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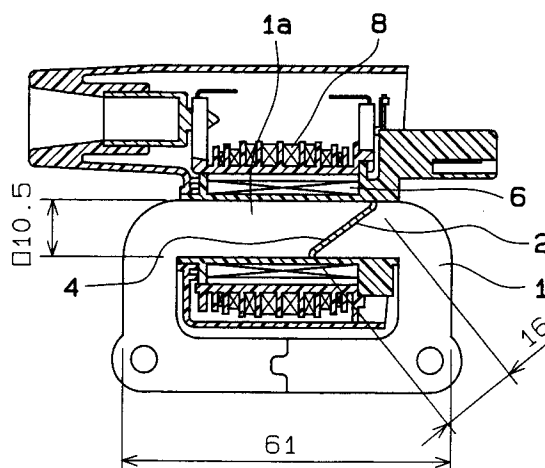
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(54) **Ignition coil.**

(57) Disclosed is an ignition coil which is most small in size without degrading performance under low primary current. The ignition coil includes an iron core (1) forming a closed magnetic circuit through an air gap (2), a primary winding (6) wound around the iron core (1) for magnetizing the iron core (1) and a permanent magnet (4) magnetized in an opposite direction to a magnetizing direction by the primary winding current. A cross-sectional area (SG) of the iron core (1) at which the permanent magnet (4) is inserted is made substantially equal to that (SM) of the permanent magnet (4). In order for the permanent magnet (4) to bias by 2/3 of the magnetic flux saturation point of the iron core (1), the permanent magnet (4) is so shaped that its thickness (LM) satisfies $0.6 \text{ mm} < LM < 1.8 \text{ mm}$ and its cross-sectional area (SM) and the cross-sectional area (SF) of winding portion of the iron core (1) satisfies $1.3 < SM/SF < 3.0$.

FIG. 1**EP 0 635 856 A1**

BACKGROUND OF THE INVENTION

[Field of the Invention]

The present invention relates to an improved ignition coil mainly used for internal combustion engines for vehicles. [Description of the Related Art]

Various kinds of ignition coils are known hitherto, wherein a permanent magnet is inserted into an air gap portion of an iron core in order to increase stored energy. Japanese unexamined Patent Publication No. 2-37705 (USP 4,990,881), for example, discloses one of improvements of these coils. Fig. 6 is a schematic view showing a fundamental magnetic circuit of an iron core which has a permanent magnet inserted into an air gap portion of the ignition coil. In a magnetic circuit shown in Fig. 6, reference mark SF is a cross-sectional area of the iron core through which magnetic flux Φ flows, SG is a cross-sectional area of a permanent magnet supporting portion of the iron core, LF is a mean magnetic path length, SM is a cross-sectional area of the permanent magnet which is hatched, and LM is a thickness of the permanent magnet.

Figs. 7 and 8 are performance characteristic diagrams for illustrating magnetic performance of the ignition coil according to the above Japanese Patent Publication.

Referring to Fig. 7, when a primary winding is wound by n turns on a winding part of the ignition coil and exciting or primary current I_p' flows through the primary winding so as to generate magnetic flux $+\Phi'$ in opposite direction to the direction of magnetization by the permanent magnet which generates a magnetic flux $-\Phi'$ in the negative direction, energy stored in the primary winding is represented by a hatched area W' and expressed by the following equation.

$$W' = (1/2)(2\Phi') \cdot nI_p' = \Phi' \cdot nI_p'$$

In order to maximize the energy W' stored in the primary winding of the ignition coil which has the inserted permanent magnet, magnetizing force of the permanent magnet must magnetize the iron core to a point P close to the saturation point of the negative flux in the iron core in negative flux region in the lower left of Fig. 8.

In Fig. 9 which is a fragmentary diagram of the positive flux region, a curve (a) represents a magnetization characteristic of the iron core, a straight line (b) represents a magnetization characteristic of the permanent magnet, and a curve (c) represents a magnetization characteristic of the primary winding. The maximum working magnetic flux density BF of the iron core is given by a value correspond-

ing to a point T which is a tangent point on the curve (a) with a straight line being parallel to the straight line (b) as a resultant summation of (a) and (b).

On the other hand, since the gradient of the magnetization curve of the primary winding is determined by permeability μ of the permanent magnet, it is of significance that a permanent magnet material which has a permeability value close to 1 should be selected in order to increase the energy stored in the primary winding represented by a hatched area W in Fig. 8, so that the permeability value close to 1 may contribute as an air gap which stores energy and to decline the magnetization curve of the primary winding shown in Fig. 8.

