July 23, 1968 W. SCHMIDT 3,394,282

ELECTRON BEAM DISCHARGE WITH PERIODIC PERMANENT MAGNET FOCUSSING

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Fig.1

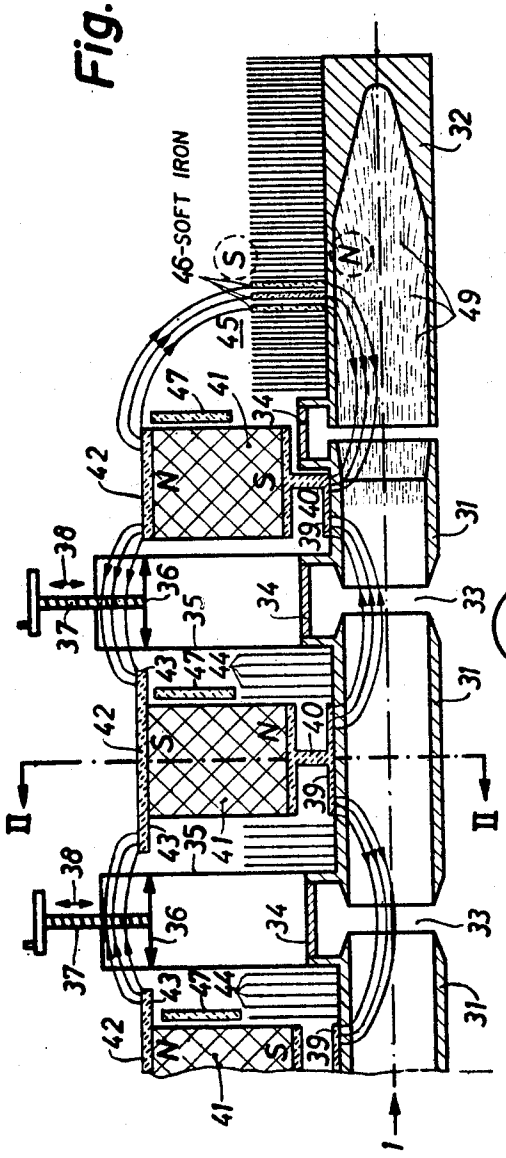
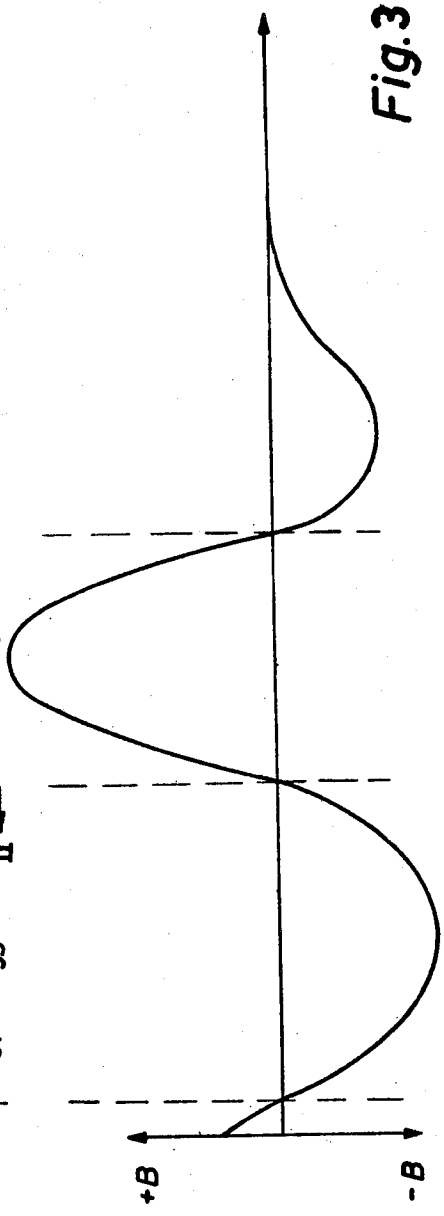


