May 24, 1966 L. K. PARKER 3,253,194

MAGNET ASSEMBLIES

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Fig. 1.

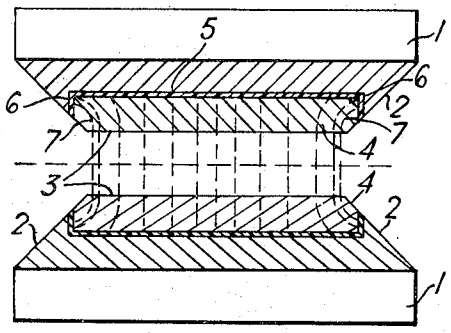


Fig. 2.

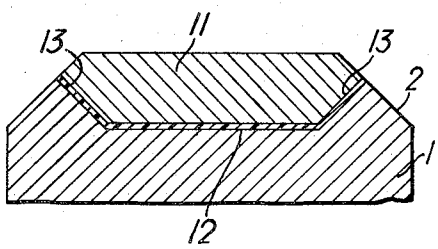
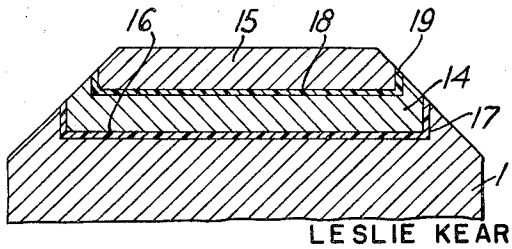


Fig. 3.



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Fig. 4.

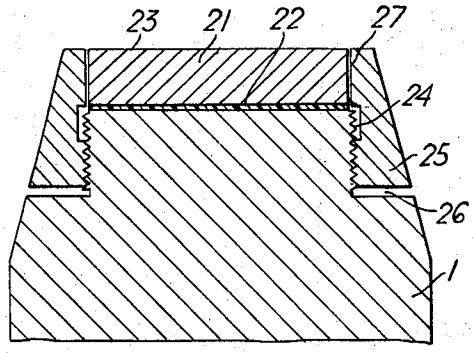
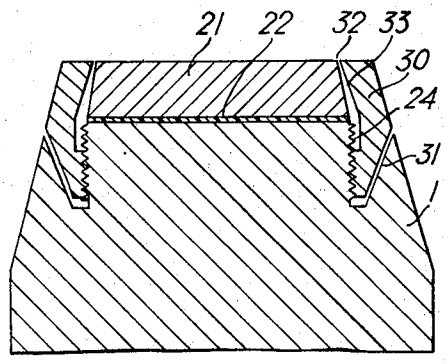


Fig. 5.



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MAGNET ASSEMBLIES

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8 Claims. (Cl. 317—158)

The magnetic field in the working air gap of a magnet is normally a maximum at the geometrical center of each pole piece and decreases towards the edges due to fringing effects which reduce the strength of the field. For many applications such a field form is not suitable. For example, there are many cases where a field which is substantially uniform at least over the central region is desirable.

According to the present invention the working face of a pole piece of a magnet is fitted with an insert of high permeability material which is separated from the body of the pole piece by a gap at least partially filled with non-magnetic material and which is of a width and configuration such as to produce a redistribution of the magnetic flux across the working face of the pole piece. The presence of this non-magnetic gap introduces additional reluctance into the magnetic circuit and variation of this reluctance across the interfaces of the pole piece and inset owing to variations in the width and configuration of the gap thus produces the necessary redistribution of the magnetic flux with a consequent adjustment of the field form.

