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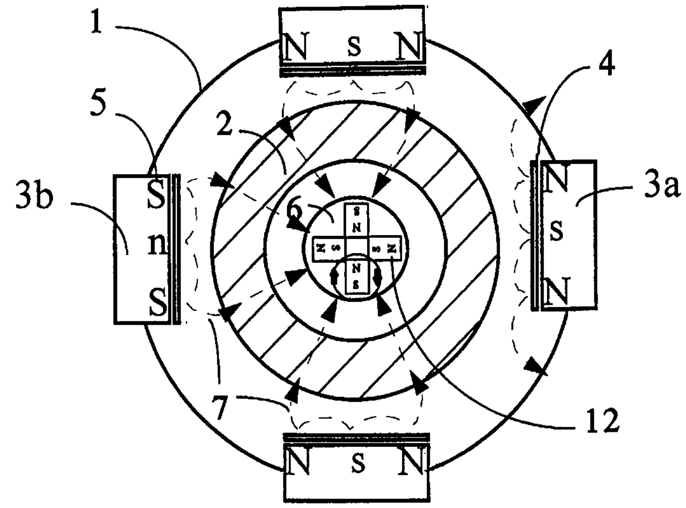

(57) Abstract

The invention relates to a vapour deposition coating apparatus. More particularly it relates to an apparatus in which the ion current density is carefully controlled to improve coating. This control enhances the versatility and enlarges the range of deposition conditions which can be achieved within a single apparatus, so that coatings with very different properties can be deposited in the same equipment. The vapour deposition apparatus includes a vacuum chamber (1), at least one coating means or ionisation source (3) disposed at or about the periphery of a coating zone (2), one or more internal magnetic means (6) positioned such that the magnetic field lines (7) are generated across the coating zone (2) and means for altering the strength or position of the magnetic field lines to aid confinement.

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VAPOUR DEPOSITION COATING APPARATUS

TECHNICAL FIELD

This invention relates to a vapour deposition coating apparatus. More particularly it relates to an apparatus in which the ion current density is carefully controlled to improve coating. This control enhances the versatility and enlarges the range of deposition conditions which can be achieved within a single apparatus, so that coatings with very different properties can be deposited in the same equipment. Also, the present invention enables high quality coatings to be deposited in a large volume apparatus improving the coating productivity and component throughput. The deposition apparatus is based upon magnetron sputtering sources in which the ion current driven towards the samples is carefully controlled.

BACKGROUND ART

Magnetron sputtering is a very well established technique which is able to produce high quality vapour deposited coatings for a wide range of applications.

A number of improvements in magnetron sputtering have occurred during the last ten years. The first break through was provided by the unbalanced magnetron [B. WINDOWS, N. SAVVIDES, J. Vac. Sci. Technol., A4 (1986) 453] which improved the ion flux escaping the magnetron surrounding so the samples to be coated were subjected to a higher ion bombardment with beneficial effects in the structure of certain types of coatings. Variations in this principle and control modes for the degree of unbalancing have been previously disclosed [W. MAASS, B. CORD, D. FERENBACH, T. MARTENS, P. WIRZ, Patent DE 3812379 14 April 1988].

In the case of large volume coating apparatus it has been necessary to provide high ionisation sources in areas well away from the magnetron. This extra ionisation has been implemented by the use of supplementary excitation sources such as radio-frequency and microwave means [M. NIHEI, J. ONUKI, Y. KOUBUCHI, K. MIYAZAKI, T. ITAGAKI, Patent JP 60421/87 Priority 16 March 1988] and the provision of magnetic arrangements next to the magnetron sources [D.G. TEER, Proceedings for the First International Symposium on Sputtering and Plasma Processing - ISSPO91,Tokyo, Japan, February 1991; and A.FEUERSTEIN, D. HOFMANN, H. SCHUSSLER, Patent DE 4038497 ,Priority 3 Dec 1990, and S. KADLEC, J. MUSIL, Patent CS4804/89, Priority 14 Aug 89; and W.D. MÜNZ, F.J.M. HAUZER, B.J.A. BUIL, D. SCHULZE, R. TIETEMA, Patent DE 4017111 Priority 28 May 1990]. All described methods have had a limitation in the maximum chamber size, generally limited to 0.5 to 1 metres in diameter, that can be used for the deposition of a successful coating.

The present invention overcomes such a limitation and can give rise to a novel apparatus which could be up to four meters in diameter.

DISCLOSURE OF THE INVENTION

According to one aspect of the present invention there is provided a vapour deposition coating apparatus comprising a vacuum chamber (1), at least one coating means or ionization source (3) disposed at or about the periphery of a coating zone (2), characterised in that the apparatus is provided with one or more internal magnetic means (6) positioned such that magnetic field lines (7) are generated across the coating zone (2) and means for altering the strength or position of the magnetic field lines.

According to a further aspect of the present invention there is provided a multi-station deposition unit comprising a plurality of coating stations (3,6) each defining a confinement volume, the unit comprising a plurality of coating means or ionization sources (3) disposed at or about the periphery of the coating zone and one or more internal magnetic means (6) (10) positioned such that magnetic field lines (7) are generated across each coating zone (2) and means for altering the strength or position of the magnetic field lines.

According to yet a further aspect of the present invention there is provided

a vapour deposition coating method characterised in that magnetic field lines (7) can be regulated across a coating zone (2) by means (3) (6) which enable an ion current density to be controlled.

The apparatus can incorporate a number of coating means of which one is preferably a magnetron cathode which will be situated around the samples to be coated. At or towards the interior of the chamber a single or plurality of means generate a magnetic field. These means could comprise a single or plurality of magnetic polarities which could be the same or different to those of the outer magnetic array of the magnetron source. These magnetic sources provide a means enabling deposition under different ion bombardment conditions to be controlled in different areas of the coating apparatus and/or at different times in the deposition process.

The magnetic strength of these poles could be controlled by different means, e.g. by changing the current of the electromagnet units or by mechanical displacement of the permanent magnetic means or both.

Identical or different magnetron polarities could be used within the same apparatus.

The magnetic strength of the magnetrons could be also varied as could the relative position of the inner and outer magnetic poles.

