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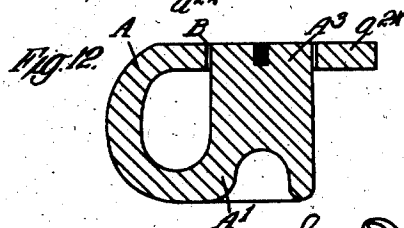
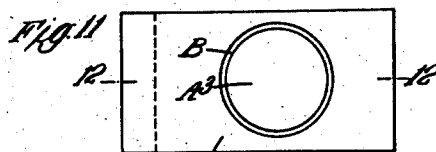
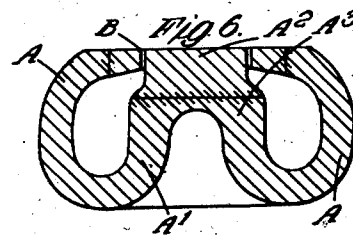
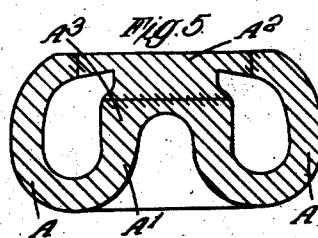
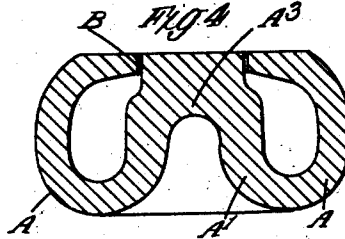
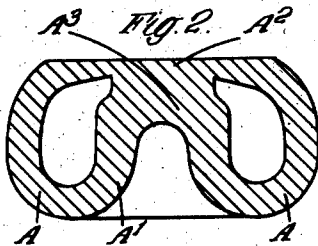
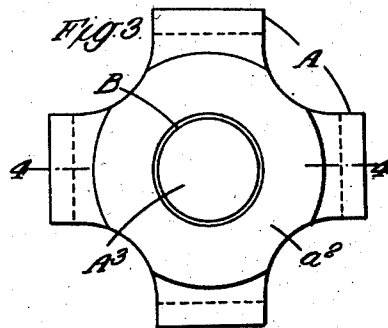
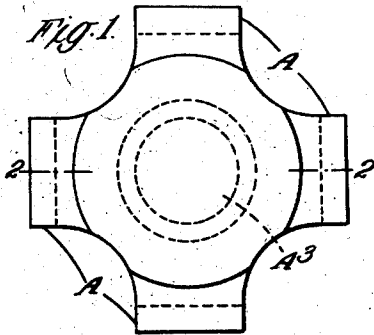
G. D. L. HORSBURGH ET AL

