Sept. 30, 1958 M. H. CUNNINGHAM 2,854,273

MAGNETIC HOLDING DEVICE

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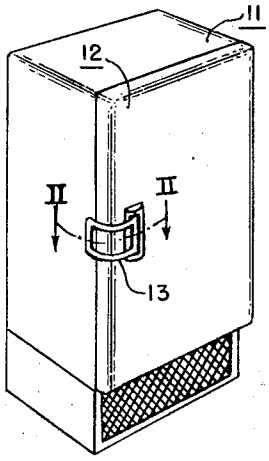


FIG. 1.

FIG. 3.

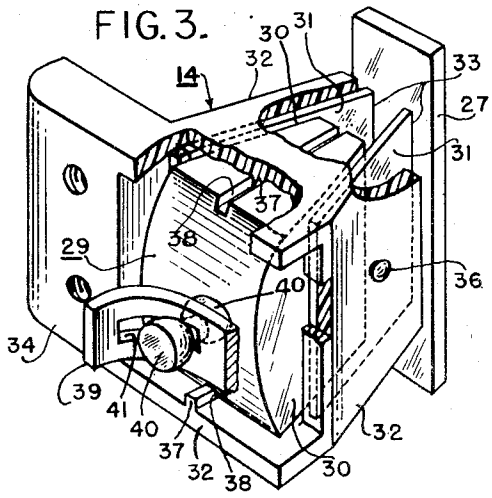
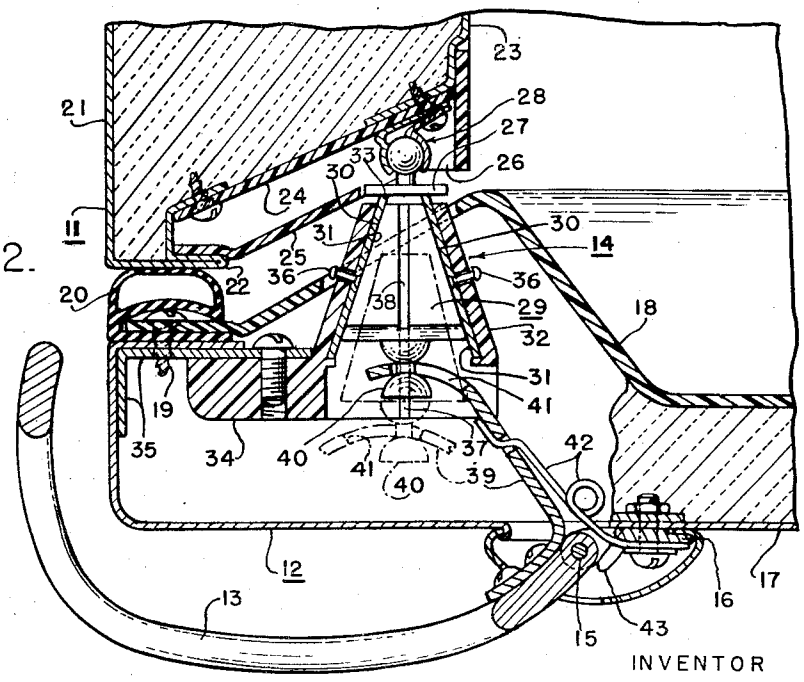


FIG. 2.



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FIG.4.

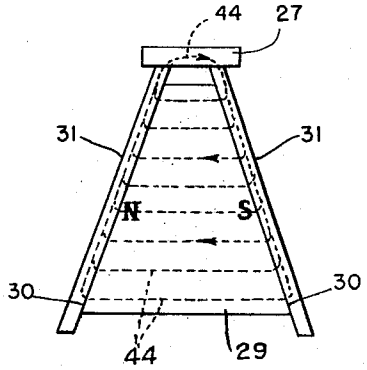
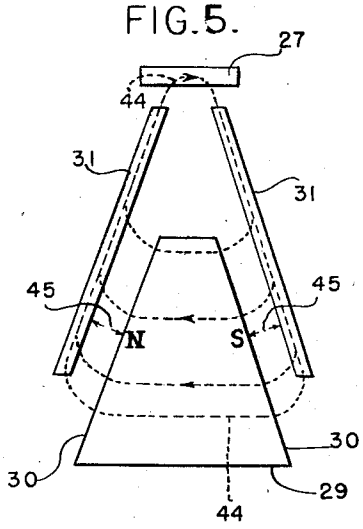


FIG.5.