Fig.3



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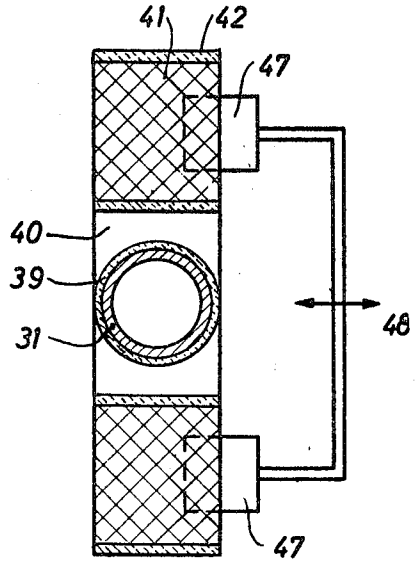


Fig. 2

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Fig.4

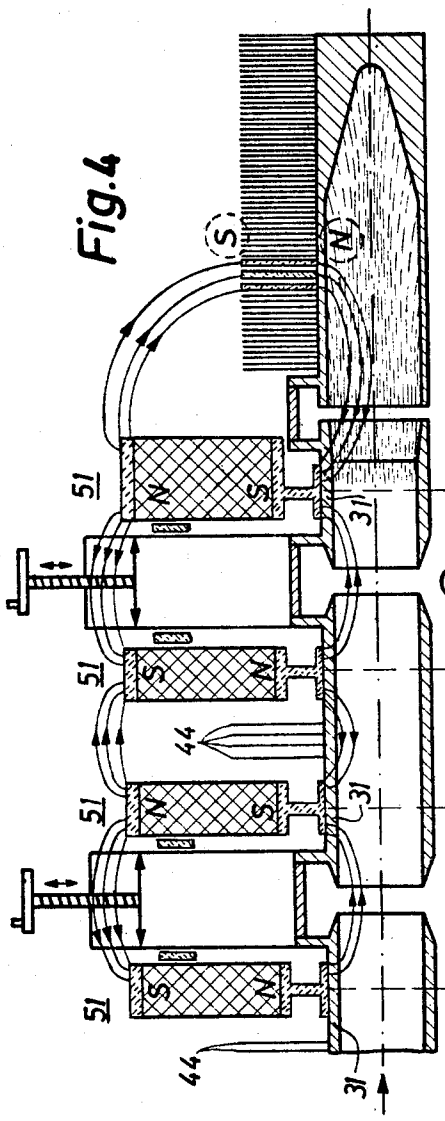
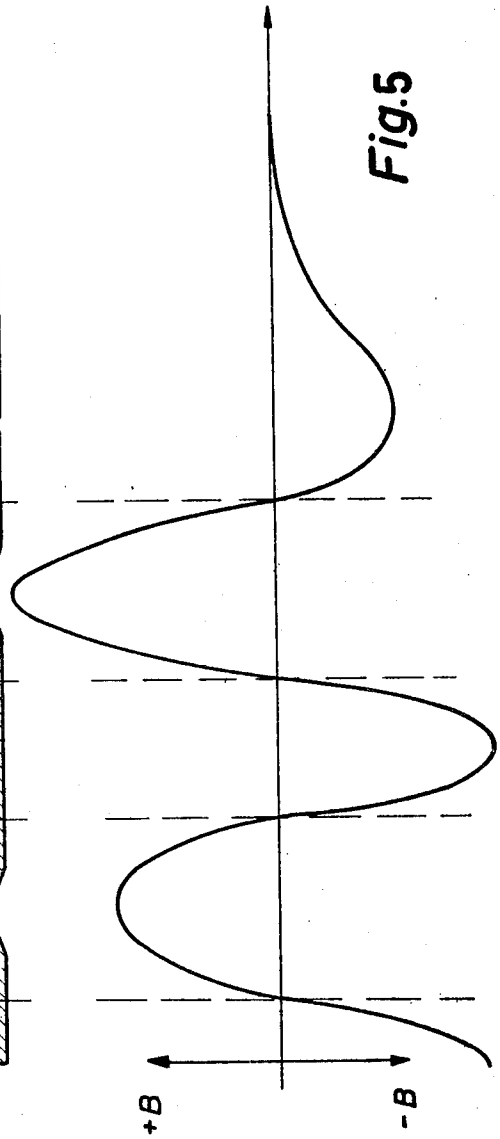


