

Aug. 3, 1943.

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2,325,844

MAGNETIC RECORDING AND REPRODUCING APPARATUS FOR USE  
WITH STEEL BANDS, WIRES, OR THE LIKE

Filed Feb. 20, 1940

4 Sheets-Sheet 1

FIG. 1

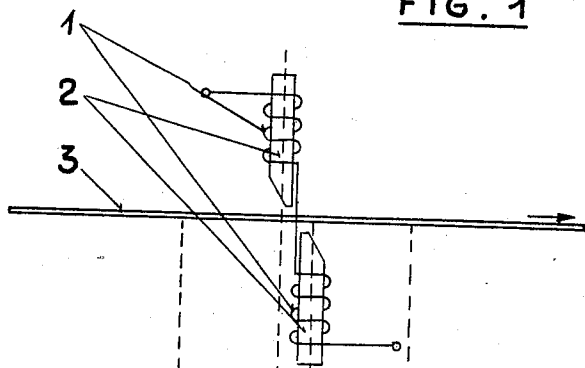


FIG. 1a

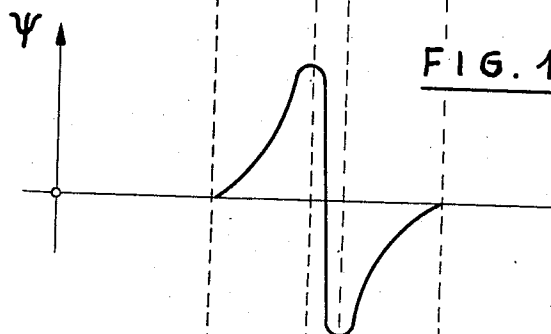
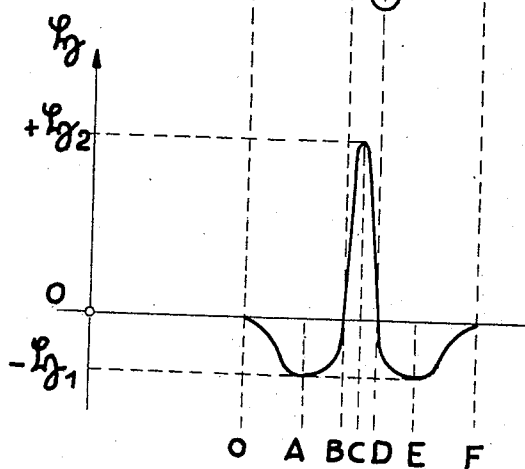


FIG. 1b



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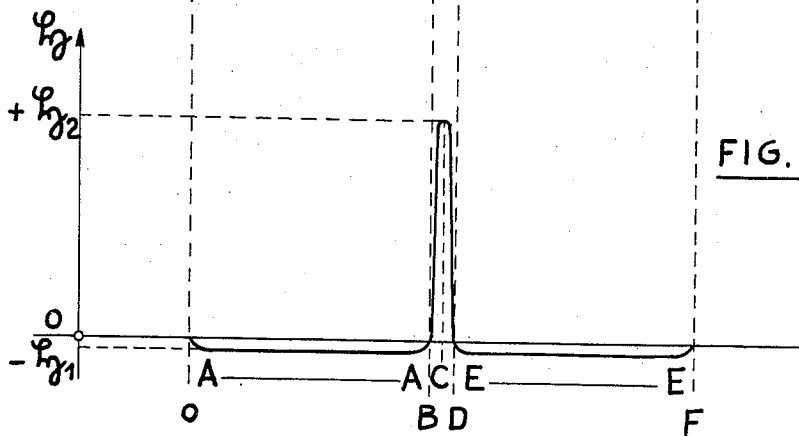
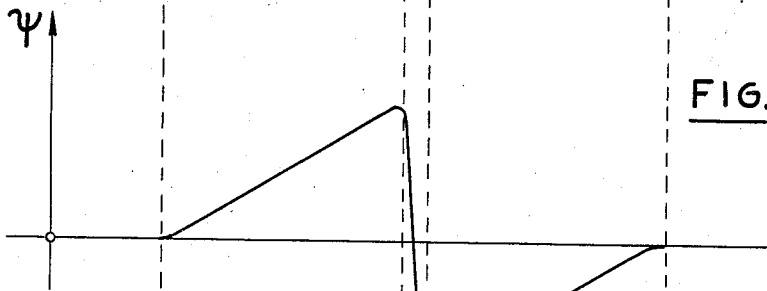
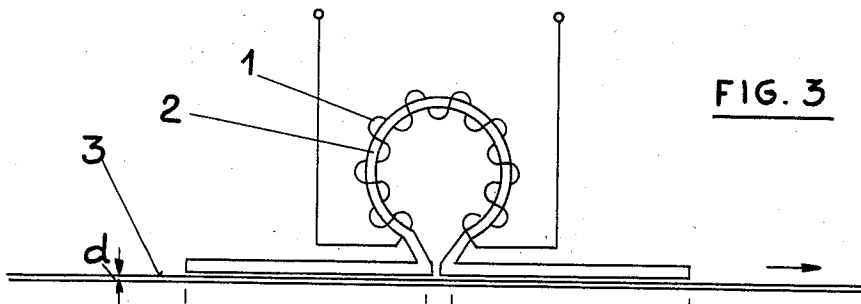
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FIG. 4.