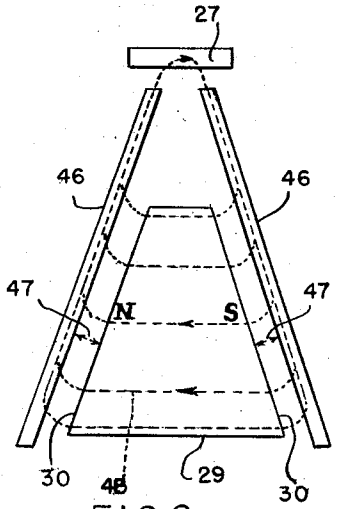


FIG.6.

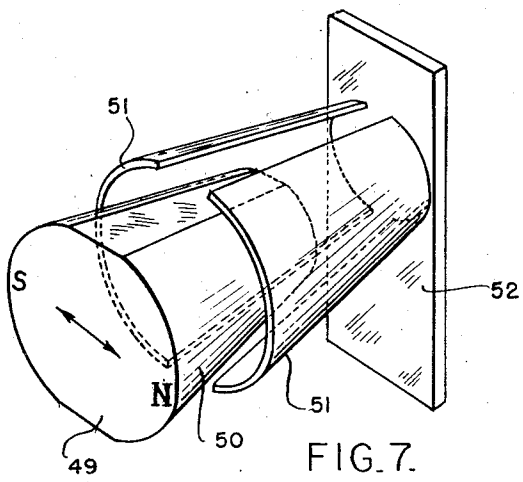


FIG.7.

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MAGNETIC HOLDING DEVICE

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Application June 11, 1956, Serial No. 590,603

7 Claims. (Cl. 292—251.5)

This invention relates to magnetic holding devices and more particularly to a permanent magnet latch suitable for use with refrigerator doors and the like.

It is the principal object of this invention to provide a permanent magnet holding device that possesses sufficient attractive force to hold a refrigerator door in closed and sealing position and in which the attractive force may be reduced sufficiently to enable the user of the refrigerator to open the door easily.

Another object of the invention is to provide a magnetic holding device in which the magnetic attractive force may be varied at the will of the user.

It is another object of the invention to provide a unique arrangement of elements in a magnetic holding device that permits movement of the magnet with respect to its pole pieces to vary the magnetic flux in the pole pieces.

It is a further object of this invention to provide a unique permanent magnet structure for use in magnetic holding devices.

These and other objects are effected by the invention as will be apparent from the following description and claims taken in connection with the accompanying drawings, forming a part of this application, in which:

Fig. 1 is a perspective view of a domestic refrigerator cabinet of the type in which the magnetic holding device of this invention may be utilized;

Fig. 2 is a horizontal sectional view taken as indicated by the line II—II of Fig. 1 and illustrating the magnetic holding device of this invention applied to a domestic refrigerator cabinet;

Fig. 3 is a perspective view of the magnetic holding device shown in Fig. 2 with portions broken away to clarify the illustration;

Figs. 4 and 5 are diagrammatic representations of the magnetic circuit of the holding device of this invention and illustrate the operation of the device;

Fig. 6 is a diagrammatic illustration of the magnetic circuit of a holding device embodying a modification of this invention; and

Fig. 7 is a perspective view of a modified magnet and pole piece combination usable in the holding device of this invention.

Referring now to the drawings for a detailed description of the invention, Fig. 1 illustrates a domestic refrigerator comprising a cabinet **11** and a door **12** for closing an access opening in the front of the cabinet. The door **12** carries near its free edge a handle **13** adapted to be grasped by the user of the refrigerator in opening the door **12**.

The portions of the refrigerator door **12** and cabinet **11** lying immediately behind the handle **13** are illustrated in section in Fig. 2 to show in detail the magnetic holding device of this invention which is identified generally by the numeral **14**. The handle **13** is pivotally mounted at **15** to a hinge member **16** secured to the door outer shell **17**. The inner face of the door **12** is formed by a plastic inner pan **18** secured at its peripheral edges

to a flange portion of the outer shell **17** by screws **19**. Clamped beneath the periphery of the inner pan **18** and also held in place with the screws **19** is a gasket **20** that serves as a sealing member between the door **12** and the cabinet **11**.

