Feb. 10, 1959

M. F. REYNST

2,873,413

MAGNETIC-FIELD-PRODUCING DEVICE

Filed Nov. 30, 1955

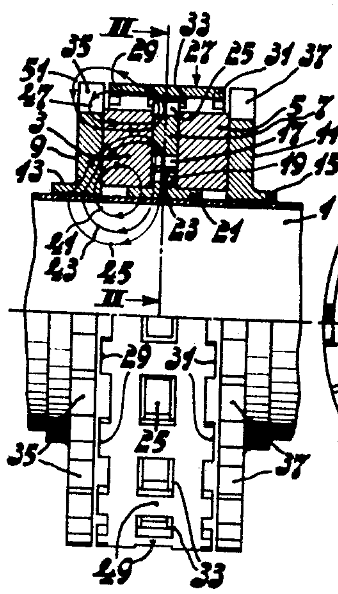

Fig. 1.

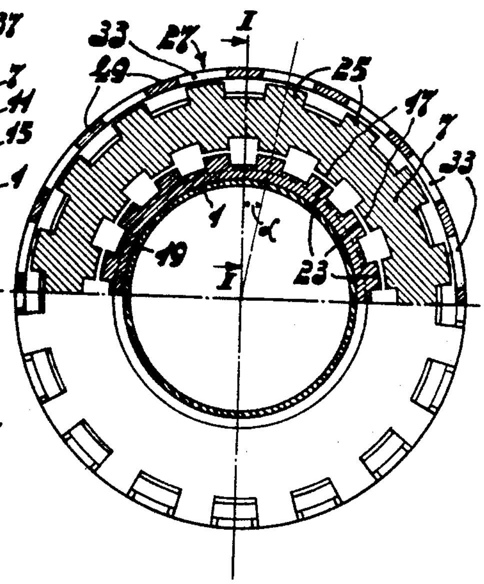

Fig. 2.

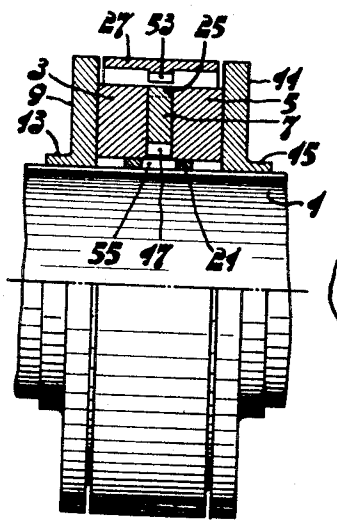

Fig. 3.

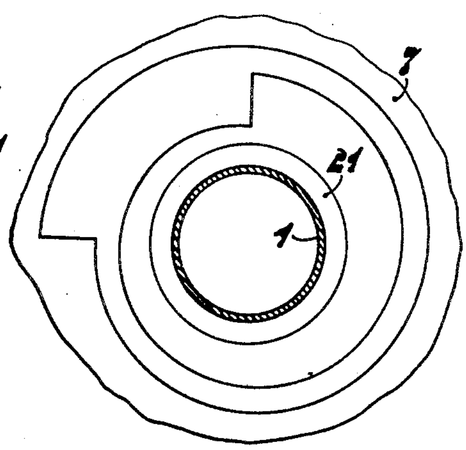

Fig. 4.

INVENTOR.
M. F. REYNST
BY
Fred M. Vogel
AGENT

United States Patent Office

2,873,413

Patented Feb. 10, 1959

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MAGNETIC-FIELD-PRODUCING DEVICE

Maximilien Felix Reynst, Eindhoven, Netherlands, assignor, by mesne assignments, to North American Philips Company, Inc., New York, N. Y., a corporation of Delaware

Application November 30, 1955, Serial No. 550,115

Claims priority, application Netherlands December 4, 1954

7 Claims. (Cl. 317—200)

This invention relates to devices for producing permanent magnetic fields, more particularly electron lenses, comprising at least two annular magnets arranged co-axially in juxtaposition and magnetised axially.

The object of the invention is to provide devices of the said kind in which the field strength can be controlled directly through a comparatively large range by means of a rotational movement. The device according to the invention is characterized in that an annular soft-iron disc is arranged between the magnets and co-axially therewith, at least one edge of the disc having a particular profile for controlling the magnetic flux, co-operating with a likewise profiled substantially annular and coaxial soft-iron pole-piece, in such manner that the flux in the gap between the profiles flows substantially between the magnetic rings. The cooperating parts are preferably provided with adjacent toothed portions with the same pitch of teeth.

It may be mentioned that devices for controlling a magnetic flux by means of relatively movable teeth are known per se. However, the control range obtainable therewith is limited, as will be explained hereinafter.

In order that the invention may be readily carried into effect, it will now be described, by way of example, with reference to the accompanying drawing, in which

Figs. 1 and 2 show an embodiment, one half in axial section and cross-section, respectively, and the other half in side view and elevation view, respectively.