Auxiliary magnetic poles could be used in the chamber surroundings in order to optimise the plasma confinement. Magnetic confinement enhancement could be achieved by magnetic means which present opposite polarity to the central pole. Also suitable electric currents could provide adequate magnetic confinement by generating magnetic fields for this purpose, especially when they are combined with other magnetic means.

All these magnetic variations make the apparatus versatile in its applications.

Generally, the apparatus will enable maximum magnetic confinement necessary in larger deposition apparatus to ensure high quality coatings. The internal magnetic means could have independent biasing from the samples to be coated. The samples to be coated could be biased or un-biased. The bias applied to the samples to be coated could be powered by direct current (DC) and alternative excitation means at different frequencies such as alternating current (AC) at very low frequencies (1-1000 Hz), or pulsed voltages at low frequencies (Pulsed-LF) (1-1000 KHz), or medium frequency (MF) waves (1-3 MHz),or radiofrequencies (RF) waves (1-1000 MHz), or any combination or modulation of these or other excitation means.

The apparatus could incorporate any other number of means in order to enhance the ionisation such as microwaves and/or medium and high frequency devices and means suitable for the generation of glow discharges and ion vacuum techniques such as arcs, hot filament, lasers, electron guns and ion beams.

Larger apparatus, above two metres in diameter can be produced by magnetic linkage between magnetrons and internal poles. Spatial distribution of magnetrons and additional magnetic means could be varied in order to achieve optimisation of spaces where magnetic confinement conditions are appropriate for coating depositions. A large coating apparatus could comprise of one or more confinement areas or stations.

Various aspects of the invention will be described, by way of example only with reference to figures 1 to 11 below in which:

Figure 1 shows an example of a deposition apparatus which includes the basic magnetic confinement described by the present invention;

Figure 2 illustrates a three-dimensional view of a deposition chamber described by the present invention;

Figure 3 illustrates a deposition unit described by the present invention which has additional magnetic means;

Figure 4 illustrates a deposition unit with additional magnetic means which could modulate the magnetic confinement as described by the present invention;

Figure 5 illustrates a cross section of a deposition unit with independent biasing for the central magnetic mean from the samples as described by the present invention;

Figure 6 shows a multi-station deposition unit described by the present invention;

Figure 7 represents a multi-station deposition unit described by the present invention;

Figure 8 illustrates a system with higher levels of magnetic confinement made by retracting to some degree the inner magnetron magnetic pole as described by the present invention;

Figure 9 illustrates a system with low levels of magnetic confinement brought about by the switching of the central polarity such that it is the same as the outer pole of the magnetron as described by the present invention;

Figure 10 illustrates a system with very low levels of magnetic confinement which are further decreased by withdrawing the magnetrons outer magnetic pole to some degree as described by the present invention; and

Figure 11 illustrates a system with different levels of magnetic confinement for different areas of the coating station as described by the present invention.

Referring to the figures in turn:

Figure 1 represents the top view of a cylindrically shaped chamber. The deposition unit includes a vacuum chamber **1**, which is evacuated by means of a pumping system. The elements due for coating **2** could rotate so they could face the different magnetrons **3** or other possible coating means or ionisation sources. The sputtering process takes place on the surface of the magnetron targets **4**. The front face of the outer magnetic pole of the magnetrons **5** have opposite polarity to the magnetic means placed at the central zone of the chamber **6** so that the magnetic field lines **7** cross the zone of elements due for coating **2**. The magnetic poles contained within the magnetron may or may not have one or several ferromagnetic elements, such as a soft iron backing plate, at the rear of the magnetic pole. The vacuum chamber **1**, could be constructed from non-ferromagnetic or ferromagnetic material in order to either affect or not affect the magnetic circuits.

Figure 2 represents a deposition apparatus where the magnetrons **3** are placed on the chamber wall **1**. A magnetic assembly **6** is placed within a central pole. Samples **2** are coated with the target material **4** or any other chemical compounds formed in plasma reactions during the deposition process.

Figure 3 represents a top view of a two magnetron apparatus where the central magnetic means **6** has an opposite magnetic polarity to that of the outer magnetic means **5** of the magnetrons **3**. Additional magnetic means **8** situated around the samples, e.g. by the chamber walls, provide magnetic fields which complement and enhance magnetic confinement within the system so magnetic field lines **7** cross the samples **2** towards the central pole.

Figure 4 represents a top view of a three magnetron apparatus where the central magnetic means **6** has an opposite polarity to that of the outer magnetic means **5** of the magnetrons **3**. Additional magnetic means **8** and **9** enhance confinement. Magnetic means **6** and **9** could be varied either by mechanical displacement or electronic currents so that the degree of confinement could be modulated as magnetic lines **7** are altered.

Figure 5 represents a cross sectional view of a deposition apparatus where the central magnetic means **6** could be independently biased from the samples **2**. This magnetic array could be left at a floating potential (where electronic current is equal to the ionic current), or biased at the same or a different potential to that of the samples with a positive or negative polarity. The samples could be biased by for example DC, AC, Pulsed-LF, MF, RF or any combination or modulation of the above.

Figure 6 represents a multi-station coating apparatus where the deposition units comprise four different coating stations which provide four different confinement volumes. Each station, in the present example, has different magnetrons **3** and coats different samples **2**. Magnetic confinement is produced between magnetrons **3** and a local central pole **6**.

Figure 7 represents a multi-station coating apparatus. The deposition apparatus comprises three different sample holders **2**. In the present example all the magnetrons are situated on the chambers wall **1**. Two series of magnetic poles **6** and **10** of opposite polarity direct the magnetic field lines **7** across the samples.

Figure 8 represents a single station coating apparatus with the magnetrons inner magnetic means **11** being withdrawn independently of the magnetrons outer magnetic means **5** so as to further enhance the magnetic linkage **7** to the central pole **6** and the magnetrons outer magnetic means **5**. Central magnetic means **6**, as an example, comprises a number of independently controlable magnetic means **12** each of which can independently have its polarity changed by for example rotation and/or translation of their constitutive permanent magnets.

Figure 9 represents a single station apparatus where the central magnetic means 12 have been reversed such that the polarity is the same as the magnetrons outer magnetic means 5, hence having the effect of preventing linkage with the inner magnetic pole **6**.