The insulated wall structure of the cabinet **11** is of conventional construction in which an outer metallic shell **21** is provided with an inwardly flanged portion **22** at its forward edge, which serves as a seat for the gasket **20** carried by the door. An inner metal liner **23** of the cabinet **11** is maintained in spaced relationship with the outer shell **21** by non-heat conducting support members **24** secured to flanged portions of the outer shell **21** and inner liner **23**. The opening between the outer shell and the inner liner at the front of the cabinet is covered by a decorative breaker strip **25**, which is provided with an opening **26** in which is mounted a strike or armature element **27**, which is attracted by the metallic holding device **14** carried by the door **12**. The armature **27** forms a part of the magnetic circuit of the holding device **14** as will be explained hereinafter. The armature **27** is preferably securely mounted on the cabinet **11** and in such a manner as to permit adjustment of the angular position of the face of the armature with respect to the cabinet. For purposes of illustration, an adjustable ball and socket connection, indicated at **28**, is shown as a means for mounting the armature **27** to one of the support members **24** in the cabinet wall.

The magnetic holding device **14** of this invention has three principal components which are carried by the door **12**. These components are: a permanent magnet **29** characterized by broad flat pole faces **30** on opposite sides thereof, which are arranged in converging or tapering relationship; a pair of plate-like pole pieces **31** which are also arranged in converging relationship in such a manner that the inner faces thereof may engage the pole faces **30** of the magnet as illustrated in Fig. 2; and a housing **32** made of plastic or other non-magnetic material for supporting and maintaining in operative relationship the magnet **29** and the pole pieces **31** of the holding device.

The holding device housing **32** supports the magnet **29** and pole pieces **31** in the door **12** in such a position that exposed edges **33** at one end of the pole pieces **30** may engage the armature **27** carried by the cabinet **11**. For the purpose of mounting the housing **32** in the door **12**, the housing is provided with a mounting flange extension **34** at one side thereof which is attached by means of screws or other suitable fastening means to an angle bracket **35** carried by the door **12**. The pole pieces **31** may be mounted in any suitable manner within the housing **32** but are preferably retained against the side walls of the housing in such a manner as to permit slight movement of the pole pieces with respect to the housing. The retaining means shown comprises rivets **36** which pass through over-size openings in the housing side wall and permit limited movement of the pole pieces **31** with respect to the housing in order that the pole pieces may align themselves with, and rest flatly against, the pole faces **30** of the magnet **29**. The housing **32** supports the magnet **29** for movement therein and is provided with rib-like projections **37** on the inner surfaces of its upper and lower walls. These ribs **37** project into elongated grooves **38** in the upper and lower surfaces of the magnet **29** and guide the magnet for movement into and out of the space between the inner faces of the pole pieces **31**. This action is illustrated in Figs. 2 and 3 wherein, in Fig. 2, the magnet **29** has each of its pole faces **30** in contact with a pole piece **31**, while in Fig. 3 the magnet **29** is partially withdrawn from between the pole pieces **31** along the path designated by the guide ribs **37** in the housing.

In the preferred embodiment of the invention, the guide ribs 37 define a plane or path of movement for the magnet 29, which path bisects the angle between the inner surfaces of the pole pieces 31.

Movement of the magnet 29 as described above is effected by the user of the refrigerator when moving the handle 13. The handle is provided with an extension 39 which is loosely coupled to the magnet 29 by a bearing-like connector 40. The handle extension 39 is provided with an elongated slot 41 through which the connector 40 passes to permit the magnet 29 to undergo linear motion, as determined by the guide ribs 37, as the handle extension 39 swings through an arc with the handle 13. When the handle is released, a spring 42 biases the handle extension 39 with respect to the door shell 17 to effect return of the handle and the magnet 29 to the position shown in Fig. 2, i. e., to the position in which the magnet pole faces are in contact with the pole pieces 31.

The magnet 29 is preferably formed by molding from a so-called "ceramic" magnetic material. These materials are characterized by a composition of polyoxides of iron and at least one of the metals, barium, strontium and lead. The most common of these materials is identified approximately by the chemical formula $BaFe_{12}O_{19}$ and possesses a high coercive force coupled with a very low permeability, considerably less than 2. The high coercive force of this material makes it difficult to demagnatize and renders it excellent for use as a permanent magnet. The low permeability of the material, which approaches that of air, gives a magnet made therefrom some additional characteristics which render the magnet particularly useful in the holding device of this invention, as will be explained more fully hereinafter.