If a field is required which is substantially uniform over at least the greater part of the working face of the pole piece as previously described, this may be achieved most simply by means of an insert which fitted into a recess so as to define a non-magnetic gap having a central portion parallel with the working face of the pole piece and of uniform width and edge portions of lesser width extending at an angle to the central portion. The reduced width of these edge portions and the correspondingly smaller reluctance leads to a proportionately greater magnetic flux, with the result that the flux at the edges of the pole piece is diverted inwardly so as to reinforce the flux in this region and to give substantial uniformity of magnetic field over the central area. The edge portions of the gap may, for example, extend substantially perpendicularly to the working face of the pole piece or alternatively may be inclined outwardly so that if, for example, the working face is circular the edge portions of the non-magnetic gap form a part-conical surface. Whatever the inclination of the edge portions of the non-magnetic gap their proportions and general configuration may be selected in accordance with the characteristics of the magnet as a whole to give the required field form.

Other shapes of insert may also be used according to the particular operating requirements. For example the insert may have a convex face fitting into a corresponding concave recess, the radius of the convex surface being slightly greater than that of the concave surface so that the non-magnetic gap is slightly wider in the middle than at the edges thus reinforcing the magnetic flux at the edges of the pole-piece in the same way as with the constructions previously described. Such a construction is not so easy to machine, however, and for this reason an insert with flat faces is preferred. Yet again more than one insert may be used so as to define a number of non-magnetic gaps in series. For example an insert having any of the shapes previously described may have a secondary insert fitted within it and separated from it by a non-magnetic gap.

The non-magnetic material in the gap is preferably

constituted by a resinous bonding agent such as an epoxy resin, for example, that sold under the registered trademark "Araldite." Alternatively the material may be constituted by an inert plastic such as nylon in which case the insert is required to be a relatively tight fit within its recess since it may then be held only by frictional forces.

As so far described it has been assumed that a particular field form will be required from any specific magnet. In some cases, however, the field form may need to be adjustable in accordance with the particular requirements of the magnetic circuit. This result may be achieved by means of a construction in which the non-magnetic gap has a fixed central portion parallel with the working face of the pole piece of the magnet and adjustable edge portions defined by a space between an axially movable member and the body of the pole piece. By appropriate adjustment of this movable member so the width of the space defining the edge portions of the gap and hence the reluctance of these edge portions may be adjusted accordingly.

Constructions in accordance with the invention will now be described by way of example with reference to the accompanying drawings in which:

FIGURE 1 shows a pair of pole pieces of a permanent magnet with a diagrammatic illustration of the magnetic field between them;

FIGURE 2 and 3 show modified constructions of polepiece; and,

FIGURES 4 and 5 show constructions of pole pieces in which the field form is adjustable.

Turning first to FIGURE 1 this shows a pair of pole pieces **1** which taper at **2** to a working face **3**, the tapered portion **2** being shown in cross-section. The working magnetic flux thus extends across the gap between the faces **3** and is indicated diagrammatically by the dotted lines. Each pole piece **1** is fitted with an insert **4** fitting into a correspondingly shaped recess so as to leave a non-magnetic gap. The insert is held in position by a resinous bonding agent which is non-magnetic and thus defines a non-magnetic gap having a central portion **5** and slightly narrower portions **6** extending at right-angles to the central portion **5**. The presence of this gap introduces additional reluctance into the magnetic circuit but owing to the smaller width of the edge portions **6** their reluctance is less, thus leading to a proportionately greater magnetic flux in these regions. As a result, the flux at the edges of the pole piece is diverted inwardly as indicated diagrammatically at **7** thus leading to greater uniformity of flux over the central region. In a particular construction where the working face **3** is circular and of 4.5 inches diameter, the insert **4** has a thickness of 1 inch, while the central portion of the non-magnetic gap is 0.006 inch wide and the edge portions **6** are 0.003 inch wide.

FIGURE 2 shows a modification of the arrangement of FIGURE 1 and only part of a single pole piece is illustrated for purposes of simplicity. The pole pieces are again shown as **1** with a tapered portion **2** but the insert which is of somewhat different configuration is shown at **11** and is again held in position by a resinous bonding agent to define a non-magnetic gap having a central portion **12** and narrower edge portions **13** which are inclined outwardly from the central portion **12** to form a part-conical surface. Again owing to the reduced reluctance of the edge portions the magnetic flux is diverted inwardly to give increased uniformity of field over the central portion of the pole piece.