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PERMANENT MAGNET

Filed Jan. 31, 1930

2 Sheets-Sheet 1



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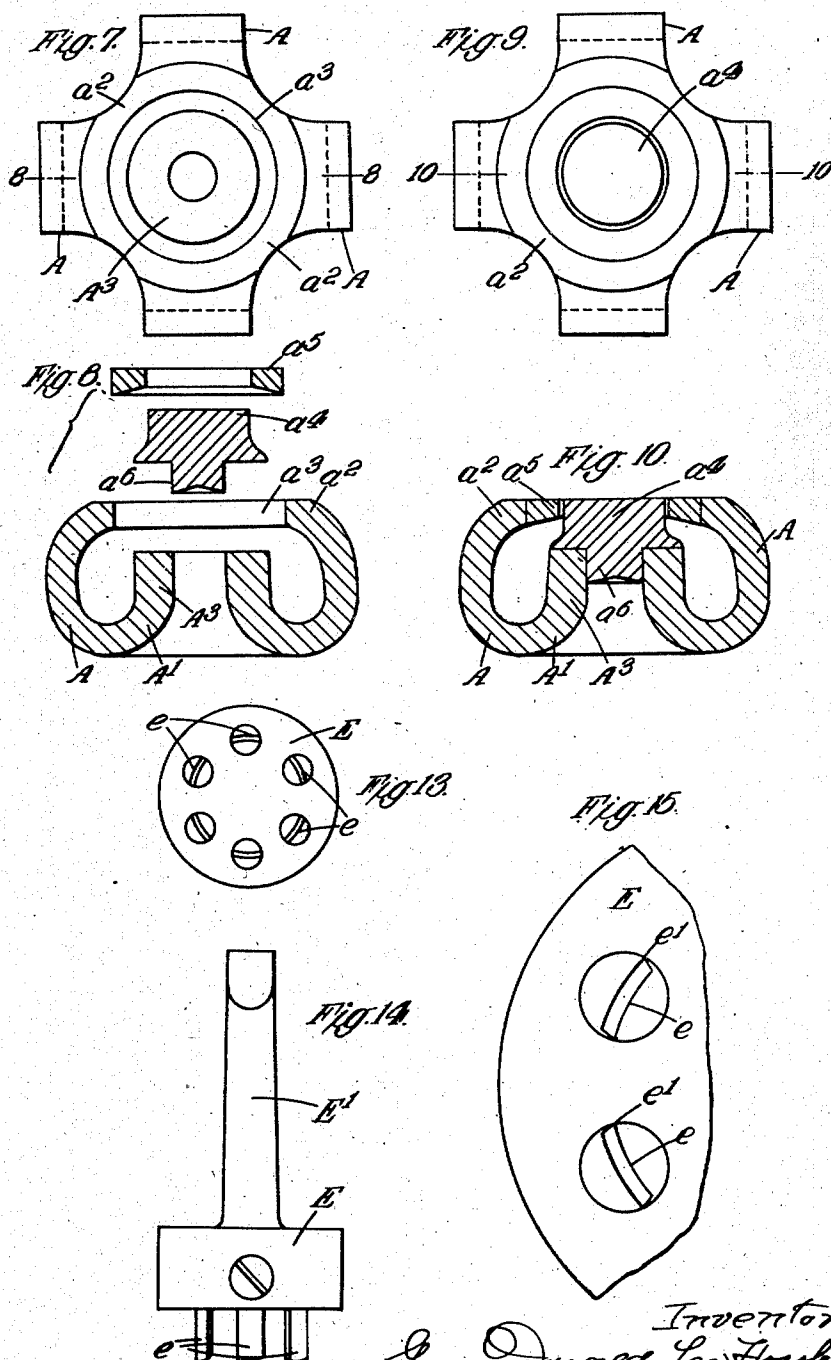
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PERMANENT MAGNET

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2 Sheets-Sheet 2



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PERMANENT MAGNET

Application filed January 31, 1930, Serial No. 424,957, and in Great Britain August 22, 1929.

This invention relates to permanent magnets and more particularly to permanent magnet "units" intended for use with sound reproducing or transmitting apparatus of the kind in which a diaphragm is connected to a coil situated in a magnetic field or gap.

Various attempts have been made to produce a satisfactory permanent magnet unit of the above kind, but these have not been altogether successful. In cases where the magnet unit has been built up of separate parts it possesses certain defects, particularly in that it has not realized adequate magnetic strength owing to the presence of mechanical joints, or to the necessity for assembling the parts after the magnets have been magnetized, or to the units being so costly as to be commercially prohibitive except in special cases; moreover, there is a liability of certain of the parts to move and thus disturb the continuity of the gap.