In connection with the ignition coil referred to Fig. 6, relationship between the thickness LM of the permanent magnet and cross-sectional area ratio SG/SF of the core has been examined. When considering the positive flux region in Fig. 8, the magnetizing force $nI_p/2$ produced by an exciting current flowing through the primary winding is the resultant of a magnetizing force $HF \cdot LF$ of the iron core (where HF is a magnetic field in the iron core) and a magnetizing force $H \cdot LM$ across the air gap portion containing the permanent magnet (where H is a magnetic field generated in the air gap portion). Thus, the above-mentioned relation is expressed by the following equation. In this case, I_p means maximum primary winding current, that is, the current under normal operation.

$$nI_p/2 = HF \cdot LF + H \cdot LM$$

Then, the following equation results.

$$H = (nI_p/2 - HF \cdot LF)/LM \text{ [AT/m]}$$

On the other hand, the following equation is deduced so that the magnetic flux density MB in the permanent magnet is expressed as follows.

$$BM = \mu \cdot H$$

$$BM = \mu \cdot (nI_p/2 - HF \cdot LF)/LM$$

Given that mean magnetic flux density in the air gap portion containing the permanent magnet is BG, the following relationship is also deduced.

$$BG \cdot SG = BF \cdot SF$$

As will be described later, in the event $SG \approx SM$ is preferably chosen in the relationship between the iron core and the permanent magnet of the ignition coil, the above equation is immediately reduced to $BM \cdot SG = BF \cdot SF$. By combining this equation with the above equation indicative of BM, there results the following relation.

$$BM = BF \cdot SF / SG = \mu \cdot (nlp/2 - HF \cdot LF) / LM$$

Consequently, the thickness LM is indicated by the following relation.

$$LM = [SG/SF] \cdot [\mu \cdot (nlp/2 - HF \cdot LF) / BF]$$

Thus, this is reduced further to the following equation as an equation indicative of the cross-sectional area ratio SG/SF.

$$SG/SF = 2 \cdot BF \cdot LM / [\mu \cdot (nlp - 2HF \cdot LF)] \quad (1)$$

In the negative flux region of the hatched region in the performance characteristic curve diagram of Fig. 8, the iron core is required to be magnetized by magnetizing force of the primary winding in opposition to energy possessed by the permanent magnet, so that positive flux may pass through the iron core. Therefore, where the iron core is first magnetized to the point P close to the saturation point in the negative flux region of the iron core depicted in the lower left region in Fig. 8 by the magnetizing force of the permanent magnet as described previously. Thereafter the iron core is magnetized to the point T near the saturation point in the positive flux region depicted at upper right region in Fig. 8 by the magnetizing force nlp due to the exciting current Ip through the primary winding. In this instance, the maximum energy EM of the permanent magnet, which depends on the material and shape of the permanent magnet, is related to the energy W in Fig. 8 which is stored in the primary winding, by $EM = (1/2)W$. The area indicative of W in Fig. 8 is $W = (1/2)(2 \cdot BF \cdot SF) \cdot nlp = BF \cdot SF \cdot nlp$.

On the other hand, since the maximum energy product of a permanent magnet is expressed as $(B \cdot H)_{MAX}$, and the theoretical value of maximum energy EM possessed by the permanent magnet is expressed by $EM = (B \cdot H)_{MAX} \cdot (SM \cdot LM)$. As an operating point of the permanent magnet to be determined by the gradient of the magnetization curve (b) of the permanent magnet shown in Fig. 9, chosen is the point which gives the maximum energy product $(B \cdot H)_{MAX}$ or which is around such optimum point.

Thus, the energy stored in the primary winding is expressed as follows.

$$W = BF \cdot SF \cdot nlp = 2EM = 2 \cdot (B \cdot H)_{MAX} \cdot (SM \cdot LM)$$

From this equation, the following equation indicative of the cross-sectional area ratio SM/SF is obtained.

$$SM/SF = BF \cdot nlp / [2 \cdot (B \cdot H)_{MAX} \cdot LM] \quad (2)$$

The above two equations (1) and (2) indicate the relationship between dimensions of individual portions of the magnetic circuit in the ignition coil.