In the modification of FIGURE 3 two inserts **14** and **15** are mounted in series with one another. The first insert **14** defines a non-magnetic gap having a central portion **16** and narrower edge portions **17** while the second insert **15** defines a non-magnetic gap having a central portion **18** and narrower edge portions **19**. The

effect of the reduced reluctance of the edge portions **17** and **19** is additive in diverting the magnetic flux at the edges inwardly so as to give greater uniformity over the central portion as described above.

The constructions of FIGURES 4 and 5 enable adjustable field form to be provided. Turning first to FIGURE 4 the body of the pole piece is again shown as **1** and is provided with an insert **21** which is separated from the body of the pole piece by a non-magnetic gap having a fixed central portion **22** parallel with the working face **23**. The pole piece is circular in cross-section and is formed with a screw thread **24** onto which is screwed a member **25** of the same material as the pole piece **1**. The screw threaded connection thus renders the member **25** adjustable in an axial direction so as to adjust the width of an air gap **26** between the member **25** and the body of the pole piece **1**. A second air gap **27** extends in an axial direction between the edge of the insert **21** and the inner face of the member **25** but since the faces of this gap are parallel its width is not varied by adjustment of the member **25**. The air gaps **26** and **27** together constitute the edge portions of the non-magnetic gap of which the reluctance is varied by adjustment of the member **25**. This may be carried out either manually or automatically in accordance with the requirements of any particular system.

The construction of FIGURE 5 is similar in that the pole piece **1** is fitted with an insert **21** defining a non-magnetic gap having a fixed central portion **22**. The pole piece **1** is threaded at **24** and carries an adjustable member which in this figure is of somewhat different construction and is shown as **30**. An inclined air gap **31** is defined between one face of the member **30** and a corresponding face on a pole piece **1** while a second air gap **32** is defined between another face **33** of the member **30** and an opposing face on the insert **21**. Axial adjustment of the member **30** adjusts the width of both gaps **31** and **32** and additional adjustment is produced by the fact that the face **33** is not parallel to the corresponding face of the insert **21**.

In the constructions of FIGURES 4 and 5 the part **21** is referred to as an insert although there is an air gap on either side of it and the term "insert" is used both in the specification and claims to include this type of construction.

I claim:

1. A magnet having a pole piece of which the working face is fitted with an insert of high permeability material which insert is separated from the body of the pole piece by a gap, at least partially filled with a non-magnetic material and of a width and configuration such as to produce a re-distribution of the magnetic flux across the working face of the pole piece, the confronting surfaces of said pole piece and said insert defining said gap being of such shape that said non-magnetic gap has a central portion, parallel with the working face of the pole piece, which portion is of uniform width as measured normal to said confronting surfaces across said gap, and edge portions, extending at a substantial angle to said central portion, which gap edge portions are of lesser width as measured thereacross.

2. A magnet according to claim **1**, in which said working face is circular, and said edge portions of said non-magnetic gap are inclined outwardly to form a part-conical surface.

3. A magnet according to claim **1** and including more than one insert defining a plurality non-magnetic gaps in series.

4. A magnet according to claim **3**, in which each of said plurality of gaps defined by the various confronting surfaces of said inserts and said pole piece includes edge portions, each of which has a lesser width than the central portion of the same gap.

5. A magnet according to claim **1** in which the non-magnetic material in said gap is a resinous bonding agent.

6. A magnet according to claim **1**, in which said edge portions of said non-magnetic gap are adjustably defined by a space between an axially movable member and the body of said pole piece.

7. A magnet according to claim **6**, in which said edge portions of the non-magnetic gap are further defined by a space between the axially movable member and the side of said insert.

8. A magnet according to claim **7**, in which the side of said axially movable member adjacent the insert is inclined to the axis of said pole piece.

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