In the case where the block is cast in one with a number of loop-like limbs (two, four or six, for example) integral with the crown, they may radiate from the base and crown of a common or central pole-piece forming part of what has been termed above the body portion, which is preferably circular in cross-section, the adjacent ends of the loop-like limbs being separated from the crown by the aforesaid trepanning or similar operation so that they are curved in conformity therewith to form a number of segmental gaps between the crown and the adjacent ends of the limbs. It is preferable however, that the block be so cast and the trepanning or similar operation be so performed that the adjacent ends of the limbs remain united together by a web of metal forming an integral part of the casting so that the central pole-piece is surrounded by metal constituting the outer wall of a continuous circular gap with the result that the magnetic flux is substantially equalized around the whole of the gap. The web of metal moreover prevents the loop-like limbs from becoming distorted especially during hardening or operations subsequent to the casting, which might occur, and to different extents, if no web of metal were present. Instead of forming the circular gap by trepanning as aforesaid it may be formed by casting the unit with a space between the crown and the adjacent ends of the limbs for soft iron pole pieces suitably shaped to form the gap.

According to this invention most of these defects are overcome by making the permanent magnet or magnet unit of magnet steel cast in the form of a block having one or more loop like limbs extending outwardly or radially from the base and crown of the body portion of which they form an integral part and forming a gap around the crown by a trepanning or similar operation to accommodate the coil or moving part of a sound reproducing or transmitting apparatus, the block thus formed with the said gap being subjected to a hardening operation and subsequently magnetized. In a magnet unit thus made, and having the gap formed as above stated there are no mechanical joints and thus the full magneto-motive force of the magnet steel is available right up to the gap, unhindered by any reluctances introduced by mechanical joints. In this case however as the unit is composed of magnet steel alone, the magnetic flux density obtainable at the gap is limited by the permeability of the magnet steel, but if the unit is made so that the poles at the opposite sides of the gap are provided with material of higher permeability than the magnet steel (for example soft iron or cobalt iron and herein- after referred to in the specification and

In the case where the unit has only a single loop-like limb, as it may have, especially where lightness is a desideratum, the portion of the metal, around the crown from which the limb extends outwardly (whether cast of magnet steel or of magnet steel and soft iron) may be separated therefrom by

the aforesaid trepanning or similar operation to form a circular gap surrounding the crown, the outer wall of said gap being continuous; or the circular gap may be formed by casting the unit with the crown and the adjacent ends of the limbs separate and providing them with soft iron pole pieces suitably shaped to form the gap.

It is desirable that in all cases the aggregate cross-sectional area of the individual limbs or the cross-sectional area of the single unit should be equal to the cross-sectional area of the common pole piece.

The magnet steel used is preferably a high percentage cobalt steel (9% to 35% cobalt). We do not however confine ourselves to the use of this steel as other magnet steels suitable for the manufacture of permanent magnets may be employed.

In order that the said invention may be clearly understood and readily carried into effect, the same will now be more fully described with reference to the accompanying drawings in which:—

Figures 1 and 2 are respectively a plan and a vertical section on the line 2—2 of Figure 1 showing one form of the metal block cast wholly of magnet steel and prior to being formed with the gap, and

Figures 3 and 4 are similar views showing the block after it has been formed with the gap.

Figures 5 and 6 are vertical sections showing a metal block cast in two metals viz. magnet steel and soft iron, before and after trepanning of the gap respectively.

Figure 7 is a plan showing the metal block as cast for use with soft iron pole pieces and

Figure 8 is a section on the line 8—8 of Figure 7, but with the soft iron pole pieces shown separate from the block and also in section.

Figures 9 and 10 are similar views showing the block after it has been fitted with the pole pieces.

Figures 11 and 12 are respectively a plan and a vertical section on the line 12—12 of Figure 11 showing the gapped cast metal block having a single loop-like limb.

Figures 13 and 14 are respectively a plan and a side elevation of a tool suitable for use in forming the gap in the cast metal blocks by a trepanning operation, and

Figure 15 is an enlarged plan view of a portion of the tool shown in Figure 13.