As a material for permanent magnet, SmCo5 (samarium cobalt) is used and specifications of the elements are as follows.

$$(B \cdot H)_{MAX} = 20 \text{ MG} \cdot \text{Oe and } \mu = 1.05$$

The iron core is formed of non-oriented silicon steel plates and value of elements therefore are as follows.

$$SF = 49 \text{ mm}^2, BF = 1.4 \text{ Wb/m}^2, \\ nlp = 800 \text{ AT}, HF = 150 \text{ AT/m, and} \\ LF = 0.1 \text{ m}$$

The value of the elements are substituted into the equations (1) and (2) to obtain the relationship between LM and each area ratio SG/SF and SM/SF are graphically shown in Figs. 10 and 11. Illustrated in Figs. 10 and 11 is a secondary voltage V2 generated in the secondary winding which is obtained from performance tests conducted for various ignition coils which have different dimensions of individual portions depending on the changes in thickness LM of the permanent magnet. Particularly, Fig. 11 shows distribution curves of the secondary voltage V2 shown in Fig. 10 after converting them into a two-dimensional characteristic curve and as a relationship between the thickness LM of the permanent magnet and the magnitude of the secondary voltage V2.

As a result of thus obtained data illustrated in Figs. 10 and 11 under given dimensional conditions of the ignition coil, taught are the following relations.

(a) $SG \approx SM$, that is, the cross-sectional area of the permanent magnet supporting portion of the iron core should be substantially equal to the cross-sectional area of the permanent magnet.

(b) As long as the values of LM, SM/SF and SG/SF are within the following ranges, a secondary voltage V2 is remarkably high.

$$0.6 \text{ mm} < LM < 1.8 \text{ mm}$$

$$2 < SM/SF < 6$$

$$1.5 < SG/SF < 4.5$$

Figs. 15 and 16 show cross-sectional and side views of another conventional ignition coil which has no permanent magnet, respectively. Figs. 17 and 18 respectively show the cross-sectional and side views of the ignition coil which utilizes the permanent magnet according to the above prior art 1. As it is clearly understood by reference to each Figures and dimensions respectively, the ignition coil applied with the permanent magnet may drastically realize small size (see the typical dimension values in the Figures) and light weight (190 grams)

ignition coil compared with the prior art (350 grams) which has no permanent magnet.

The ignition coil in the prior art described hereinabove and illustrated in Fig. 17 is mostly effective in a highly sophisticated ignition system which may supply 6A (Amperes) drive current constantly to the primary winding which has less than one ohm resistance even in a case when a battery voltage dropped below the specified value as to maximize the magnetic flux density. The relationship between the primary cut-off current and secondary output voltage (I1-V2) of the ignition coil in the prior art which has no permanent magnet but has the same secondary output voltage at the same primary current of 6A is graphically compared in Fig. 12 by a solid and dotted lines respectively.

The I1-V2 relationship in Fig. 12 indicates that the secondary output voltage of both ignition coils in the prior art is mostly same at around 6A of the primary current, but the output voltage of permanent magnet type is clearly less than that without permanent magnet particularly in the lower primary current range than 3A. As illustrated in Fig. 13, this comes from the reason that magnetizing characteristic of the primary winding actually has a curvature in the case when the ratio between the cross-sectional area of the permanent magnet SM and that of iron core SF is chosen as 3 ($SM/SF = 3$), and the iron core is negatively magnetized into magnetic saturation region by the permanent magnet. In other words, as illustrated in Fig. 14, the stored energy W3' in lower primary current range is less than the energy W' of the ignition coil which has no permanent magnet by the amount corresponding to magnetic saturation, and this results in output performance degradation.

For the ignition system in which the ignition coil has a primary winding of more than 1 ohm resistance and primary current is mainly controlled by dwell angle, the output performance at around 3A primary current range becomes very important, particularly in an engine cranking time under high temperature and low battery voltage. Technical study and understanding regarding this phenomenon is a basic motivation for inventors of the present invention.

SUMMARY OF THE INVENTION

It is an object of this invention to newly realize a small and light weight ignition coil without losing the output performance in lower primary current range.

According to the invention for attaining the above object, thickness LM of a permanent magnet and SM/SF ratio between two cross-sectional areas SM and SF are chosen as follows so that the

working magnetizing zone of a primary winding does not reside in the curved zone of magnetization characteristics in the negative region as illustrated in Fig. 4.

