is provided in which horizontal bores **1105** and **1106** are formed. Through these bores slides **1110** and **1111** can be passed. These slides can be used as the object mounts and/or as diaphragm mounts. The objective lens consists of a lens split into two parts **504** and **514** and is provided with a superconducting winding. The two lens sections are surrounded by a housing **516** of ferromagnetic material. Pole piece **534** is provided for the objective lens. The first intermediate lens **515** produces secondary magnification and has pole pieces **535** which are located inside the support tube and inside the sleeve **23.** Support tube **522** and sleeve **523** at the locations where housing **516** and pole pieces **534** and **535** touch each other or approach each other are made of ferromagnetic material. In the neighborhood of the gap between the individual pole pieces of the pairs **534** and **535,** the materials of the support tube and sleeve are not ferromagnetic so that no magnetic short circuit can occur at this location.

FIG. **3** illustrates a further modified form of the invention including a housing section **1304** which corresponds essentially to section **4** of the embodiment shown in FIG. **1,** with a support tube **1224** with a stepped down construction directly below the objective lens. The objective lens consists of the sections **604** and **614** and is of the type previously described in connection with FIGS. **1** and **2.** In the embodiment of FIG. **3,** a superconducting shielding lens is provided with a superconducting shielding housing **1314** and with superconducting shielding elements **1246** and **1247.** These cylindrical shielding elements surround the inner portion of the support tube **1224.** The support tube **1224** has a diameter as small as possible so that the shielding elements **1246** and **1247** are in as close proximity as possible to the specimen or object, with their mutually opposite edges forming the magnetic field, the specimen being located at the tip of the slide **1210** which is introduced through a bore **1206** in the plate **1204.** An opening **1206** is provided for the introduction of liquid helium.

Inside that portion of the support tube **1224** which has the larger cross-section, there is a sleeve **1225** of the type previously described in connection with the other embodiments. Inside the sleeve **1225** there is a diaphragm **1245.** In the construction shown in FIG. **3,** the sleeve **1225** can only be removed from the support tube **1224** from below, but this does not constitute any appreciable restriction. The other details of the embodiment shown in FIG. 3 correspond with the structure shown in FIG. 1, and the same reference numerals have been applied.

FIG. 4 is a fragmentary view of a further embodiment of the invention in which the shielding lens acts as an objective lens. In the embodiment of FIG. 4, the shielding lens is split into two parts **704** and **714** between which a plate **1704** is located, the latter corresponding essentially to the plates **1104** and **1204**. Superconducting shielding elements **716** and **717** are also provided, and the coils have been identified at reference numerals **718** and **719.**

A support tube **724** is provided about which the casings **716** and **717** are arranged. Those parts of the support tube **724** indicated by reference numerals **726** and **728** are made of superconducting material. In the areas **704** and **714,** the parts **730** and **731** which are arranged inside the support tube **724** act as shielding elements as explained in connection with the embodiment shown in FIGS. **1** and **3.** The sections **727** and **729** of the support tube **724** consist of a material which is neither superconducting nor ferromagnetic but does have good thermal conductivity. The material of the sections **727** and **729** therefore has no influence upon the shaping of the magnetic field in that zone in which the shielding elements **726** and **728** are located opposite each other. The sections **727** and **729** can, for example, be an integral part of the support tube **724** and the plate **1704.** The parts of the support tube **724** can preferably be integrally attached by welding. A pair of rings **732** and **733** serve to cool those sides of the shielding elements which are disposed toward the gap. They should be made of material having good thermal conductivity which is neither ferromagnetic nor superconducting. In operation, the interior of the support tube **724** is evacuated for the passage of the electron beam and consequently the welds provided in this area should be made vacuum tight.

The embodiment of FIG. **5** illustrates a structure with pole pieces both inside a support tube **822** and inside a sleeve **823.** A housing **816** surrounds a lens winding **818.** The heavily cross-hatched sections **841** and **842** of the support tube **822** and a sleeve **823** consist of ferromagnetic material so that closure of the magnetic field between the pole pieces **834** and **835** and the housing **816** is possible. The section **843** of the support tube and the corresponding section of the sleeve is neither ferromagnetic nor superconducting so that the magnetic field which is to be developed between the tips of the pole pieces **834** and **835** is not short circuited.