In Figures 1 to 4, A, A are the loop-like limbs of the cast metal block which extend radially from the base A¹ and crown A² of the body portion or central pole-piece A³ with which they form an integral or mechanically jointless part, prior to the formation of the gap B (see Figures 1 and 2) which is subsequently effected by a trepanning or similar operation as aforesaid, the said

block then presenting the appearance shown by Figures 3 and 4. In the example shown the said limbs A are of rectangular cross-section while the central pole-piece A³ is circular in cross-section, and the gap B is circular and concentric with the crown A².

The metal block illustrated in Figures 5 and 6 is cast in two metals, one magnet steel, and the other soft iron or other material of higher permeability than the magnet steel. In casting such a metal block the appropriate quantity of one metal is poured into the mould and is followed by the second metal so that the two metals unite or combine at their junction during the casting operation as indicated by the cross hatching in Figures 5 and 6. The metal block may be cast in an inverted condition in a moulding box by first pouring the molten soft iron through a suitable feeding aperture into a central opening in the mould until it reaches the requisite height which is about one third of the height of the main portion of the block. After allowing a time interval to elapse sufficient for the soft iron already cast to become in a more or less semi-plastic condition the molten magnet steel is poured into the mould through the said feeding aperture until the entire mould is filled. In the plane of contact of the two metals indicated by the cross hatching in Figures 5 and 6 merging takes place between them. After the metals have solidified the moulding box is opened and the casting removed. The loop-like limbs A, A, the base A¹ and the central pole piece A³, which constitute the bulk or main portion of the block, are of magnet steel while the crown A² and the adjacent portions of the limbs and web are of soft iron. The gap B is trepanned in the block in the same manner as in the case of the block illustrated in Figures 1 to 4 after the casting operation so that the parts immediately surrounding the gap are of soft iron as shown in Figure 10.

It is important that the said gap should be in all cases accurately formed and as its width will not generally exceed two millimeters, it is made after the casting operation and before hardening by a trepanning or similar operation in which a tool like that illustrated by Figures 13 to 15 is employed with advantage. This tool comprises a number of cutters *e* so carried or mounted on a support or head E as to lie on or near the circumference of a circle the diameter of which corresponds with that of the circular gap B to be made. The cutters *e* are slightly less in width than that of the gap to be made and are curved to conform to the curvature of the gap and the cutting edges *e*¹ of consecutive cutters are on opposite sides (see Figure 13) so that while one cutter acts on the inner face of the gap under formation, the next cutter acts on the outer face thereof and so on. The cutter sup-

port or head E is of cylindrical form carrying at one end the cutters and having at the other end a tapered portion E' for securing it in position in a lathe or other machine tool.

5 The depth of the cutters is such that there is at all times a clearance between the top of the magnet unit and the bottom of the tool support or head, which assists in the clearing of the tool from turnings or chips.

10 In the arrangement illustrated in Figures 7 to 10 the block is cast in the form shown in cross section in the lower part of Figure 8, i. e. with the crown and the adjacent ends of the limbs separated with a central circular opening a^3 and a central pole piece or body portion A' of reduced length. The inner

15 edge of the opening a^3 and the annular face of the hollow central pole piece or body portion A' are machined and the opening in the pole piece or body portion reamed out. The

20 central pole piece A' is provided with a soft iron extension piece or body portion a^4 and a soft iron ring a^5 is fitted to the inside of the opening a^3 . A concentric stub a^6 on the extension piece a^4 enters the hole in the central

25 pole piece or body portion, the stub a^6 being turned so that it is a slack fit in the aforesaid hole and its end being counter-sunk. The ring a^4 also is turned so that it is a press fit in the opening a^3 . In order to complete the

30 magnet unit the ring is pressed in and the extension piece is loosely placed in position in the opening and a spacing tube of dimensions corresponding to those of the gap is placed

35 between them so as to maintain them concentric. The unit is then turned upside down and placed on a rigid surface and a tool inserted through the hole in the central pole piece or body portion and given a blow in

40 order to expand the stub on the extension piece against the wall of the hole to maintain it in position. The spacing tube is then withdrawn leaving the ring and extension piece secured in position. It is to be observed