0.6 mm < LM < 1.8 mm and 1.3 < SM/SF < 3.0

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a sectional view of an ignition coil according to one embodiment of this invention; Fig. 2 is a side view of the ignition coil according to the embodiment;

Fig. 3 is a magnetization performance diagram of a non-oriented silicone steel sheet;

Fig. 4 is a magnetic characteristic performance diagram illustrating the magnetic performance of the ignition coil according to the embodiment;

Fig. 5 is a characteristic diagram illustrating a relation between a primary cut-off current and a secondary voltage of the ignition coil of the present embodiment which has a permanent magnet in comparison with a prior art which has no permanent magnet;

Fig. 6 is a schematic view illustrating a fundamental magnetic circuit for the iron core in the prior art which has a permanent magnet;

Fig. 7 is a performance characteristic diagram illustrating the fundamental magnetic performance of the ignition coil of the prior art;

Fig. 8 is a performance characteristic diagram illustrating the magnetic performance of the ignition coil of the prior art;

Fig. 9 is an explanatory diagram for explaining a process of determining a suitable value for the maximum working magnetic flux density of the iron core in the positive flux region of the magnetic performance characteristics shown in Fig. 8;

Fig. 10 is a characteristic diagram illustrating a relationship of a cross-sectional area ratio SG/SF and SM/SF and the voltage V2 generated by the secondary winding versus the thickness LM of the permanent magnet;

Fig. 11 is a characteristic diagram illustrating a relationship between the secondary voltage V2 and the thickness LM of the permanent magnet;

Fig. 12 is a characteristic diagram illustrating a relationship between secondary voltage and cut-off current of primary winding of the ignition coils of the prior art with and without permanent magnet;

Fig. 13 is a magnetic performance characteristic diagram in the case of the cross-sectional area ratio being SM/SF = 3;

Fig. 14 is a magnetic performance characteristic diagram of the ignition coil which has no permanent magnet;

Fig. 15 is a sectional view of the ignition coil which has no permanent magnet;

Fig. 16 is a side view of the ignition coil which has no permanent magnet;

Fig. 17 is a sectional view of the ignition coil according to the prior art; and

Fig. 18 is a side view of the ignition coil according to the prior art.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The present invention is described hereinafter in more detail with reference to an embodiment illustrated in Figs. 1 through 5. Fig. 1 is a sectional view of an ignition coil according to an embodiment of this invention and Fig. 2 is a side view of the same. In Figs. 1 and 2, an iron core 1 is made by laminated non-oriented silicone steel sheets and forms closed magnetic flux circuit via an air gap 2 diagonally arranged in the iron core 1.

A permanent magnet 4 is inserted into the air gap 2 of the iron core 1. A primary winding 6 is wound on the iron core 1. The permanent magnet 4 is magnetized in the opposite direction to the direction of magnetization by the exciting current flowing through the primary winding 6. Electrical resistance of the primary winding 6 in case of this embodiment is made to be more than 1 ohm. However, it is another solution to make more than 1 ohm electrical resistance by connecting an external resistance in series with the primary winding 6.

Further, a secondary winding 8 is wound on the primary winding 6. Here, the mutual relationship between of thickness LM of the permanent magnet 2, diagonal cross-sectional area SM of the permanent magnet 4 and non-diagonal or normal cross-sectional area SF of the iron core 1 at the winding portion is selected to satisfy the following condition. In addition to this condition, the diagonal cross-sectional area SG of the iron core 1 at the air gap portion is so formed as to be nearly equal to the cross-sectional area SM of the permanent magnet 4.

$$0.6 \text{ mm} < LM < 1.8 \text{ mm}$$

$$1.3 < SM/SF < 3.0$$

Here, referring to the relationship of magnetic flux density B versus magnetizing force H on the B-H characteristic curve of non-oriented silicone steel sheet in Fig. 3, increment of the magnetizing force H becomes larger from the point where the flux density B equals 1 [T]. That is, the flux density B start its saturation over the point of B=1 [T], then stored magnetic energy does not increase, because the magnetic energy is integrated product of the magnetizing force H by magnetic flux density B.

Therefore, as illustrated in Fig. 4, it is possible to control magnetization curve by the primary winding not to come into curved portion in the negative magnetizing region in the left lower side of the diagram. Since the magnetic saturation point of the iron core 1 is generally at the point where BF nearly equals 1.5 [T], it is better to specify magnetic working range up to 1.5 [T] on the magnetization curve of the core 1 in the positive region and to specify negatively biased magnetic working point of the permanent magnet around the point of 2/3 of the saturation point.

Left lower side of Fig. 4 illustrates that magnetization by the primary winding in the negative region does not come to the magnetic saturation zone. Excessively small negative bias of the permanent magnet causes counter-effect for purpose to minimize the ignition coil. Practically, in case when the thickness LM of the permanent magnet 4 is the same as that of the prior art, the cross-sectional area SM of the permanent magnet results in roughly 2/3 of that of the permanent magnet applied in the prior art. As the permanent magnet in this embodiment of the present invention, the same magnet material as in the above described prior art which has specification of $\mu = 1.05$ and $(BH)_{MAX} = 20 \text{ MG} \cdot \text{Oe}$ is used.