The magnet is formed to the desired shape by any of the well known methods. The magnet can, for example, be formed by pressing together and thereafter sintering the ingredients of the ceramic-like material, or the magnet may also be formed by molding, under heat and pressure, a mixture of finely powdered $BaFe_{12}O_{19}$ and phenolic resin. Such products are not easily machinable and are therefore preferably molded to the desired shape. These products may, however, be dressed or finished to shape by grinding.

The pole pieces 31 are preferably made of a high permeability ferromagnetic material, such as soft iron or mild steel. Though plate-like pole pieces are illustrated, and are preferred because of their low cost, other shaped pieces may be employed, as will be pointed out later; the only critical characteristics of the pole pieces that need be satisfied are (*a*) the inner, opposing faces of the pole pieces should be shaped to conform to the pole faces 30 of the magnet, and (*b*) the pole pieces should have sufficient cross-sectional area to carry all of the magnetic flux collected from across the poles of the magnet 29 without becoming saturated.

Operation

When the magnet 29 of the holding device 14 is positioned as shown in Fig. 2, the holding device 14 is capable of exerting its maximum magnetic attractive force to retain the armature 27 against the edges 33 of the pole pieces 31. This force is sufficient to maintain the door 12 in closed position and to compress the gasket 20 into sealing relationship with the cabinet flange 22. This attractive force will vary with the design of the holding device, but in the case of a domestic refrigerator will be of the order of 15 to 20 pounds with the device shown. When the user of the refrigerator grasps the handle 13 to open the door 12, the handle is rotated counterclockwise (as viewed in Fig. 2) and moves the magnet 29 with respect to the pole pieces 27 and in the direction in which the pole pieces 27 are diverging. By virtue of the converging or tapering relationship of the pole pieces 31 and the magnet pole faces 30, an air gap is established between the magnet pole faces and the pole pieces. This movement of the magnet 29 reduces the magnetic flux at the edges of the pole pieces 31 and reduces the attractive force between the armature 27 and the holding device 14. Depending upon the distance the magnet is moved, the holding force may be reduced to as low as ½ pound or less. This reduced attractive force maintaining the door in closed position is easily overcome by the user of the refrigerator by pulling on handle 13, which encounters a stop 43 and permits the pulling force on the handle to be transferred to the door.

The theory of operation of the magnetic holding device of this invention is illustrated by the diagrammatic illustrations in Figs. 4 and 5.

Referring to Fig. 4, the dotted lines 44 illustrate, diagrammatically, the flux path through the magnetic circuit which comprises the magnet 29, the pole pieces 31 and the armature 27. It will be noted that the dotted lines 44 are prevalent in the body of the magnet 29 when the tapering pole faces 30 of the magnet are in contact with their respective pole pieces 31, illustrating that all of the magnet-motive force, i. e., the flux available from the magnet 29, is flowing into and being collected by the pole pieces 31. These lines of force are concentrated at the edges of the pole pieces, which are close together, and flow through the armature 27, holding the armature against the pole pieces with the maximum force available from the magnet. Now consider the situation when the magnet is partially withdrawn from between the pole pieces 31 in the direction in which the pole pieces are diverging. This condition is illustrated in Fig. 5. It will be apparent that, since the pole pieces 31 are converging and the pole faces 30 of the magnet are converging, movement of the magnet a short distance from the position it occupied in Fig. 4 will establish air gaps between the pole faces of the magnets and the pole pieces. These air gaps are identified by the numeral 45. The air gaps 45 add reluctance to the magnetic circuit and considerably reduce the magnetic flux density in the pole pieces 31. Consequently, the magnetic flux at the edges of the pole pieces is reduced substantially and the armature 27 may be readily separated from the edges of the pole pieces 31 because of the reduction in the magnetic attractive force acting on the armature.