Figure 10 represents a single station coating apparatus where the central magnetic means **12** have been reversed such that the polarity is the same as the magnetrons outer magnetic means 5, with the further retraction of the magnetrons outer magnetic means **5** increasing the effect of preventing linkage with the inner magnetic pole **6**.

Figure 11 represents a single station coating apparatus where the central magnetic means **12** have two different polarities. At the same time the magnetrons have two different polarities **3a** and **3b**, providing different magnetic confinement in different areas of the station. This situation allows coating deposition at different degrees of ion bombardment. Targets **4** could be of the same or of different materials. In the present example three of the magnetrons present a magnetic confinement due to complementary polarity with the central magnetic means. One of the magnetrons presents the same polarity as the corresponding central magnetic mean preventing linkage with the inner magnetic pole **6**.

CLAIMS

1. A Vapour deposition coating apparatus comprising a vacuum chamber (1), at least one coating means or ionization source (3) disposed at or about the periphery of a coating zone (2), characterised in that the apparatus is provided with one or more internal magnetic means (6) positioned such that magnetic field lines (7) are generated across the coating zone (2) and means for altering the strength or position of the magnetic field lines.

2. An apparatus as claimed in claim 1 in which the at least one coating means or ionisation source is a magnetron (3).

3. An apparatus as claimed in claim 1 or 2 in which the coating means or ionization source comprises permanent or electromagnetic arrays capable of generating strong magnetic fields.

4. An apparatus as claimed in any of the preceding claims in which the internal magnetic means are positioned substantially at the centre of the chamber.

5. An apparatus as claimed in any of the preceding claims wherein the internal magnetic means (6) comprises a single or plurality of polarities.

6. An apparatus as claimed in any of the preceding claims, comprising means for displacing the internal magnetic means.

7. An apparatus as claimed in any of the preceding claims in which the coating means or ionization source (3) and/or the internal magnetic means (6) (10) have different polarities and are arranged such that the polarities can be altered with respect to one another.

8. A multi-station deposition unit comprising a plurality of coating stations (3,6) each defining a confinement volume, the unit comprising a plurality of coating means or ionization sources (3) disposed at or about the periphery of the coating zone and one or more internal magnetic means (6) (10) positioned such that magnetic field lines (7) are generated across each coating zone (2) and means for altering the strength or position of the magnetic field lines.

9. A multi-station coating apparatus as claimed in claim 8 in which the one or more internal magnetic means comprise two series of magnetic poles (6) (10) of opposite polarity which direct the magnetic field lines (7) across each coating zone (2).

10. A vapour deposition coating method characterised in that magnetic field lines (7) are regulated across a coating zone (2) by altering their strength or position.