Thickness LM of the permanent magnet 4 of the present invention is selected within the same range ($0.6 \text{ mm} < LM < 1.8 \text{ mm}$) of that of the prior art, because this range provides maximum secondary voltage V2 as indicated in Fig. 11. The cross-sectional area ratio SM/SF is also selected within the range of $1.3 < SM/SF < 3.0$ due to the following relationship. That is, when the condition $SG = SM$ is added to relationship $1.5 < SG/SF < 4.5$ and $2 < SM/SF < 6$ in the prior art, the relationship between SM and SF results in the following rather limited range.

$$2 < SM/SF < 4.5$$

In the embodiment of the present invention, new condition, that is, 2/3 times factor which has been discussed in detail should be added to the above condition, then it makes concluded allowable lower and upper limit of the ratio SM/SF as follows.

$$1.3 < SM/SF < 3.0$$

As illustrated in Fig. 4, the ignition coil of the present invention may use its straight line portion as the magnetization curve for the primary winding by the introduction of the 2/3 factor and SM/SF ratio of 1.5. Further, as illustrated in Fig. 14 in relation to the prior art, the stored energy $W'_{1.5}$ on the lower current range is approximately equal to the energy W' of ignition coil which has no permanent magnet. Further, Fig. 5 shows that there is no difference in the secondary output voltage V2 versus cut-off current of the primary winding 6 of both ignition coils of the present invention and the prior

art which has no permanent magnet.

As it is clearly understood referring to the dimensions of the ignition coil of the present invention provided for easy understanding in Figs. 1 and 2 comparing with that of the one shown in Figs. 15 and 16, small and light weight (240 grams) can be realized compared with one of the prior art (350 grams) without degrading output performance at low primary current range.

The present invention should not be limited to the above-described specific one but may be modified in various ways without departing from the essence and spirit of the invention.

Disclosed is an ignition coil which is most small in size without degrading performance under low primary current. The ignition coil includes an iron core (1) forming a closed magnetic circuit through an air gap (2), a primary winding (6) wound around the iron core (1) for magnetizing the iron core (1) and a permanent magnet (4) magnetized in an opposite direction to a magnetizing direction by the primary winding current. A cross-sectional area (SG) of the iron core (1) at which the permanent magnet (4) is inserted is made substantially equal to that (SM) of the permanent magnet (4). In order for the permanent magnet (4) to bias by 2/3 of the magnetic flux saturation point of the iron core (1), the permanent magnet (4) is so shaped that its thickness (LM) satisfies $0.6 \text{ mm} < LM < 1.8 \text{ mm}$ and its cross-sectional area (SM) and the cross-sectional area (SF) of winding portion of the iron core (1) satisfies $1.3 < SM/SF < 3.0$.

Claims

1. An ignition coil comprising:
 - an iron core (1) forming a closed magnetic path through an air gap (2) provided therein;
 - a primary winding (6) wound on said iron core for magnetizing said iron core when supplied with an electric current, said primary winding having a primary resistance being higher than 1 ohm;
 - a secondary winding (8) wound on said iron core; and
 - a permanent magnet (4) inserted in said air gap of said iron core and magnetized in an opposite direction to a magnetizing direction by the supply of electric current to said primary coil, wherein a cross-sectional area (SG) of said iron core at which said permanent magnet is inserted is made substantially equal to a cross-sectional area (SM) of said permanent magnet, a thickness (LM) of said permanent magnet is within a range from 0.6 mm to 1.8 mm, and a ratio (SM/SF) between the cross-sectional area of said iron core (SM) and a cross-sectional area (SF) of said iron core at

which said windings are wound is within a range from 1.3 to 3.0.

2. An ignition coil according to claim 1, wherein said ignition coil is used for an internal combustion engine of an automotive vehicle.
3. An ignition coil according to claim 2, wherein a permeability (μ) of said permanent magnet is substantially 1, said permanent magnet includes samarium and cobalt, and said iron core includes non-oriented silicone steel plates.
4. An ignition coil according to claim 2, wherein said primary coil is connected to an outside resistor which provides said primary resistance with said primary coil, and wherein the magnetization in the opposite direction by said permanent magnet is limited to 1.0 [T].
5. An ignition coil according to claim 1, wherein the magnetization in the opposite direction by said permanent magnet in a negative region is substantially equal to two thirds of magnetizing force magnetizing said iron core in a positive region by a maximum value of the electric current flowing through said primary coil normally.
6. An ignition coil comprising:
 - an iron core (1) forming a closed magnetic path through an air gap (2) provided therein;
 - a primary winding (6) wound on said iron core for magnetizing said iron core when supplied with an electric current;
 - a secondary winding (8) wound on said iron core; and
 - a permanent magnet (4) inserted in said air gap of said iron core and magnetized in an opposite direction to a magnetizing direction by the supply of electric current to said primary coil, wherein a cross-sectional area (SG) of said iron core at which said permanent magnet is inserted is made substantially equal to a cross-sectional area (SM) of said permanent magnet, a thickness (LM) of said permanent magnet is within a range from 0.6 mm to 1.8 mm, and a ratio (SM/SF) between the cross-sectional area of said iron core (SM) and a cross-sectional area (SF) of said iron core at which said windings are wound is within a range from 1.3 to 2.0.
7. An ignition coil according to claim 6, wherein said ignition coil is used for an internal combustion engine of an automotive vehicle.