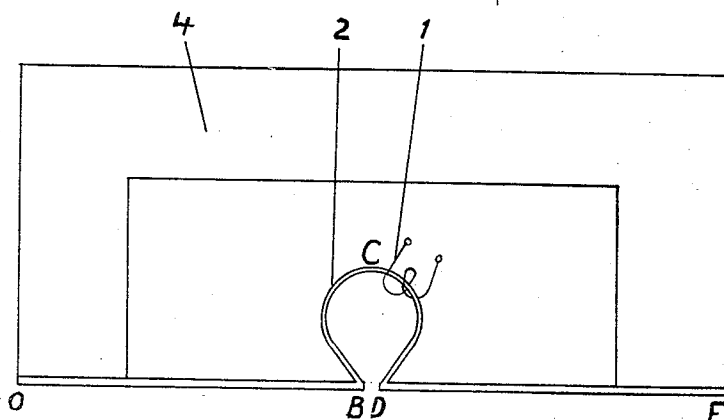
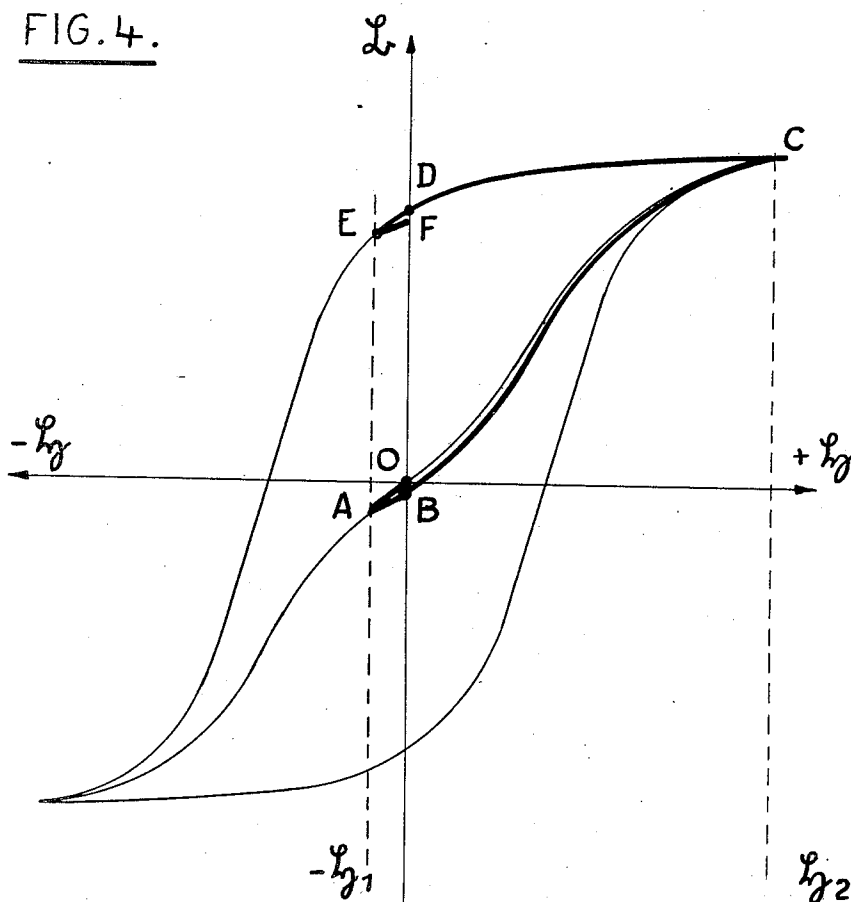


FIG. 5.