The magnetic flux at the edge of the pole pieces 31 is further reduced by another phenomena associated with the unique characteristics of the "ceramic" magnet chosen for this application. As mentioned previously, ceramic magnetic materials have very low permeability. Therefore, a magnet made from these materials preferably possesses relatively broad pole faces, i. e., the exterior dimensions of the pole faces are large as compared to the thickness of the magnet in the direction in which it is magnetized. The flux density across the pole face of this type of magnet is comparatively low, but powerful holding forces may nevertheless be obtained therefrom by utilizing high permeability pole pieces for collecting the lines of force across the face of the magnet as is done in the case of this invention. The additional reduction in flux at the edges of the pole pieces 31 due to these characteristics of the ceramic magnet may be explained as follows: With the magnet 29 withdrawn to the position shown in Fig. 5, portions of the pole faces 30 of the magnet are outside the extent of the pole pieces 31. The magnetic flux available from this "uncovered" portion of the magnet 29, in flowing to the pole plates 31, passes through an even longer air gap than that illustrated at 45. These lines of flux will not flow through the magnet 29 and then cross at the shorter air gap 45 because of the low permeability of the magnet. These lines of flux flow through the longer air gap to the pole pieces. The magnetic flux from the "uncovered" portion of the magnet 29 therefore flows through a path having a higher reluctance than the path across air gap 45 through which the flux from the remainder of the magnet passes and an additional reduction in the

magnetic field at the edge of the pole pieces results. Stated differently, it could be said that the magnetic flux is not collected as effectively from the "uncovered" portions of the magnet pole faces as it is from those portions of the pole faces which remain within a projected area of the pole pieces **31**.

Modifications

A permanent magnet holding device may be made in accordance with this invention in which the magnet is not withdrawn, even partially, from between the pole pieces, and in which creation of an air gap through relative movement of the tapering elements is relied on to reduce the magnetic field at the edges of the pole pieces. Such a holding device is illustrated diagrammatically in Fig. 6 in which **29** identifies the magnet having pole faces **30**, the armature is identified by the numeral **27** and the modified or "extended" pole pieces are identified by the numeral **46**. The magnet is shown in the position in which an air gap **47** is established between the magnet pole faces **30** and the pole pieces **46**. Even though the magnet **29** has been moved from a position in which its faces **30** were in contact with the pole pieces **46**, the entire area of each pole face **30** lies within the projected area or span between the pole pieces **46**. The air gap **47** is of substantially the same length across the entire pole faces of the magnet. In this position the flux path identified by the numeral **48** does not have the same amount of reluctance as the magnetic circuit of Fig. 5, but the air gaps **47**, nonetheless, establish sufficient reluctance to reduce the magnetic field at the edges of the pole pieces **46** to permit the pole pieces and the armature **27** to be easily disengaged.

It should be apparent to one skilled in the art that the pole faces of the magnet utilized in the holding device of this invention need not necessarily be flat, as they are in the preferred embodiment of the invention. Fig. 7 illustrates somewhat diagrammatically a modified holding device in which the pole faces of the permanent magnet **49** are given a generally frusto-conical surface configuration as indicated at **50**. Pole pieces **51** are provided with curved configuration complementary to the surface configuration of the magnet pole faces **50** and an armature **52** is provided for engaging and being attracted to the edges of the pole pieces **51**. Obviously, in the holding device of Fig. 7, some means would be provided for moving as well as guiding the magnet along a path between the pole pieces **51** in a manner similar to that shown in the preferred embodiment of the invention.

In each of the embodiments of this invention described above, provision is made for moving the magnet relative to its pole pieces along a path bisecting the angle between the pole pieces in such a manner as to create an air gap at each pole face of the magnet. It should be apparent, however, that the path of movement of the magnet may be altered within certain limits without affecting the operation of the device. The path of movement of magnet **29** in Figs. 2 and 3 might, for example, lie parallel to the inner face of one of the pole pieces **31**. Thus, movement of the magnet along such a path in the direction in which the pole pieces are diverging would create an air gap at but one of the pole faces **30** of the magnet. Such an air gap would be substantially twice as long as the two gaps created by moving the magnet along a path equidistant from the pole pieces and would add substantially the same reluctance to the magnetic circuit to reduce the magnetic attractive force on the armature **27**. Other intermediate paths might also be chosen with similar results.

Other modifications within the scope of this invention will occur to those skilled in the art. It has been mentioned previously that the pole pieces **31** of the preferred embodiment need not necessarily have plate-like configuration. It should also be pointed out that the armature **27** of the holding device need not necessarily be arranged in such a manner as to contact and be attracted to the edges of the pole pieces but might contact other portions of the pole pieces as desired.