8. An ignition coil according to claim 7, wherein a permeability (μ) of said permanent magnet is substantially 1, said permanent magnet includes samarium and cobalt, and said iron core includes non-oriented silicone steel plates. 5
9. An ignition coil according to claim 7, wherein said primary coil is connected to an outside resistor which provides said primary resistance with said primary coil. 10
10. An ignition coil according to claim 9, wherein the magnetization in the opposite direction by said permanent magnet is limited to 1.0 [T], 15 and the magnetization is the opposite direction by said permanent magnet in a negative region is substantially equal to two thirds of magnetizing force magnetizing said iron core in a positive region by a maximum value of the electric 20 current flowing through said primary coil normally.

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FIG. 1

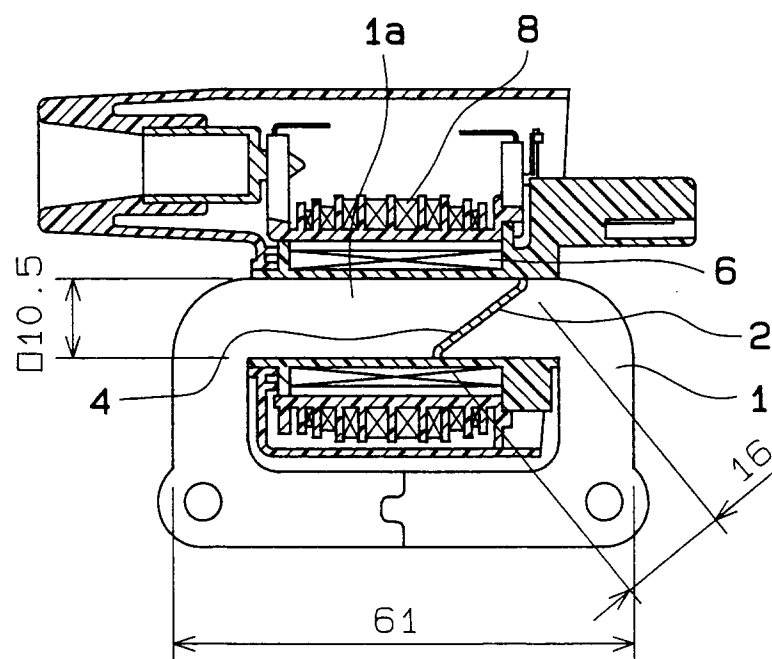


FIG. 2

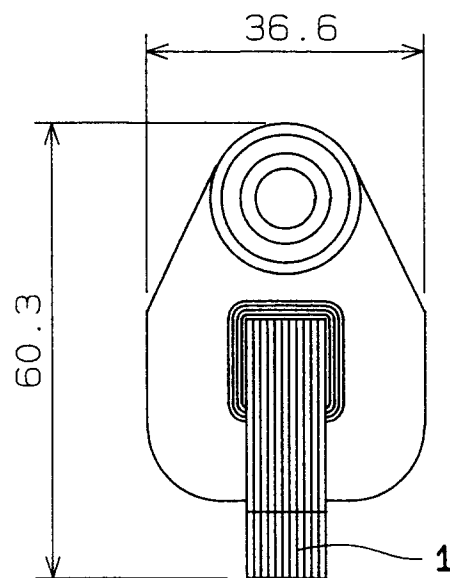


FIG. 3

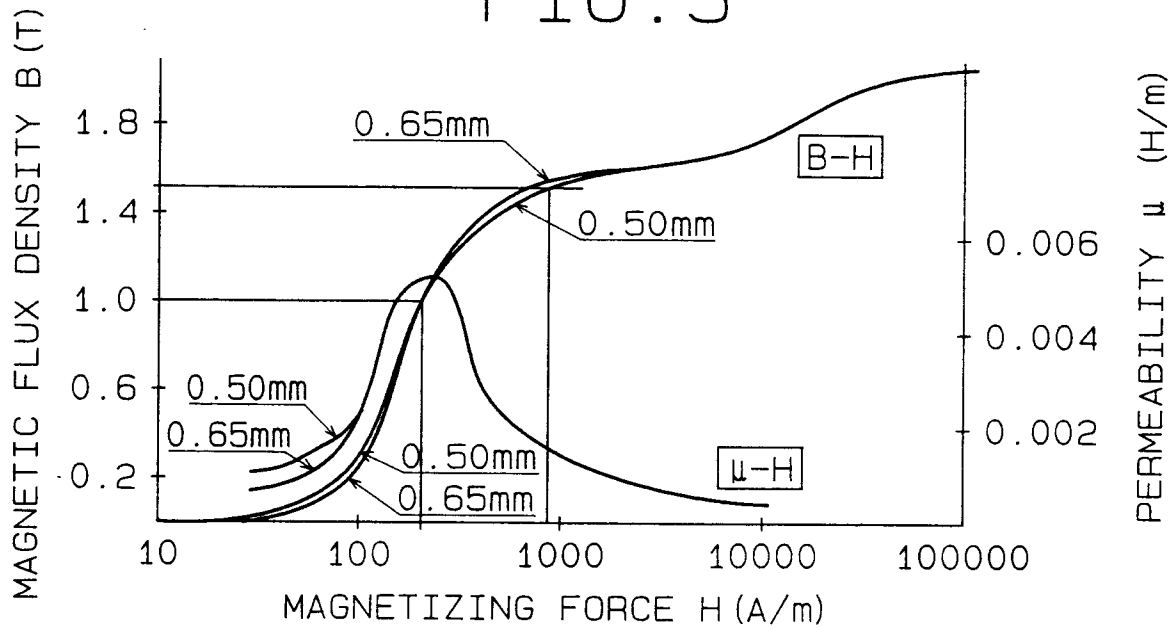
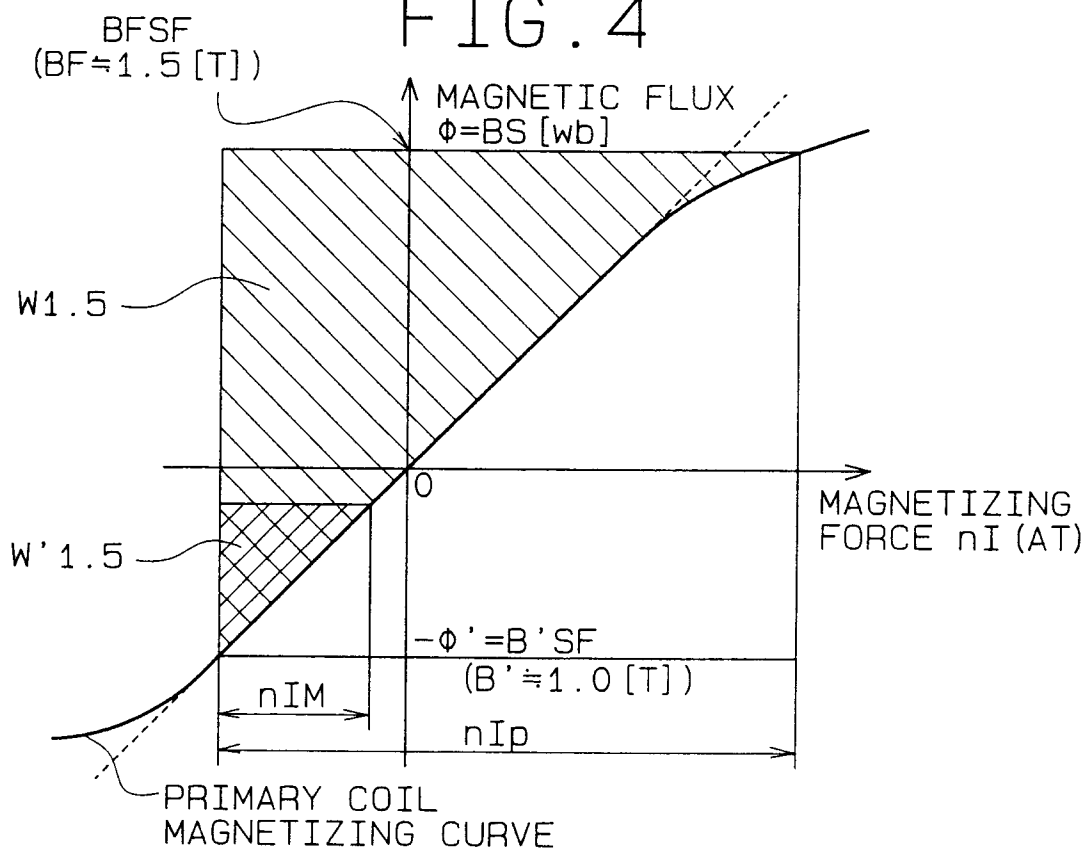