Fig. 3 shows a slightly modified construction in axial section and

Fig. 4 shows a detail of another variant.

Figs. 1, 2 and 3 show a magnetic electron lens which may surround the neck of a cathode-ray tube **1** (not shown further). The lens substantially comprises two flat rings **3** and **5** which are axially magnetized and consist of permanent magnetic material, preferably ceramic material of the kind described in British Patent No. 708,127. The two rings **3** and **5** are co-axially arranged side by side with the poles of like polarity—in this case the north poles—adjacent one another. Arranged co-axially between the two rings **3** and **5** is a substantially annular disc **7** of soft iron (this is to be understood to include not only soft iron but also all materials having the same magnetic properties as soft iron, such as nickel, ferrites, etc). The assembly **3, 5, 7**, is externally covered with two soft-iron discs **9** and **11**, constituting flanges on two short soft-iron pieces of tube **13** and **15**.

The inner edge of disc **7** is provided with teeth **17** and concentrically embraces a soft-iron disc **19** constituting a flange on a short soft-iron piece of tube **21** of approximately the same diameter as that of the tube pieces **13** and **15**. The flange **19** externally comprises the same number of teeth (indicated by **23**) as the disc **7**, which teeth thus have the same pitch as the teeth **17** and in the position shown are in opposition to said teeth (that is to say in straight opposition). The disc **7** is externally provided with teeth **25**, the number and the pitch of which are thus equal to those of the teeth **17** and **23**.

The disc **7** and the magnets **3** and **5** are coaxially surrounded by a soft-iron piece of tube **27** comprising teeth **29** and **31** on the two edges and a series of windows **33** provided centrally on its circumference. The series of teeth **29** and **31** are in opposition to series of teeth **35** and **37** formed on the edges of the flanges **9** and **11**. The numbers and the pitches of all these teeth and windows are equal to those of the teeth previously described.

Magnetic fields occurs between the piece of tube **21** and the pieces of tube **13, 15**, which fields may be used in known manner for concentrating an electron beam passing through the neck of the tube **1**. Said fields extend wholly symmetrically with respect to the disc **7** and for the sake of convenience only the field at the left of the disc will be considered more fully hereinafter. Part of the flux—represented by a line of force **41**—flows, starting from the magnet **3**, directly via the piece of tube **21**. A larger portion—represented by two lines of force **43** and **45**—flows via the teeth **17** and **23** and across their separating air-gap; the extent of this portion is greatly dependent upon whether the teeth **17** and **23** are in opposition or not. At the position shown (see Fig. 2), the teeth **17** and **23** are in straight opposition and it will be evident that at this position the gap is at a minimum and the magnetic reluctance in the circuit of the lines of force **43, 45** is minimum, and maximum at the position at which the parts **7** and **19** have been turned through an angle α equal to the half pitch of the teeth. The magnetic flux in the neck of the tube **1** is as great and as small as possible at the said two positions, it thus being possible to control the flux (and the field strength) by turning the part **7** or **19** relative to the other.

In know control devices with gearings, it has been found that the control range is greatly limited by the fact that at the position of minimum field strength a considerable stray flux laterally (axially) emerges from and enters the toothed discs. Consequently the minimum field strength is usually only slightly lower than the maximum field strength. According to the invention, said disadvantage is obviated in that (see Fig. 1) the flux which passes from the disc **7** via the teeth **17** and **23** to the disc **19** (lines of force **43** and **45**) flows between the magnets **3** and **5**, i. e., this variable flux path is located between the magnets **3** and **5**. Lateral (axial) emergence of the lines of force from the face areas of the discs is prevented owing to the faces of the magnets **3** and **5**—which are the sources of the lines of force—being positioned in facing relation to the discs, so that at the minimum position (non-opposition of the teeth **17** and **23**) the said flux is greatly decreased and hence a large control range (a variation of 1:2 and more) can be achieved.

Another possibility of control—which may also be used separately—is provided by the co-operation of the teeth **25** on the outer edge of disc **7** with the ring **27** provided with the windows **33**, since part of the flux of the magnet **3** (see line of force **47** in Fig. 1) may flow along a parallel path via the ring **27** and the flange **9** and thus be largely extracted from the useful flux traversing tube **1**. By turning one of the elements **7** and **29** with respect to the other, the parallel flux is controlled fundamentally in the same way as the flux **43, 45**, but in the opposite sense, since—see Figs. 1 and 2—the position of non-opposition of the teeth **25** and the bridge pieces **49**—which in this case are to be regarded as teeth—coincides with the position of opposition of the teeth **17** and **23**. In this case also lateral emergence of the lines of force from the disc **7** is prevented or at least substantially suppressed by the magnets **3** and **5**.

The magnetic connection between the flange **9** (or **11**) and the ring **27** extends in the case shown via teeth **35** and **29** (and **37, 31**) formed on said parts. The magnetic reluctance resulting from said transition is in series with that resulting from the teeth 25 and 49 and is controlled in the same sense. The additional variation thus obtained is not great, since lines of force (for example line of force 51) can laterally enter the flange 9, but it assists in the variation brought about by the teeth and bridge pieces 25 and 49.