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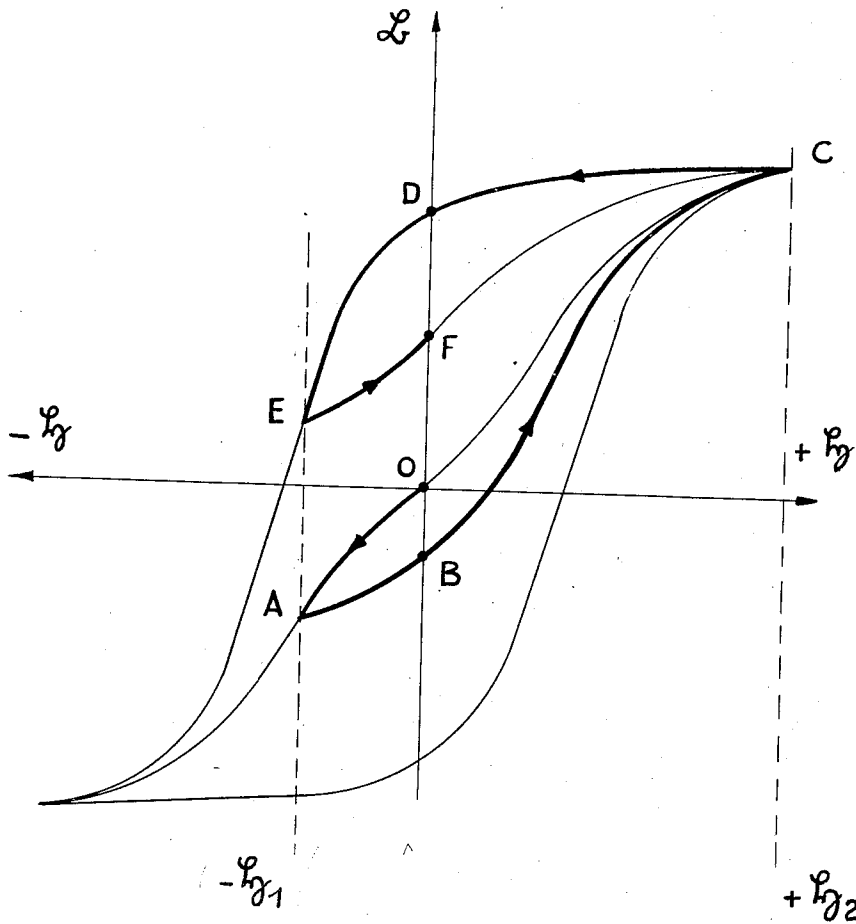


FIG. 2

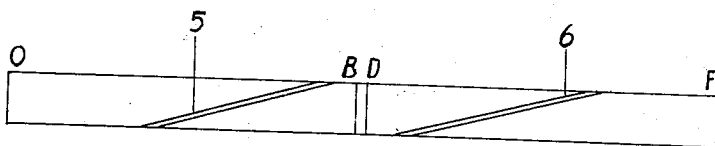


FIG. 6.

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## UNITED STATES PATENT OFFICE

2,325,844

MAGNETIC RECORDING AND REPRODUCING  
APPARATUS FOR USE WITH STEEL BANDS,  
WIRES, OR THE LIKEFriedrich Ernst Fischer, Zurich-Erlenbach,  
SwitzerlandApplication February 20, 1940, Serial No. 319,837  
In Switzerland March 13, 1939

6 Claims. (Cl. 179—100.2)

This invention relates to the magnetic recording of electrical signals, such as, for example, electrical impulses or modulated microphone currents, on steel bands, steel wires and the like, and to the subsequent reproduction of these records.