Fig.5



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ELECTRON BEAM DISCHARGE WITH PERIODIC PERMANENT MAGNET FOCUSSING

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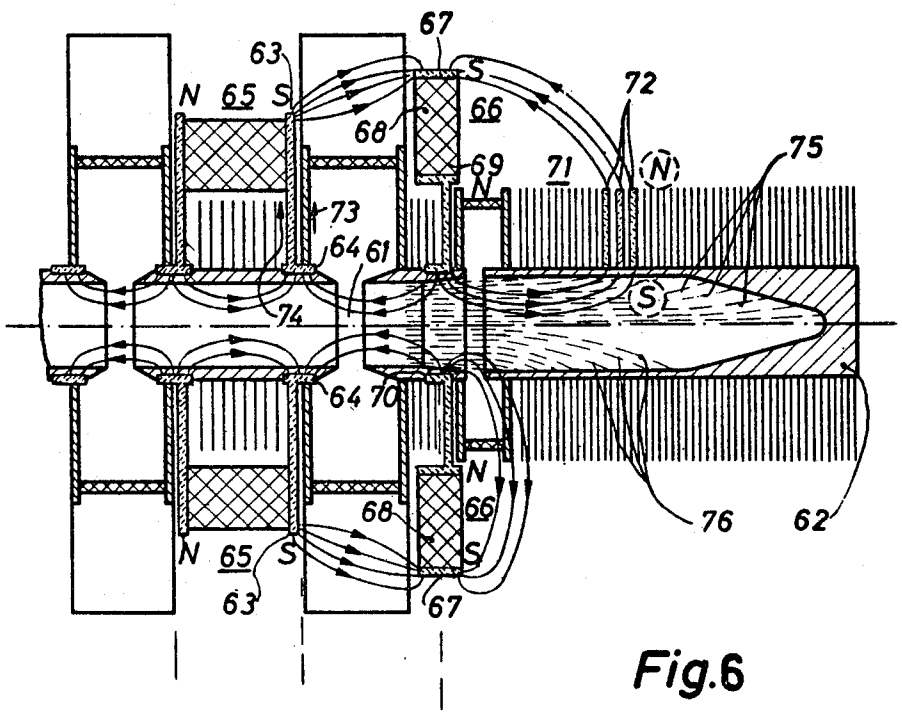


Fig.6

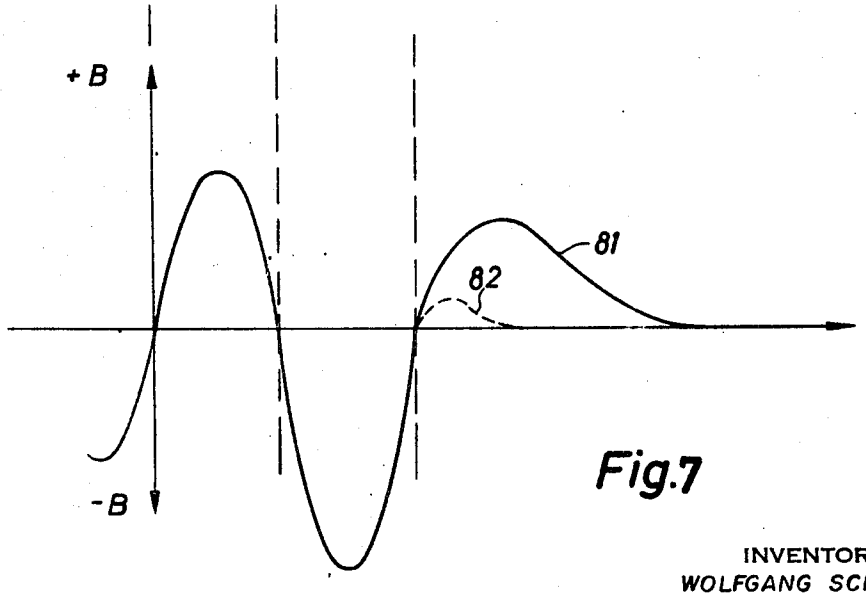


Fig.7

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3,394,282

ELECTRON BEAM DISCHARGE WITH PERIODIC PERMANENT MAGNET FOCUSSING

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Claims priority, application Germany, July 23, 1964, P 34,741
3 Claims. (Cl. 315—5.35)