FIG. **6** is a schematic illustration of an electron microscope with a lens system in accordance with the present invention. Only the cryostat housing **2000** of the lens system has been shown, this housing corresponding to the sections **2, 4** and **6** of FIG. **1.** A vacuum tight chamber **2002** contains the parts of the support tube or several individual support tubes, plus any extensions thereof in the upward or downward directions. In the top end of the vacuum chamber **2002,** there is an electron source **2003.** This, for example, may be an incandescent filament. A viewing chamber **2004** is provided at the bottom end of the vacuum tight chamber **2002.** Inside the viewing chamber there is a viewing screen for inspecting the enlarged electron microscope image. The interior of the vacuum tight chamber **2002** is connected to a pipe **2006** to a vacuum pump **2007.** The annular anode for the assembly is identified at reference numeral **2008.** A voltage source **2009** is used to maintain a voltage between the electron source **2003** and the anode **2008.** The broken line **2009** indicates the path of the electron beam inside the vacuum tight chamber through the lens system in accordance with the present invention.

It should be evident that various modifications can be made to the described embodiments without departing from the scope of the present invention.

We claim as our invention:

1. A lens system for a beam of particle radiation comprising means for adjusting the particle beam, a plurality of superconducting cryogenically cooled magnetic lenses, a cryostat in which said lenses are received, and a central support tube in said cryostat on which said lenses are mounted.

2. The system of claim **1** in which said magnetic lenses include an objective lens and an intermediate lens having coinciding optical axes.

3. The lens system of claim **1** in which there is at least one diaphragm within said support tube.

4. The lens system according to claim **1,** wherein said lens system includes at least one magnetic lens with ferromagnetic pole pieces arranged inside said support tube, said support tube in proximity to said pole pieces being composed at least partially of ferromagnetic material.

5. A lens system according to claim **1** in which shielding elements of superconducting materials associated with at least one magnetic lens are located inside said support tube, and the support tube in the vincinity of said shielding elements is composed at least partially of superconducting material.

6. A lens system according to claim **1** which includes at least one adjusting system within said support tube.

7. A lens system according to claim **1** including at least one magnetic lens with pole pieces located outside said support tube.

8. A lens system according to claim **1** including at least one magnetic lens with shielding elements located outside said support tube.

9. A lens system according to claim **1** including at least one adjusting system located outside said support tube, said support tube being neither ferromagnetic nor superconducting in proximity to said adjusting system.

10. A lens system according to claim **1** which includes a sleeve of electrically conductive material in said support tube, said sleeve being closely fit into said support tube but removable therefrom.

11. A lens system according to claim **10** in which a diaphragm is positioned within said sleeve.

12. A lens system according to claim **10** in which a pair of pole pieces is positioned within said sleeve.

13. A lens system according to claim **10** in which an adjusting system is positioned within said sleeve.

14. A lens system according to claim **1** including an objective lens, a plate in proximity to said objective lens, said plate containing at least one radial bore for the introduction of a specimen, and containing at least one axially extending bore for the circulation of coolant in said cryostat.

15. A lens system according to claim **1** including several magnetic lenses connected in series with respect to their energizing means.

16. A lens arrangement which includes a plurality of lens systems in superimposed relation, each of said lens systems comprising means for adjusting a particle beam, a plurality of superconducting cryogenically cooled magnetic lenses, a cryostat in which said lenses are received, and a central support tube in said cryostat on which said lenses are mounted.

17. A lens arrangement according to claim **16** in which said lens arrangement includes a condenser lens system, a lens system consisting of an objective lens and a first intermediate lens, and a magnification lens system including at least one intermediate lens and a projective lens.

18. A lens arrangement according to claim **16** in which the individual lens systems are assembled so as to provide a single internal space for coolant.

19. A lens arrangement according to claim **16** in which all the lens systems are disposed in a single cryostat.

20. A lens arrangement according to claim **16** in which all the lens systems are arranged on a single support tube.

21. The lens arrangement according to claim **16** which includes ferromagnetic polepieces of at least one magnetic lens arranged inside of the support tube, the support tube in proximity to said pole pieces being composed at least partially of ferromagnetic material.

22. A lens arrangement according to claim **16** in which shielding elements of superconducting materials associated with at least one magnetic lens are located inside said support tube, and the support tube in the vicinity of said shielding elements is composed at least partially of superconducting material.

23. A lens arrangement according to claim **16** which includes at least one adjusting system within said support tube.

24. A lens arrangement according to claim **16** which includes a sleeve of electrically conductive material in said support tube, said sleeve being closely fit into said support tube but removable therefrom.

* * * * *