This magnetic method of recording has the advantage, as compared with other known recording methods, such as the recording on wax discs or the like with the aid of stylo devices, that the magnetic records can always be removed again at any time so that the steel band or the like used for the record is ready to receive a fresh recording. However, what is a disadvantage is the serious distortion which is always evident in the recording and reproduction of magnetic records by the use of hitherto known devices, i. e. the present-day recording and reproducing heads.

It is an object of this invention to provide an apparatus, the construction of which is based on a fresh viewpoint, which apparatus is capable of being used both as a recording head and as a reproducing head, and which avoids the severe distortion which is unavoidable with known recording and reproducing heads.

To this end, in the apparatus according to the invention, the iron parts of the recording or reproducing head are of great length in the direction of travel of the band relatively to the thickness of the band and are so constructed that the magnetic potential along the said parts varies uniformly and slowly, whereas it changes relatively rapidly between the magnetic poles which are opposite and close to one another.

Further features of the invention will be apparent from the following detailed description of the essential constructional forms and also of the principle of operation of the invention, reference being had to the accompanying drawings in which:

Figure 1 shows diagrammatically a recording head of known type;

Figure 1a is a curve showing a varying magnetic potential which may be applied to the steel band or the like;

Figure 1b shows the varying field intensity produced by the varying potential shown in Figure 1a;

Figure 2 shows the magnetisation of the steel band;

Figure 3 shows diagrammatically a form of recording head according to the invention;

Figures 3a, 3b and 4 are diagrams illustrating the operation of the head shown in Figure 3

and corresponding to Figures 1a, 1b and 2 respectively.

Figure 5 shows diagrammatically a modified recording head according to the invention, and

Figure 6 is a detail view showing the construction of part of the head shown in Figure 5.

In the first place the conditions encountered when applying the invention to a recording head will be dealt with. It is convenient first to consider the method of operation of a known recording head shown in Fig. 1. Referring to this figure, 1 represents the winding of a recording head which has an iron core 2, past which the steel band 3 is moved. The variation of the magnetic potential impressed on the steel band 3 is shown in Fig. 1a and the resulting magnetic field intensity  $H$  is shown in Fig. 1b.

If now the steel band 3, which has previously been demagnetised in known manner in a demagnetising device (not shown), is caused to move, for example, in the direction indicated by the arrow in Fig. 1, then a certain length or element of the band traverses the entire zone of influence of the recording head 1, 2 from O to F. During this time it is magnetised in accordance with the field intensities  $H$  operative at the time, according to the known laws of magnetism. In Figure 2, this is represented on the basis of the known hysteresis curve.

The completely demagnetised steel band 3 (corresponding to the point O) is, while passing through the recording head zone, subjected to a magnetic field the intensity of which varies, during the passage between the point O and the point A, from zero to the value  $-H_1$ , becomes zero again at the point B, has a maximum of  $+H_2$  at the point C, and successively passes through the values zero,  $-H_1$  and zero at the points D, E and F. Thus, the following conditions of magnetisation are obtained in the band 3 (see Fig. 2).

From the unmagnetised state, the magnetic induction of that element of the band which is being considered first increases in accordance with the initial curve from O to A and then falls again towards B, the remanent induction of the first magnetisation corresponding to the field intensity  $-H_1$ . While the field intensity increases to the value  $+H_2$  and again returns to zero, the induction  $H$  in the band follows the magnetisation curve from B to C and returns to D on the hysteresis curve; the path OD represents the magnetisation with the field intensity  $+H_2$ . A field intensity of the magnitude  $-H_1$  is again effective from D to F, i. e. the induction  $H$  on the band 3 returns beyond E towards F. The

path OF thus represents the final remanent induction of the steel band 3 which is obtained with the recording head 1, 2 shown in Fig. 1.

It is clear that the lowering of the remanent induction from the amount OD to the amount OF represents an undesired loss. Consequently, efforts have already been made to keep the demagnetising field intensity  $-H_1$  small. For this reason, the region of saturation must not be penetrated too far with the field intensity  $+H_2$ , for with known recording heads the absolute amount of the opposing field intensity  $-H_1$  also increases proportionately with  $+H_2$ .