ABSTRACT OF THE DISCLOSURE

An electron beam discharge tube with periodic permanent magnet focussing and provided with a hollow cylindrical collector electrode constituted of soft magnetic parts magnetized by the last magnetic foussing member so that the electron beam upon penetration into the collector electrode is initially kept together by the field thus produced and is subsequently scattered gradually.

The invention relates to a magnetic focussing arrangement comprising an electric beam discharge tube provided with a hollow cylindrical collector electrode, in which arrangement a periodically focussed magnetic field in the axial direction is produced by a plurality of permanent magnet systems.

In high-power beam discharge tubes it is important that the electron beam not be concentrated excessively on a small part of the collecting surface of the collector electrode, since this would result in excessive temperatures occurring locally or in that the load capacity of the collector would have to be reduced considerably.

In focussing arrangements having a unidirectionally orientated magnetic field which is produced by means of coils, it is sometimes possible to obtain a correct distribution of the incident electrons on the collector electrode by a given course of the magnetic field. Such focussing arrangements are bulky and consume a comparatively great amount of energy, however. On the contrary, focussing arrangements having directional periodic fields produced by permanent magnets afford the advantage that a large space is available between the permanent magnet systems for cooling, conductors for supplying and for conducting away the high-frequency energy which has to be amplified and which has been amplified, and in the case of multicavity klystrons for the arrangement of these resonant cavities and their tuning devices.

The invention has for its object to provide a structure which affords advantages in comparison with the known structures.

In a magnetic focussing arrangement for an electron beam discharge tube provided with a hollow cylindrical collector electrode, in which a periodically focussed magnetic field in axial direction is produced by a plurality of permanent magnet systems. According to the invention the collector electrode comprises soft magnetic parts which are magnetized by the last permanent magnet system viewed in the direction of travel of the electron beam so that the field thus produced initially keeps together the electron beam when it penetrates into the collector electrode, whereupon this beam is gradually scattered.

The last permanent magnet system is preferably magnetized in a radial direction with respect to the axis of the discharge tube. When a maximum amount of space is left free in the axial direction, fields of sufficient strength are thus obtained inside the collector electrode in a simple manner.

A particularly favorable structure in accordance with the invention is that in which a plurality of the cooling

fins of the collector electrode cooled in air consists of flat soft magnetic discs. The desired course of the magnetic field may be realized in a simple manner by the choice of the number and the location of these soft magnetic cooling fins.

The invention will now be described more fully with reference to the drawing, in which

FIG. 1 is an axial section of a focussing arrangement in accordance with the invention, while

FIG. 2 is a sectional view at right angles to the axis, and

FIG. 3 illustrates the course of the induction of the magnetic field in the axis of the discharge tube.

FIGS. 4 and 5 and 6 and 7, respectively, are axial sections of other embodiments of an arrangement in accordance with the invention and illustrate the course of the associated magnetic fields.

FIG. 1 illustrates a focussing arrangement in accordance with the invention which comprises a multi-cavity klystron only the output portion of which is shown while moreover those parts of the permanent magnet systems are shown which are located above the axis. In the figure, a plurality of drift tubes are denoted by **31** and the collector electrode is denoted by **32**, both the drift tubes and the collector electrode consisting of copper, in which event interaction gaps are provided between the drift tubes **31**. Cylindrical ceramic rings **34** bridge the interaction gaps **33** in a vacuum-tight manner. The interaction gaps **33** are associated with resonant cavities **35** which can be tuned by tuning pistons **36** (indicated diagrammatically with arrows). The tuning device is constituted by a spindle **37** which is displaceable in the direction of the arrow **38**.