As a matter of fact (see Fig. 3), the ring 27 may have inwardly directed teeth 53 to substitute the bridge pieces 49. On the other hand, it is possible for windows 55 co-operating with the teeth 17, similar to the windows 33 in the part 27 (as shown in Fig. 1) and the teeth 25 in the disc 7, to be provided in the piece of tube 21. In the embodiment shown in Fig. 3, the edges of the flanges 9, 11 and those of the ring 27 are not provided with teeth.

In order to facilitate the relative rotation of the various parts required for the control, it is possible (see Fig. 3) to secure the parts 9, 3, 7, 5, 11 together, to secure the piece of tube 21 to the tube 1 (or to a separate non-magnetic supporting pipe surrounding it) and to secure the ring 27 to the chassis of the apparatus of which the described device forms part, while the tube pieces 13 and 15 can rotate about the tube 1. The control is then effected by rotating the assembly 9, 3, 7, 5, 11 while the rings 21 and 27 remain at rest.

Fig. 4 shows a profile of a modification of the discs 7 and 21 which may be used, for example instead of the teeth 17 and 23.

What is claimed is:

1. A magnetic-field-producing device comprising two, annular, coaxial, closely spaced, permanent magnets each magnetized in its axial direction so that like poles face each other, a first annular soft ferromagnetic member disposed between and coaxially with the two magnets, and a second annular soft ferromagnetic member arranged coaxially relative to the magnets and adjacent the first soft ferromagnetic member and the magnets, said first and second soft ferromagnetic members having portions facing each other in a radial direction and defining an air-gap therebetween and forming, in accordance with their relative positions, reluctance paths of different magnitude, said air-gap being located substantially between said two magnets and lying substantially within an area encompassed by the outer and inner diameters of the annular magnets, said first and second soft ferromagnetic members being relatively movable so as to vary the reluctance path for the flux produced by said magnets, whereby magnetic fields with a wide range of intensities are obtainable.

2. A device as set forth in claim 1, wherein the first and second soft ferromagnetic members have facing toothed portions of the same pitch.

3. A device producing a variable permanent magnetic field, comprising a pair of continuous, annular, coaxial, closely spaced, permanent magnets each magnetized in its axial direction producing poles of like polarity on facing surfaces, a first annular soft ferromagnetic member mounted between, abutting and coaxially with the two magnets, and a second annular soft ferromagnetic membert arranged coaxially with the two magnets and within and substantially coplanar with the first member, said first and second members having radially-extending, facing, toothed portions of the same pitch defining an annular space lying between and adjacent the magnets and substantially within the space bounded by the magnets, said two members being relatively axially rotatable to thereby vary the reluctance path for flux produced by the magnets and thereby vary the strength of an internally-produced permanent magnetic field.

4. A device producing a variable permanent magnetic field, comprising a pair of continuous, annular, coaxial, spaced, permanent magnets each magnetized in its axial direction producing poles of like polarity on facing surfaces, said magnets being spaced apart a distance smaller than their radial thickness, a first annular soft ferromagnetic member mounted between, abutting and coaxially with the two magnets, and a second annular soft ferromagnetic member arranged coaxially with the two magnets and substantially coplanar with the first member, said first member having a radially-extending, toothed portion, said second member having a plurality of circumferentially-arranged apertures aligned with, facing, and of the same pitch as the teeth on the toothed portion and defining between the two members air-gaps, the air-gaps between the facing portions of the first and second members being located substantially directly between the pair of magnets, said two members being relatively axially rotatable to thereby vary the reluctance path for flux produced by the magnets and thereby vary the strength of an internally-produced permanent magnetic field.

5. A device producing a variable permanent magnetic field, comprising a pair of continuous, annular, coaxial, spaced, permanent magnets each magnetized in its axial direction so that like poles face one another, a first annular soft ferromagnetic member mounted between, abutting and coaxially with the two magnets, said first member having inner and outer radially-extending toothed portions of the same given pitch, a second annular soft ferromagnetic member arranged coaxially with, within, abutting and substantially coplanar with the first member, said second member having a radially-extending toothed portion of said given pitch cooperating with the inner toothed portion of said first member to define reluctance paths for the flux produced by said magnets, and a third annular soft ferromagnetic member arranged coaxially with the first and second members, said third member having a toothed portion of said given pitch cooperating with the outer toothed portion of said first member to define reluctance paths for the flux produced by said magnets, said first member being rotatable relative to said second and third members to thereby change the reluctance paths for the flux produced by said magnets and thereby vary the strength of an internally-produced permanent magnetic field.

6. A device as set forth in claim 5 wherein the first, second and third members are so arranged that the cooperating toothed portions of the first and second members are aligned when the cooperating toothed portions of the first and third members are misaligned.

7. A device as set forth in claim 4 wherein the second member abuts the magnets.

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