In contrast to the above a device according to the invention and its principle of operation are illustrated in Figures 3 and 4. That portion of the iron part 2 of the recording head past which the steel band 3 moves, is of relatively great length (O—B and D—F) as compared with the thickness  $d$  of the band 3, being a multiple of the thickness of the band in the constructions shown in Figs. 3 and 5, whereas hitherto this portion, i. e. the pole ends, has always been kept as small as possible. Later on in this specification, it will be shown how this "extended" recording head may be constructed so that the magnetic potential along it follows the curve shown in Figure 3a. First, however, the principle of operation of this recording head according to the invention will be considered.

The intensity of the magnetic field strength  $H$  varies along the length of the recording head from O to F in the manner shown in Figure 3b. In consequence of the slow and uniform potential rise from O or F up to the poles B or D respectively, the values of the field intensity  $-H_1$  now remain small (and, with a uniform rise, constant). On the other hand, the high field intensity  $+H_2$  is maintained at C.

If the magnetisation of the band is considered with a magnetic field intensity varying as shown in Figure 3b, the conditions represented in Figure 4 are produced. Starting from the point O, the magnetic induction of an element of the steel band first varies from O to A in accordance with the initial curve, then returns to the remanent value of OB, follows the portion of the curve BC, returns to the remanent induction OD, follows, under the influence of the demagnetising field intensity  $-H_1$  (between D and F in Figure 3b), the hysteresis curve as far as the point E and finally returns, upon leaving the zone of influence of the recording head, to the state of remanent magnetisation OF. With a device according to the invention, therefore, the demagnetisation by the amount DF due to the field intensity  $-H_1$ , which demagnetisation is to be considered as a loss, is not nearly so great as with the known type of recording head (of Figure 2).

A further great advantage of the invention consists in that, with the magnetisation of the steel band with the effective magnetic field intensity  $+H_2$ , it is possible to go far into the region of saturation. Because the ratio between the absolute values of  $-H_1$  and  $+H_2$  is very small, according to the invention, the demagnetising field intensity  $-H_1$  itself remains small at comparatively high field intensities  $+H_2$ , and the demagnetisation produced thereby remains slight. Working in the region of strong saturation has the great advantage of balancing different disturbing influences such as variations in the distance between the recording head and the

steel band, which variations are unavoidable with a moving band.

The basis of the operation of the invention as described consists, therefore, in that the magnetic potential along those portions of the device past which the steel band is led, varies uniformly and slowly. This property can be produced in different ways, but is preferably produced by the particular construction of the device which will be described.

One embodiment of the device according to the invention, which is represented diagrammatically and by way of example in Figure 5, consists in that the two extreme ends of the iron part O, F of the recording head which are adjacent the steel band and are situated adjacent the path of the band, are connected with one another by a bridge 4 of very good magnetic conductivity. If the magnetic conductivity of the bridge 4 is high as compared with the conductivity of the parts O—B and D—F, it can be considered as a "magnetic short-circuit," i. e. the points O and F possess the same magnetic potential, viz: zero potential (midway between the poles). Since with the device according to the invention as shown in Figure 5, a closed iron path is provided the magnetic conductivity of which is uniformly high as compared with the magnetic conductivities of the surrounding parts including the steel band 3, a potential curve which is practically linear can be attained in the parts OB and DF, along which the magnetic conductivity is suitably chosen. Even without the yoke 4, it is possible to obtain a potential curve which is approximately uniform if the magnetic conductivity of the parts OB and DF are caused to become continuously smaller, for example, by gradually varying the cross-section of the parts from B towards O or from D towards F respectively.

If a device according to the invention is employed as a reproducing head, then similar advantages are obtained as compared with known reproducing heads, as in the case of a recording head. For example, if a magnetic "transition" point on the steel band 3, i. e. a point or place at which the state of magnetisation of the band varies abruptly, should arrive in the vicinity of an old type of reproducing head, the magnetic field around the transition point will generate in the iron part of the reproducing head a magneto-motive force which will increase to a definite maximum value which is given by the entire reproducing head arrangement approximately according to the curve shown in Figure 1. This magneto-motive force then suddenly changes its direction when the transition point passes under the reproducing head, and again fades away to zero. (Generally speaking, a reproducing head as at present constructed only consists of the upper half of the recording head shown in Figure 1.) The voltage induced in the winding of the reproducing head by such a flow of force in the iron part of the head has a curve approximately as shown in Figure 1b, i. e. it consists actually of three voltage impulses.