The soft iron pole pieces provided on the drift tubes **31** are designated by **39** and the associated magnetic yokes by **40**. These yokes **40** must prevent the permanent magnets from absorbing an excessive quantity of heat from the drift tubes **31**. The permanent magnets **42** of successive systems are magnetized in opposite senses. The permanent magnets of one system alternately have the North pole or the South pole on the side of the axis. On the outer side the permanent magnets are provided with soft iron pole plates **42** which are slightly lengthened in the axial direction so that the magnetic resistance between the ends **43** is at a minimum and moreover only a weak stray field is produced in the surroundings. Cooling fins which are cooled by a current of air are provided on the drift tubes.

Three flat circular cooling fins **46** made of soft iron are provided on the collector electrode, while the remaining cooling fins consist of copper. The last permanent magnet induces in these cooling fins magnetic poles North and South which are indicated by the characters S and N surrounded by a circular broken line. This system of induced magnets is denoted by **45**.

The course of the magnetic induction in axial direction in the tube can be seen from FIG. 3, and it is to be noted that the last system **41** is chosen to be stronger than the preceding systems in order to prevent the electron beam which has lost considerable velocity in the modulator resonant cavity and which is consequently subjected to greater space charge forces, from being excessively scattered when it penetrates into the collector electrode **32**.

FIG. 2 illustrates the manner in which the strength of the magnetic fields can be adjusted with the aid of the soft iron short-circuit plates **47** which can be displaced by means of a bracket in the direction of the arrow **48**.

In FIG. 4 the permanent magnet systems are denoted by **51** and the difference with respect to FIG. 1 resides in the fact that two permanent magnet systems are provided each time between two resonant cavities, as a result of which not only a greater freedom in the choice of the magnetic parameters is obtained, but also the stray

field at a certain distance from the tube is reduced. The last system **51** is again of greater strength.

FIG. 5 indicates the course of the axial magnetic induction in the structure of FIG. 4.

In FIG. 6, the last drift tube is not provided with a radially magnetized magnet system but with an axially magnetized system **65** the course of the lines of force of which is indicated in the pole plate **63** with **74**, while the course of the lines of force originating from the last radially magnetized system **66** is denoted by **73**. The pole pieces of the focussing arrangement which have common lines of force at both magnet systems are denoted by **64**. The coupling slit for leading out is denoted by **66**. The permanent magnets of the radially magnetized system **66** are designated by **68**, the outer pole plates by **67**, the yokes by **69** and the pole pieces by **70**. The induced magnet system **71** consists of the soft iron cooling fins **72**, which are provided between the remaining copper cooling fins on the collector electrode **62**. The electrode paths are denoted by **75**. The lower half of the drawing illustrates the course of the lines of force and of the electron paths **76** in case the soft iron cooling fins should be absent. The electrons would then be mainly collected in the first part of the collector electrode, which would result in an excessive load.

FIG. 7 shows for the arrangement of FIG. 6 the course of the axial magnetic induction, in which case in the collector part the full line **81** indicates the course in the presence of the magnetic cooling fins **72** while the broken line **82** indicates the course in the absence of these fins.

What is claimed is:

1. An electron discharge tube comprising an electron beam source within an evacuated housing, means for exchanging energy between the electron beam and electromagnetic energy, a hollow cylindrical collector electrode spaced from and defining a beam axis with said electron beam source, a plurality of axially aligned spaced permanent magnet systems between the electron beam source and the collector electrode for producing a periodically focussed magnetic field in the axial direction between the electron beam source and the collector electrode, and a plurality of discs of soft magnetic material secured to and serving as cooling fins for said collector electrode, said discs being magnetized by the magnet system adjacent the collector electrode forming a magnetic field within the collector electrode whereby the electron beam is initially kept concentrated and then subsequently scattered therein.

2. An electron beam discharge tube as claimed in claim **1** in which the magnet system adjacent the collector electrode is radially magnetized.

3. An electron beam discharge tube as claimed in claim **2** in which the collector electrode is provided with copper cooling fins as well as soft iron magnetic cooling fins.

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