45 that the ring a^5 lies in the same plane as the adjacent ends of the loop-like limbs A and the associated webs a^2 and that therefore the magnetic lines pass from the block of mag-

50 netic steel to the soft iron without appreciable or sharp change of direction. The shape of the ring and of the extension piece is such that the cross-sectional area through which the magnetic lines pass diminishes in a direction towards the gap, and, as the material is

55 one of a permeability which will allow of it, the flux density increases accordingly. This effect would not be obtained to the same extent by tapering the pole pieces of a magnet composed wholly of magnet steel on account

60 of its relatively low permeability as aforesaid. In order to obtain the best results magnetically it is desirable that the proportion of magnet steel to soft iron should be as high as practicable and for the magnet poles to be

65 as near as possible to the gap. The weight

of soft iron in the arrangement illustrated in Figures 7 to 10 is about 10% of that of the magnet steel. Similar considerations apply to the arrangement of Figure 6.

It is advisable not to reduce the proportion 70 of soft iron to below the aforesaid figure as it might then be necessary to reduce the cross-sectional area so rapidly as to be likely to lead to a leakage of magnetic lines. The soft iron pole piece or pieces should be so associated 75 with the end or ends of the loop-like limbs or with the central pole piece or body portion that they form virtually an extension thereof, that is to say, they form in effect a continuation and are not, for example, secured thereto 80 in an overlapping manner. In the case of the arrangement illustrated in Figures 7 to 10 for example the soft iron ring a^5 is for this purpose inserted in the circular opening a^3 in such a manner that it does not unduly pro- 85 trude either above or below the adjacent ends of the loop-like limbs.

The magnetizing, which is carried out after the gap has been formed and the block hardened, may be effected in any suitable manner. 90

In the example shown by Figures 11 and 12 the gapped cast metal block consists of a single loop-like limb A one end of which extends from the base A' of the cylindrical body portion or pole-piece A' and the other 95 end of which is of ring-like formation surrounding the crown of the pole piece or body portion A' and constituting a continuous outer wall a^{2x} of the circular gap B. A unit of this form may be made from a metal block 100 cast of two metals, or from one having separate pole pieces of soft iron associated therewith, as in the case of a metal block of the form having a number of loop-like limbs.

It is to be understood that the term "magnet block" referred to in the appended claims is intended to include not only a permanent magnet but also a block for use in the manu- 105 facture of a permanent magnet.

What we claim and desire to secure by Let- 110 ters Patent of the United States is:—

1. A magnet block of permanent magnet steel and having a body portion and including a loop-like limb extending outwardly or radially from the base of the body portion of 115 which it forms an integral or mechanically jointless part and inwardly towards the crown of the body portion, and a gap around the crown of said body portion.

2. A magnet block of permanent magnet steel and having a body portion, a plurality of loop-like limbs extending outwardly or radially from the base of the body portion of which they form an integral or mechanically jointless part and inwardly towards the 120 crown of the body portion and a gap around the crown of said body portion.

3. A magnet block of permanent magnet steel comprising a body portion and including a loop-like limb extending outwardly or 125

radially from the base and crown of the body portion of which it forms an integral or mechanically jointless part and a continuous gap around the crown of the body portion.

4. A magnet block of permanent magnet steel comprising a body portion, a plurality of loop-like limbs extending outwardly or radially from the base and crown of the body portion of which they form an integral or mechanically jointless part.

5. A magnet block of cast metal consisting mainly of magnet steel and partly of soft iron and comprising a body portion and including a loop-like limb extending outwardly or radially from the base of the body portion of which it forms an integral or mechanically jointless part and inwardly towards the crown of the body portion and a gap in said block in that part consisting of soft iron.

6. A block for a magnet of permanent magnet steel comprising a body portion and a plurality of loop-like limbs extending outwardly or radially from the base of the body portion of which they form an integral part and inwardly towards the crown of the body portion where they are joined by integral webs.