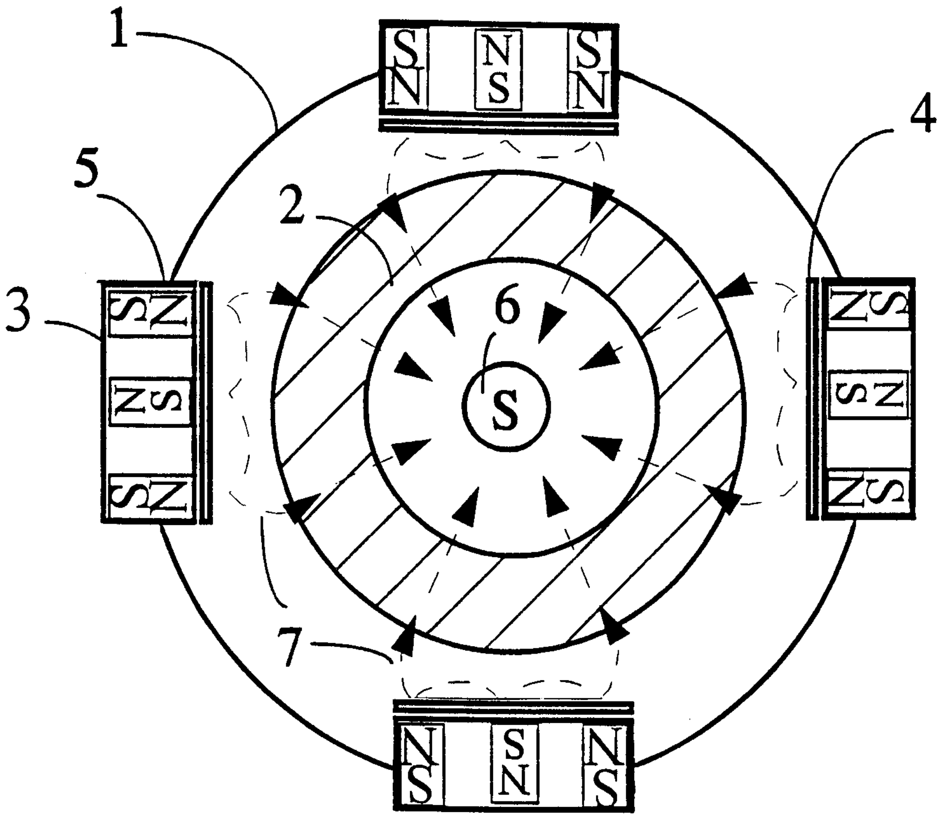

FIG. 1

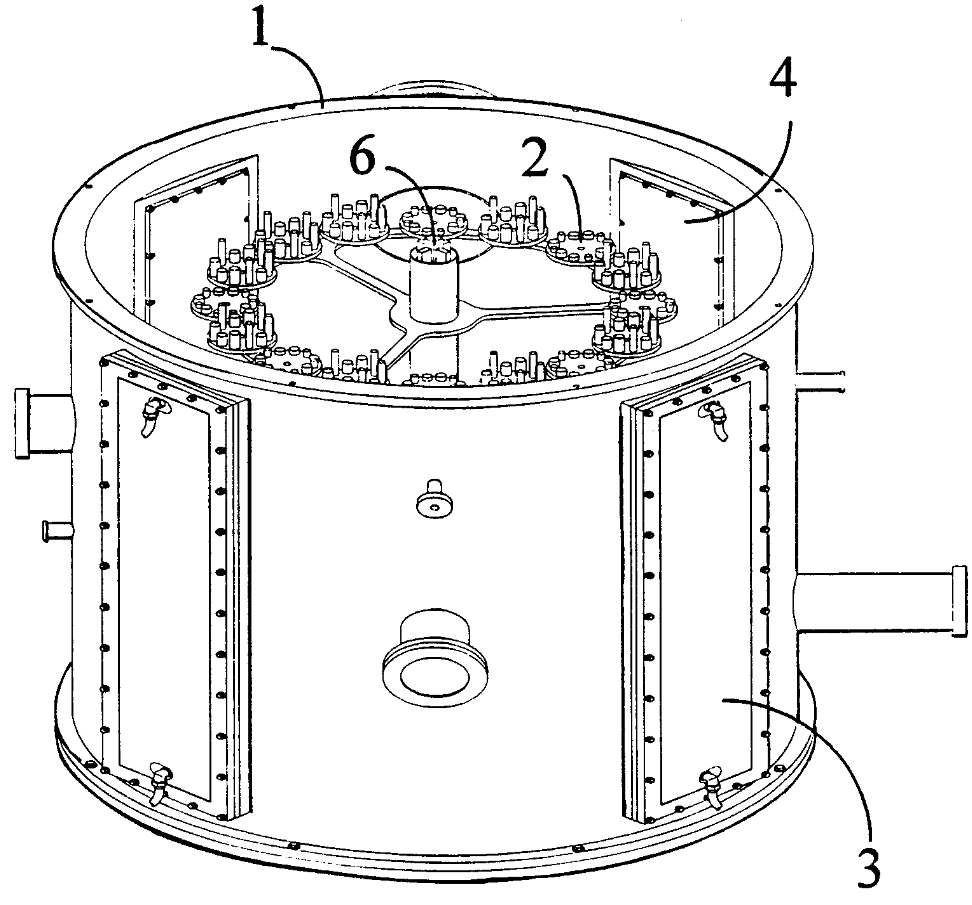

FIG. 2

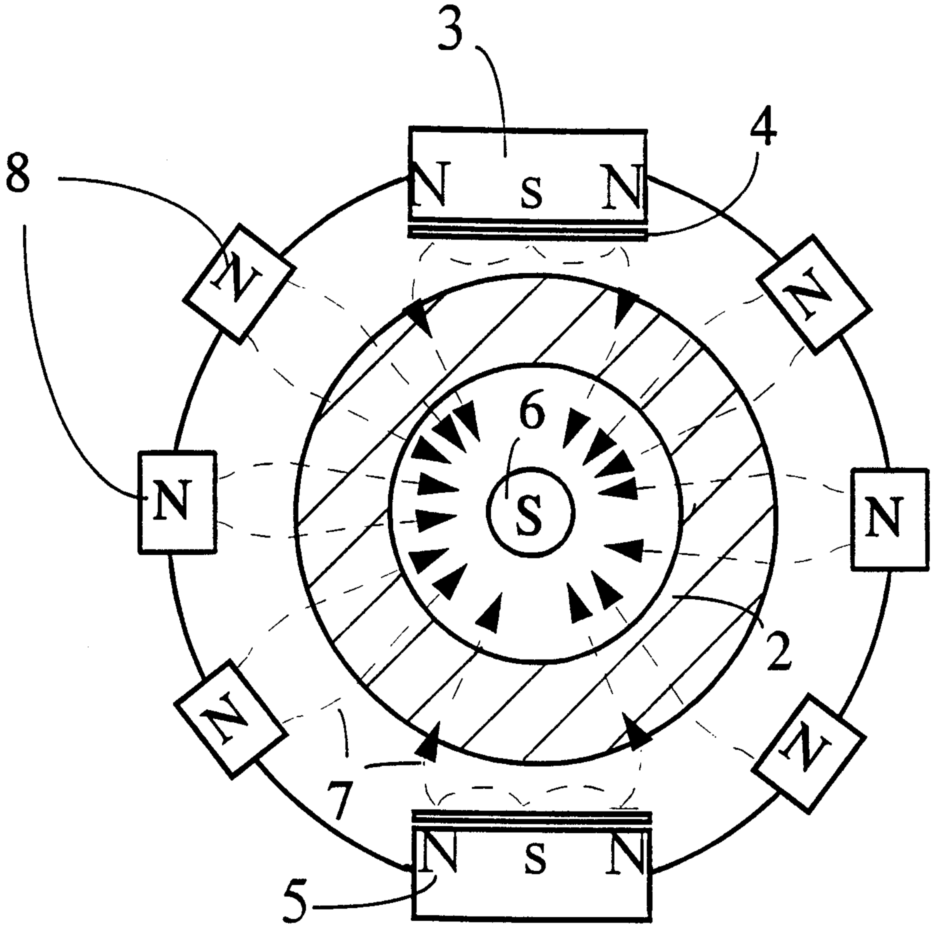

FIG. 3

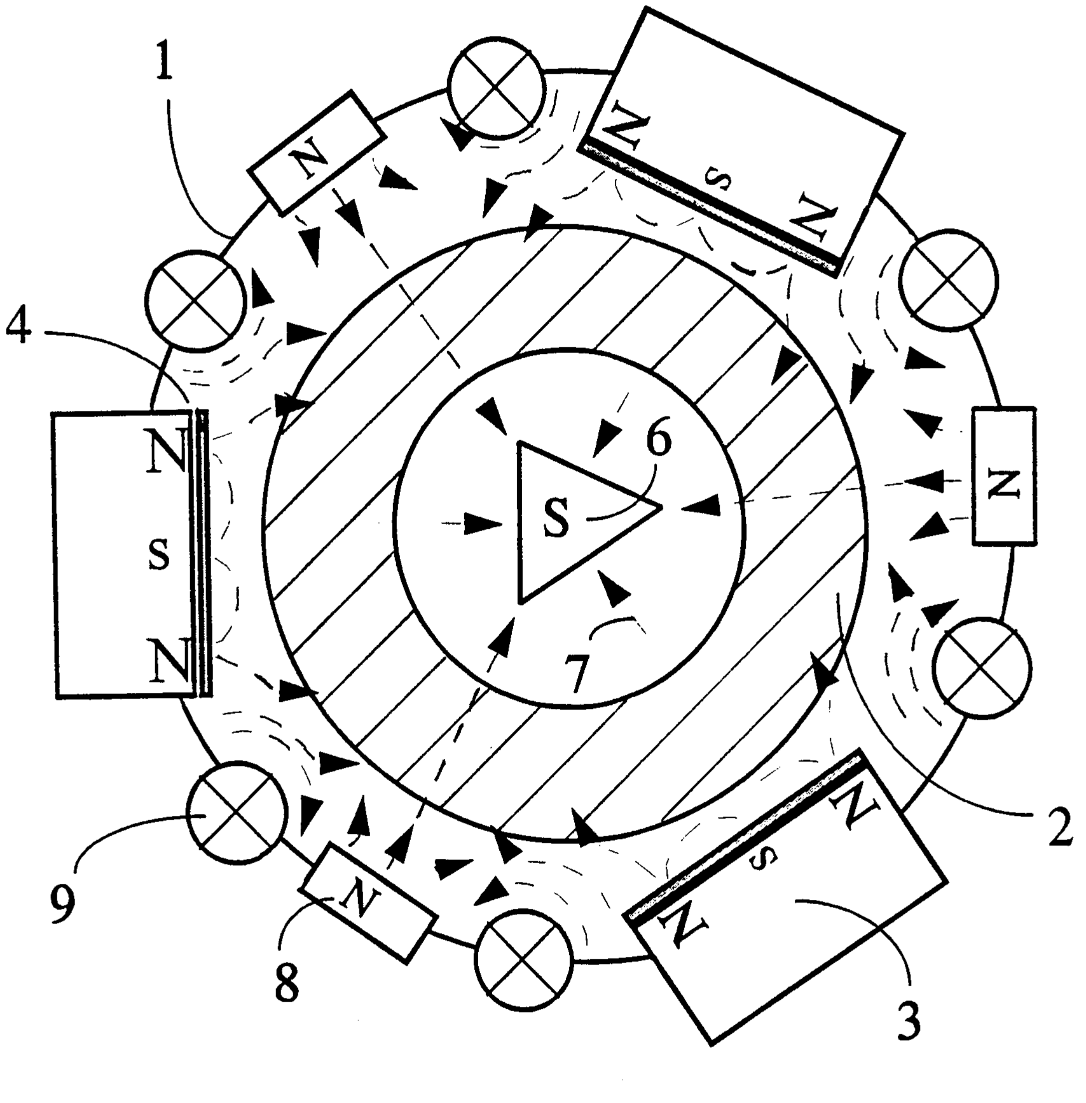

FIG. 4

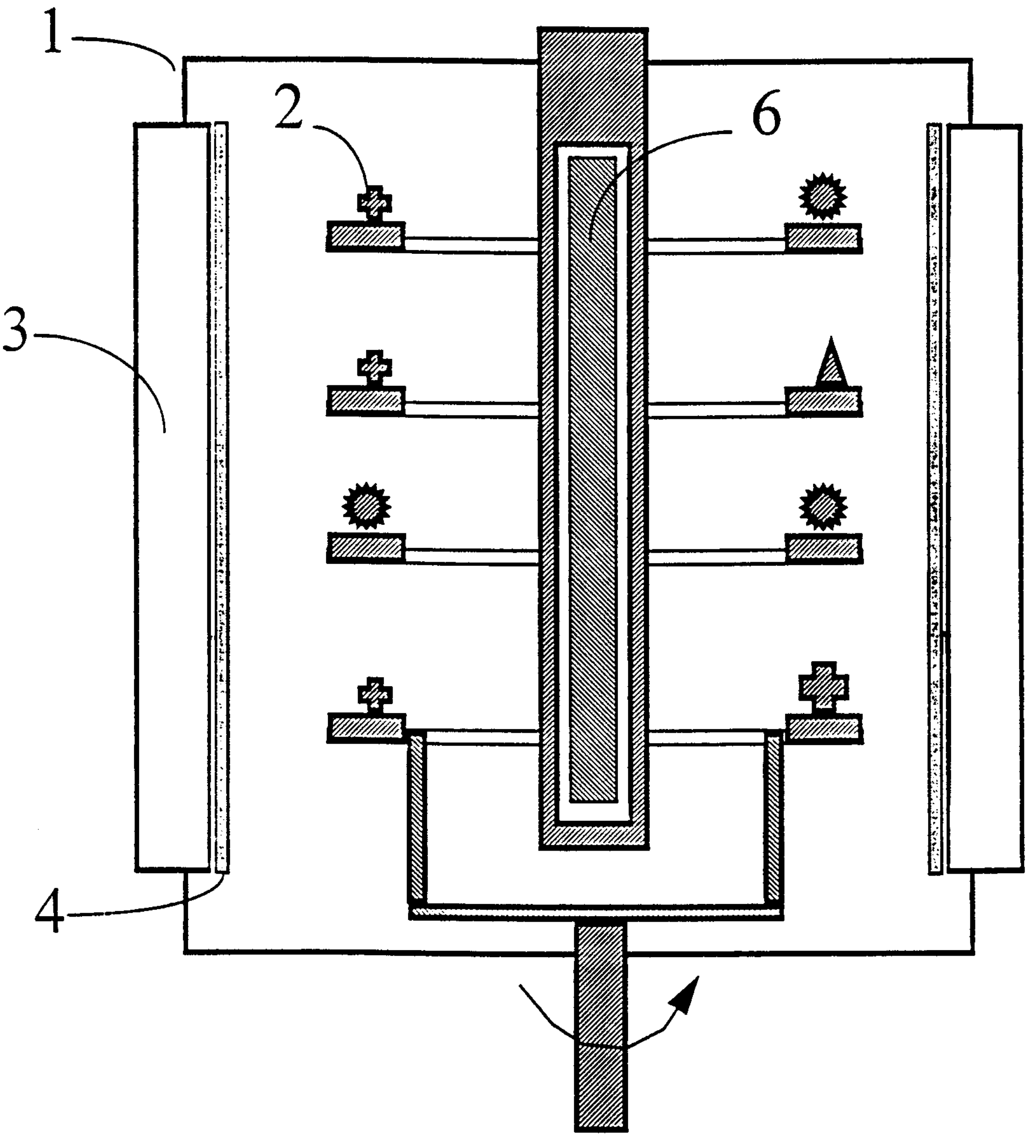

FIG. 5

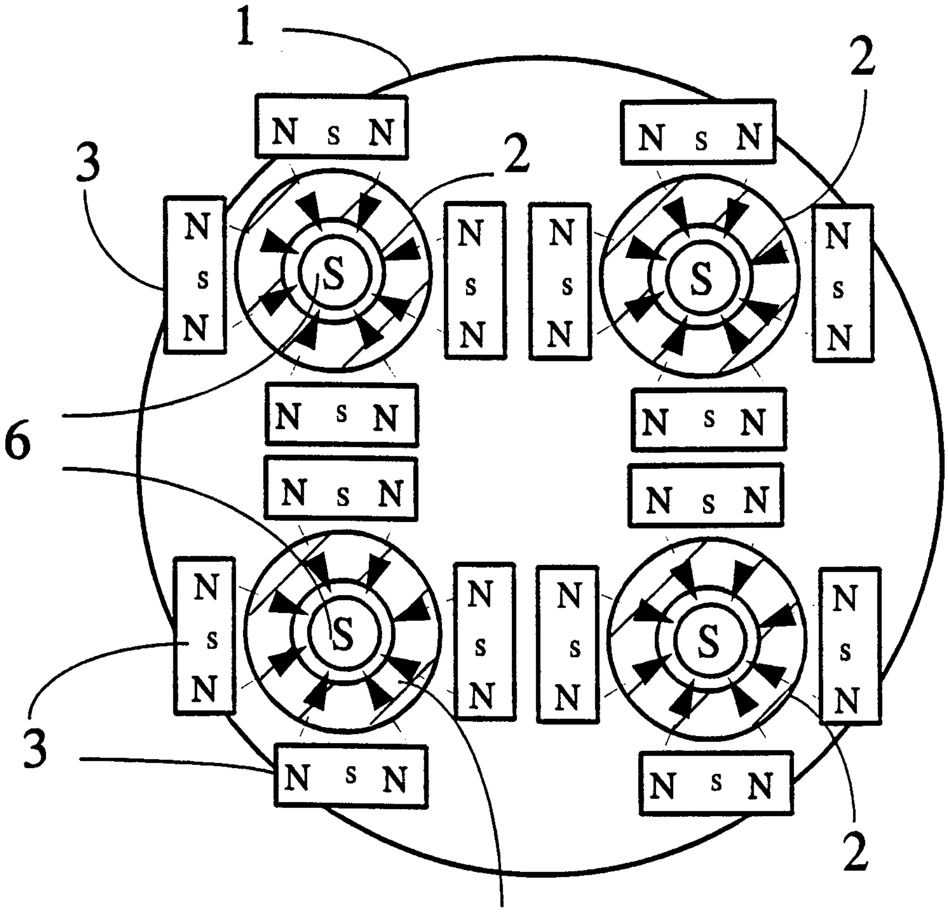

FIG. 6