From the foregoing it will be apparent that this invention provides a novel magnetic holding device that is particularly useful as a refrigerator door latch. While several forms of the invention have been shown and described, further changes and modifications will occur to those skilled in the art and falling within the spirit and scope of the invention.

What is claimed is:

1. In a magnetic holding device, the combination of a tapered magnet having poles on opposite sides thereof, complementary tapering pole pieces adapted to receive said magnet therebetween, means for moving said magnet along a path between said pole pieces and in the direction of divergence of said pole pieces to establish an air gap between the magnet and at least one of the pole pieces and to reduce the magnetic flux in said pole pieces, and an armature attractable to said pole pieces.

2. In a magnetic holding device, the combination of a tapered magnet having poles on opposite sides thereof, complementary tapering pole pieces adapted to receive said magnet therebetween, means for at least partially withdrawing said magnet from between said pole pieces to establish an air gap between the magnet and at least one of its pole pieces and to reduce the magnetic flux in said pole pieces, and an armature attractable to said pole pieces.

3. In a magnetic holding device, the combination of a permanent magnet having pole faces on opposite sides thereof and arranged in converging relationship, a pair of pole pieces formed of material of a higher permeability than said magnet, said pole pieces having opposed faces arranged in converging relationship and being adapted to collect magnetic flux from across the pole faces of said magnet when the magnet is disposed between the pole pieces and in a position in which substantially the entire surface of each pole face of the magnet is in contact with a pole piece, an armature element attractable to said pole pieces, and means for moving said magnet relative to said pole pieces along a path between the faces of the pole pieces and in the direction of divergence of said pole pieces whereby at least one air gap is created in the magnetic flux path through said magnet and said pole pieces to reduce the density of the flux in the pole pieces.

4. In a magnetic holding device, the combination of a pair of plate-like ferromagnetic pole pieces arranged in spaced converging planes whereby the like edges of said plates at one end thereof are closer together than like edges of the plates at the opposite ends thereof, a permanent magnet constructed and arranged to occupy at least a portion of the space between said pole pieces with opposite faces thereof in contact with said pole pieces, said magnet being magnetized in such a manner that said opposite faces constitute opposite magnetic poles, an armature element adapted to bridge and be attracted to the edges of said pole pieces which are closest together, and means for moving said magnet with respect to said pole pieces and generally in the direction in which said pole pieces are diverging to establish an air gap between at least one of the pole faces of the magnet and the pole piece adjacent thereto.

5. In a magnetic holding device, the combination of a pair of spaced ferromagnetic pole pieces, said pole pieces having opposed flat faces defining an acute angle therebetween, a permanent magnet disposed between said pole pieces, said magnet having opposite faces disposed at an angle which is equal to the angle between said pole piece faces, said magnet being magnetized in such a manner that said opposite faces thereof constitute opposite magnetic poles, the construction and arrangement being such that said pole pieces collect the magnetic flux from the pole faces of the magnet and concentrate said flux at the edges of the pole pieces, an armature adapted to

bridge said pole pieces and be attracted thereto, and means for moving said magnet with respect to said pole pieces along a path of movement lying in a plane bisecting the acute angle between said pole faces and in the direction in which said pole pieces are diverging whereby an air gap is established between each pole face of the magnet and the pole piece adjacent thereto.

6. In a magnetic holding device, the combination of a tapered magnet having poles on opposite sides thereof, complementary tapering pole pieces adapted to receive said magnet therebetween, and means for moving said magnet along a path between said pole pieces and in the direction of divergence of said pole pieces to establish an air gap between the magnet and at least one of the pole pieces and to reduce the magnetic flux in said pole pieces.

7. In a magnetic holding device, the combination of a permanent magnet having pole faces on opposite sides thereof and arranged in converging relationship, a pair of pole pieces formed of material of a higher permeability

than said magnet, said pole pieces having opposed faces arranged in converging relationship and being adapted to collect magnetic flux from across the pole faces of said magnet when the magnet is disposed between the pole pieces and in a position in which substantially the entire surface of each pole face of the magnet is in contact with a pole piece, and means for moving said magnet relative to said pole pieces and in the direction of divergence of said pole pieces whereby at least one air gap is created in the magnetic flux path through said magnet and said pole pieces to reduce the density of the flux in the pole pieces.

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