7. A block for a magnet of permanent magnet steel comprising a body portion having a lower base part and an upper crown part and a loop-like limb extending outwardly or radially from the base and upwardly towards the crown of the body portion of which it forms an integral or mechanically jointless part, the metal of the end of the limb adjacent to the crown forming an extension surrounding the latter.

8. A magnet block of permanent magnet steel comprising a body portion having a lower base part and an upper crown part and including a loop-like limb extending outwardly or radially from the base of the body portion of which it forms an integral part and inwardly towards the crown and separated pole pieces of soft iron interposed between the crown and the end of the limb.

9. A magnet block of permanent steel comprising a body portion having a lower base part and an upper crown part and a plurality of loop-like limbs extending outwardly or radially from the base of the body portion of which they form an integral part and inwardly towards the crown of the body portion and separated pole pieces of soft iron interposed between the crown and the ends of the limbs.

10. The manufacture of a permanent magnet or magnet unit which consists in casting a block of magnet steel integral with a number of loop-like limbs extending outwardly or radially from the base of a body portion and inwardly towards the crown thereof, forming said block with a gap around the crown thereof by a machining operation, subjecting the block thus formed with said gap

to a hardening operation, inserting soft iron pole pieces in said gap and subsequently magnetizing the block.

11. A magnet block of cast metal consisting mainly of permanent magnet steel and partly of soft iron and comprising a body portion having a lower base part and an upper crown part and including a loop-like limb extending outwardly or radially from the base of the body portion of which it forms an integral or mechanically jointless part and inwardly towards the crown of the body portion where it is joined by an integral web and a gap in said block in that part consisting of soft iron.

12. A magnet block of permanent magnet steel comprising a body portion having a lower base part and an upper crown part and including a loop-like limb extending outwardly or radially from the base of the body portion of which it forms an integral part and inwardly towards the crown and a pole piece of soft iron interposed between the crown and the end of the limb.

13. A magnet block of permanent magnet steel comprising a body portion having a lower base part and an upper crown part and including a loop-like limb extending outwardly or radially from the base of the body portion of which it forms an integral part and inwardly towards the crown and separated pole pieces consisting of a ring and of an extension piece interposed between the crown and the end of the limb.

14. A magnet block of permanent magnet steel comprising a body portion having a lower base part and an upper crown part and including a loop-like limb extending outwardly or radially from the base of the body portion of which it forms an integral part and inwardly towards the crown and a single shaped member of soft iron interposed between the end of the limb and the crown and having an air gap therein.

15. A magnet block of permanent magnet steel comprising a body portion and including a loop-like limb extending outwardly or radially from the base of the body portion of which it forms an integral part and inwardly towards the crown and a pole piece of soft iron interposed between the crown and the end of the limb the proportion by weight of magnet steel to that of iron being about ten to one.

16. A magnet block of permanent magnet steel comprising a body portion and including a loop-like limb extending outwardly or radially from the base of the body portion of which it forms an integral or mechanically jointless part and inwardly towards the crown of the body portion and a soft iron pole piece interposed between the end of the limb and the crown the soft iron portion being arranged relatively to the magnet steel so that the magnetic lines pass from the mag-

net steel to the soft iron without any abrupt change of direction.

17. A magnet block of permanent magnet steel comprising a body portion and including a loop-like limb extending outwardly or radially from the base of the body portion of which it forms an integral or mechanically jointless part and inwardly towards the crown of the body portion and a soft iron pole piece interposed between the end of the limb and the crown so that it forms extensions thereof.

18. The manufacture of a permanent magnet or magnet unit which consists in casting a block of magnet steel with a loop-like limb extending outwardly or radially from the base of the body portion of which it forms an integral or mechanically jointless part, and casting the crown of the body portion and the end of the loop-like limb of soft iron so that the two metals unite at their junction during the casting operation.

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