In contrast to the above, if a magnetic transition point of the steel band 3 comes under a reproducing head as shown in Figure 5, there is induced in the coil 1 of the reproducing head, a voltage having a curve approximately as represented in Figure 3b. Thus it is clear that a single voltage impulse is obtained corresponding to a magnetic transition point. This is achieved owing to the fact that the magnetic conductivity

of the bridge or yoke 4 (Figure 5) is very great as compared with the magnetic conductivity of the parts OB and DF, so that the point F of the reproducing head is always held at the same magnetic potential as the point O. Thus, at the instant at which a magnetic transition point of the band 3 arrives, under, for example, the point O of the reproducing head, no appreciable magnetic flow of force arising from the transition point of the steel band can occur in the part B—(C)—D of the reproducing head which carries the coil 1, i. e. there is no voltage induced in the coil 1. It is only when the magnetic transition point of the steel band moves from O towards B that the flow of force induced in the part B(C)D gradually increases by an amount depending on the extent to which the magnetic resistance of the yoke 4 with the connected part increases from O towards the magnetic transition point of the steel band as compared with the magnetic resistance of that part of the reproducing head between the magnetic transition point of the steel band and B. The flow of force in the iron of the reproducing head thus increases, when a magnetic transition point of the steel band 3 travels from O to F, uniformly and slowly up to a maximum value which is given by the state of magnetisation of the steel band and the relative positioning of the reproducing head and the steel band, then changes its direction and returns from its minimum value to the initial value, which can, for example, be zero. Naturally, in these circumstances, only a single voltage impulse, which clearly characterises the magnetic transition point of the steel band, is induced in the coil 1 of the reproducing head (see Figure 3b).

An additional and special construction of the parts OB and DF for producing the approximately linear potential curve or the uniform increase of the flow of force, is shown in Figure 6. In this figure, 5 and 6 indicate gaps in the parts OB and DF, which gaps can be filled with a material of very high magnetic resistance, such as brass wire.

In order to screen the apparatus from disturbing external magnetic leakage fields, it can according to the invention, be provided with magnetic screening in a manner known per se.

In the above description, the invention has been set out in concrete form. The advantages which it is possible to obtain thereby with respect to the known recording and reproducing heads result from the completely novel treatment of the problem of magnetic recording and reproduction. The constructional forms given by way of example will immediately be understood by one

skilled in the art and can even be varied in many ways without departing from the invention as set forth in the following claims.

Having now particularly described and ascertained the nature of my said invention, and in what manner the same is to be performed, I declare that what I claim is:

1. Apparatus for magnetically recording or reproducing electrical signals on or from steel bands, wires or other magnetic elements, comprising a recording or reproducing head having magnetic poles close to one another, and having iron parts of great length relative to the thickness of the element and extending in the direction of travel of the magnetic element, said parts being so constructed that the magnetic potential along the same varies substantially uniformly and slowly, but changes relatively rapidly between the magnetic poles, the magnetic element being in the form of a steel band, and the iron parts past which the steel band moves being formed with slots extending in a direction inclined to the direction of movement of the band.

2. Apparatus as claimed in claim 1, wherein the inclined slots are filled with a non-magnetic material.

3. Apparatus for magnetically recording or reproducing electrical signals on or from moving magnetic elements comprising, in combination, a moving magnetic element in the form of a steel band, a magnetic core of open loop form disposed adjacent to the band, the ends of the core constituting the poles and being arranged close to each other, a winding around the core, and separate, plate-like iron attachments extending in opposite directions from said ends of the core and away from each other substantially parallel to the moving band for a substantially greater distance than the distance between the ends of the core, the iron attachments past which the steel band moves being formed with gaps extending in a direction inclined to the direction of movement of the band.

4. Apparatus as defined in claim 3, wherein the inclined gaps are filled with a non-magnetic material.

5. Apparatus as defined in claim 3, including a magnetic yoke connecting the extreme ends of the iron attachments.

6. Apparatus as defined in claim 3, including a magnetic yoke connecting the extreme ends of the iron attachments, said yoke having a magnetic conductivity which is high in relation to the magnetic conductivity of the other parts of the magnetic circuit.

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