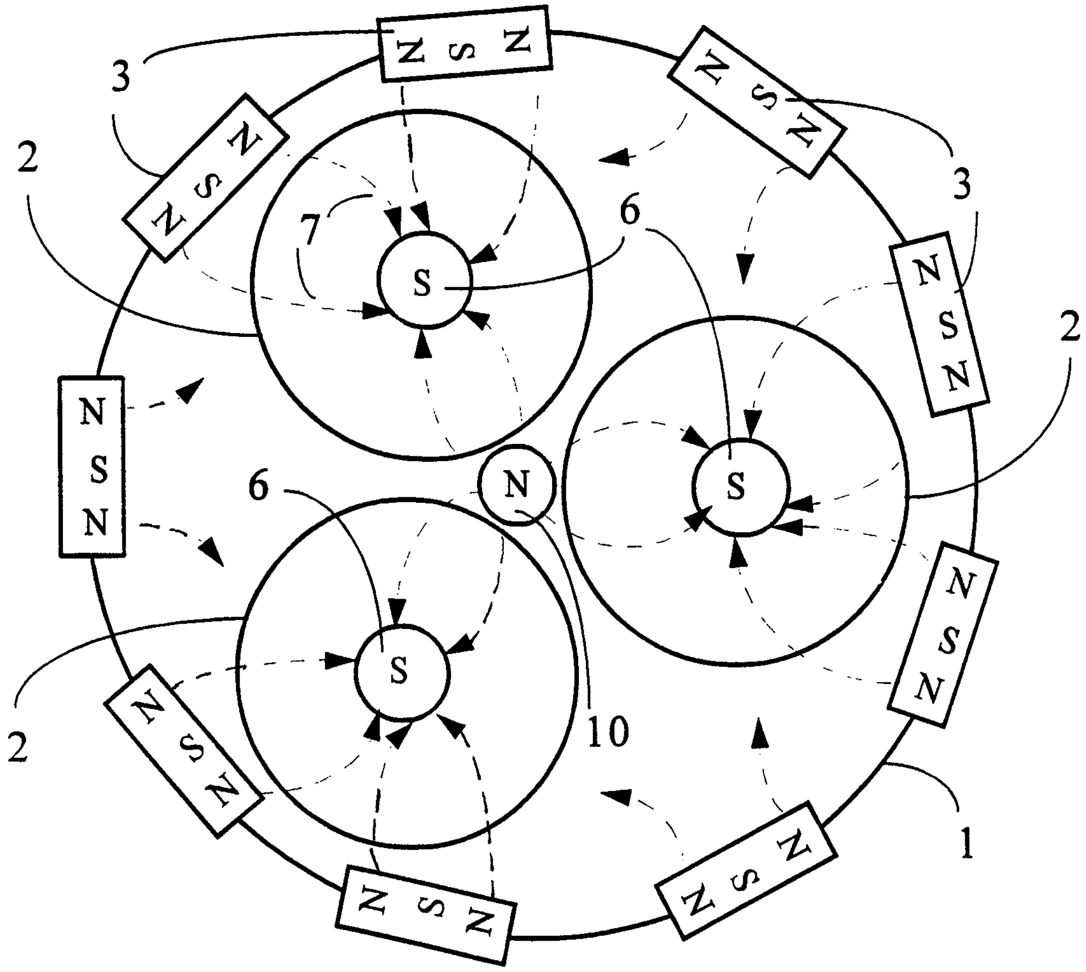

FIG. 7

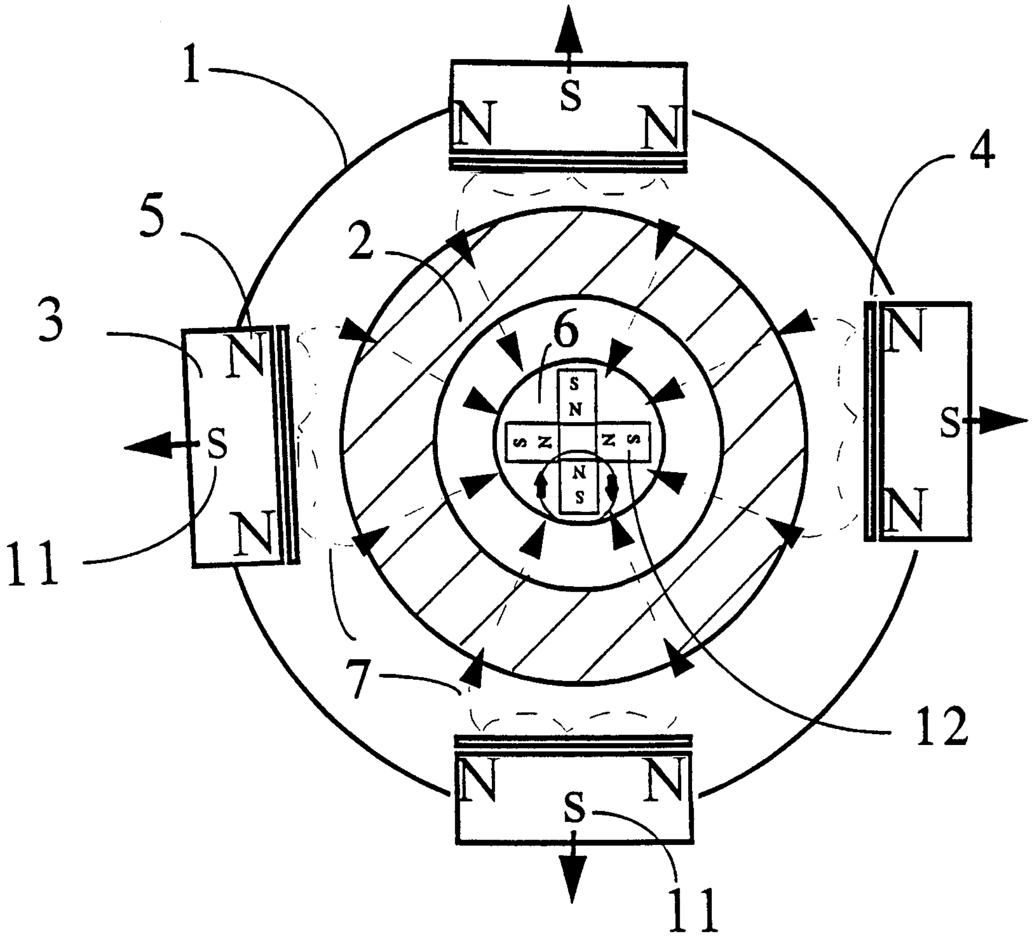

FIG. 8

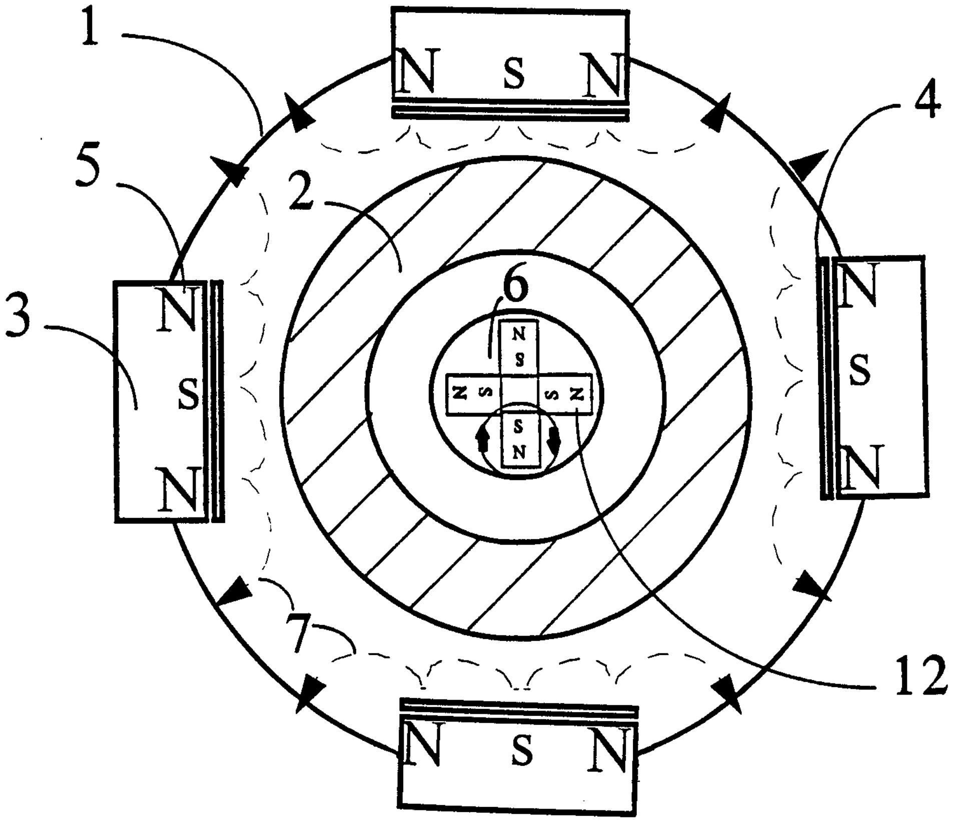

FIG. 9

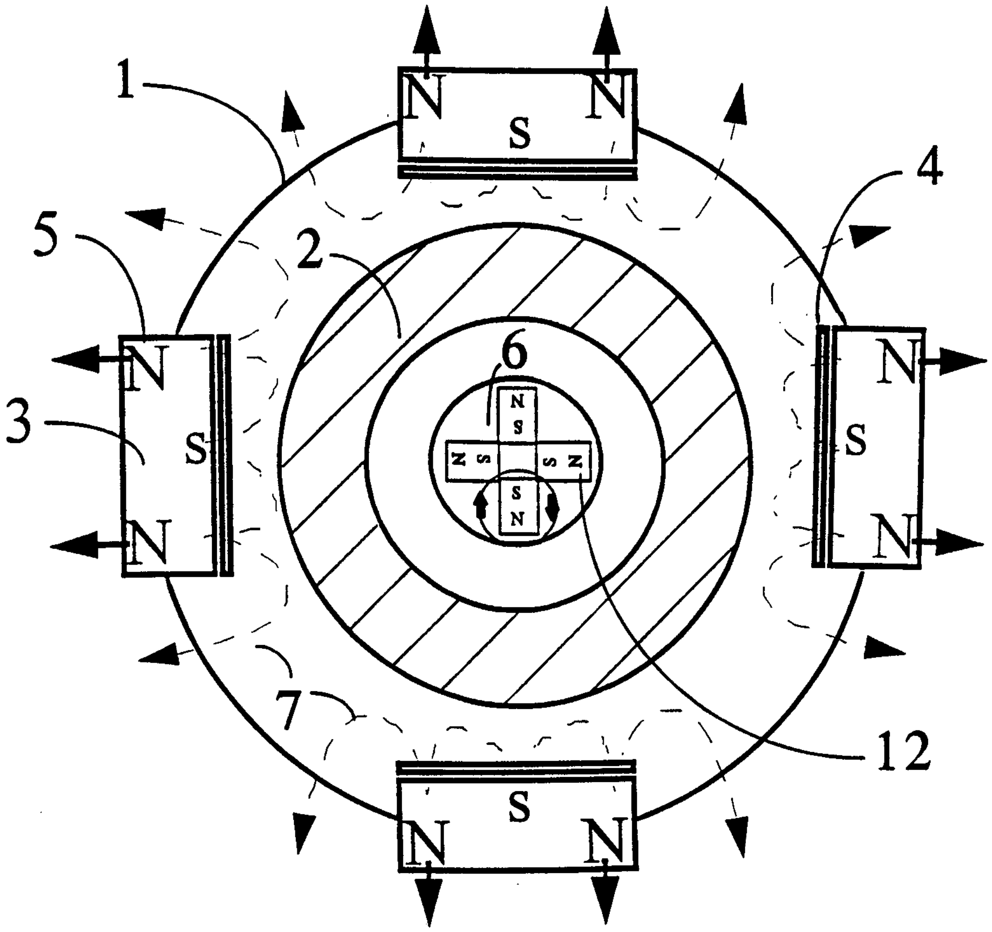

FIG. 10

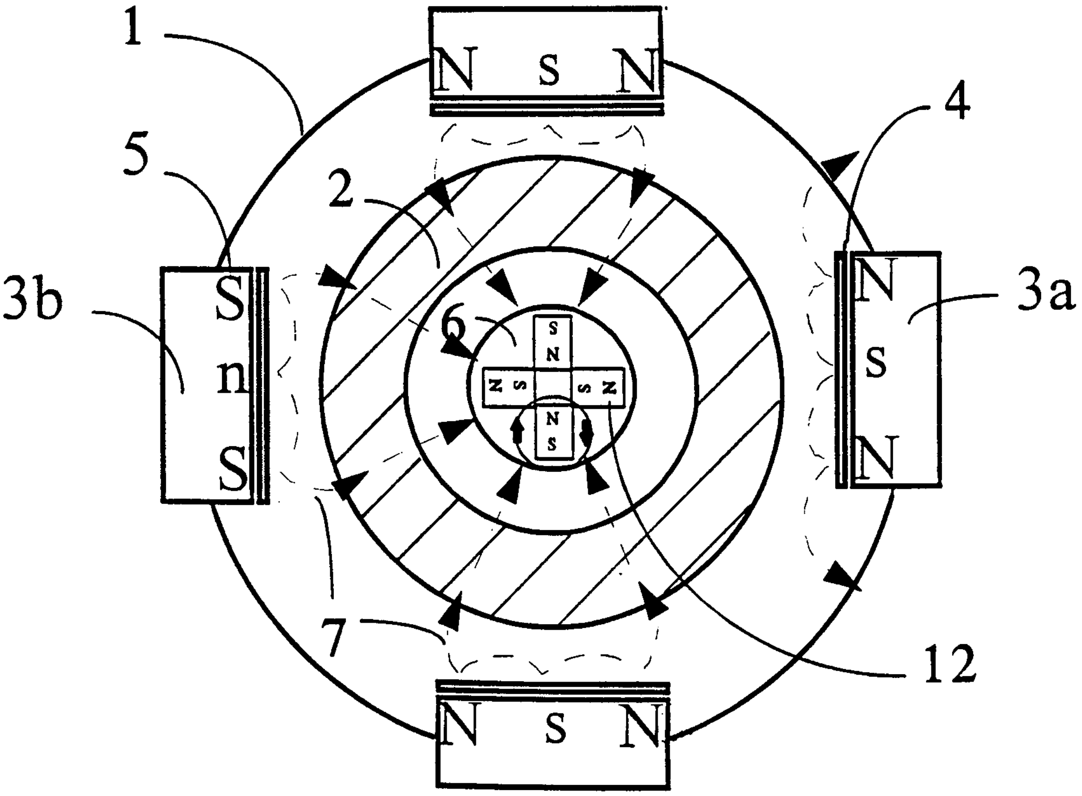

FIG. 11

INTERNATIONAL SEARCH REPORT

Inte .ional Application No
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A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 H01J37/34

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 H01J

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

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C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 3 905 887 A (KUEHNLE MANFRED R) 16 September 1975 see column 8, line 19 - column 10, line 63; figures 1,2	1-10
Y	PATENT ABSTRACTS OF JAPAN vol. 013, no. 069 (C-569), 16 February 1989 & JP 63 262462 A (UBE IND LTD), 28 October 1988, see abstract	1-10
A	EP 0 328 257 A (OPTICAL COATING LABORATORY INC) 16 August 1989 see page 5, line 9 - line 49; figures 1-3	1-10

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☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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INTERNATIONAL SEARCH REPORT

Information on patent family members

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