FIG. 4



(IN CASE OF $SM/SF=1.5$)

FIG. 5

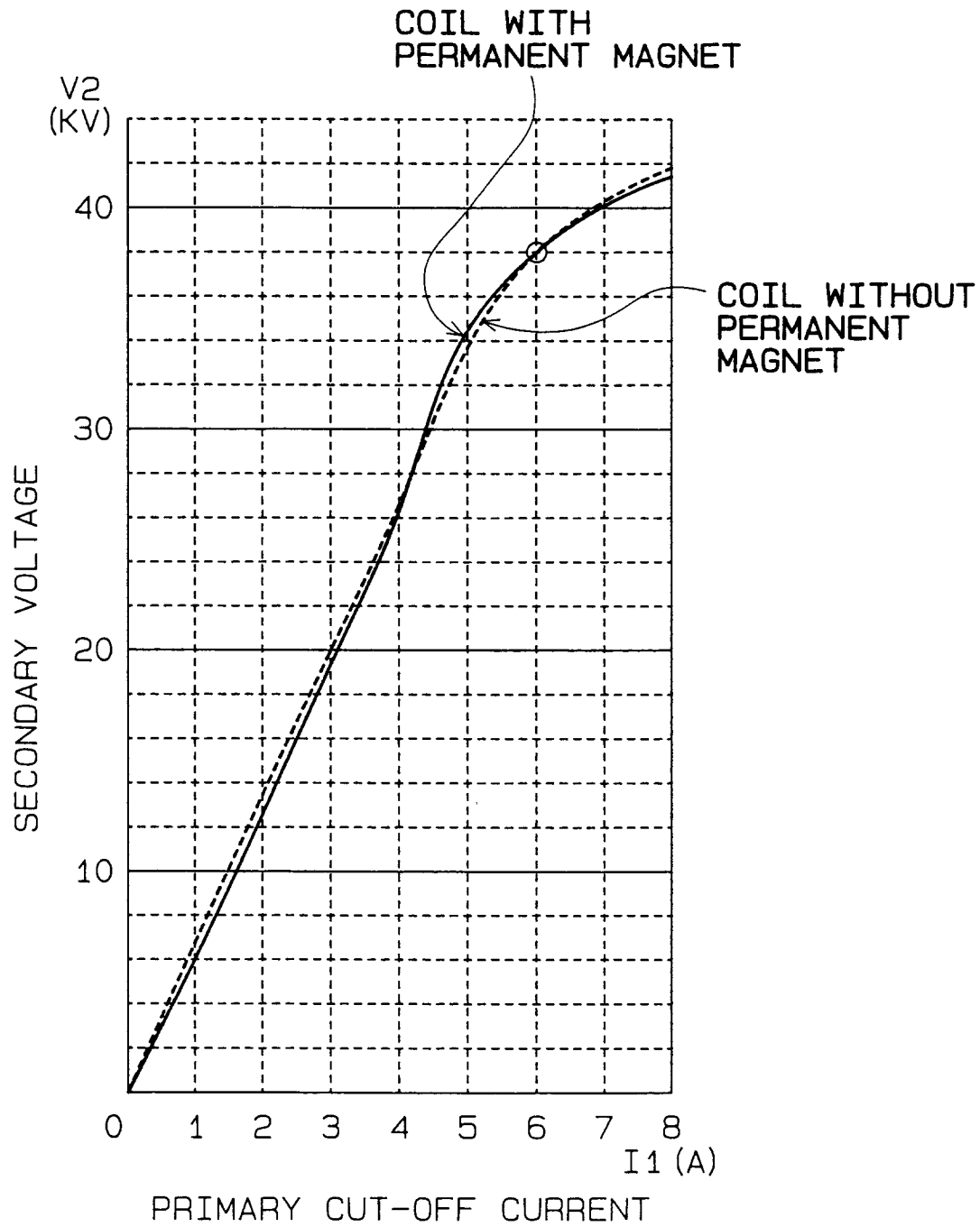


FIG. 6
PRIOR ART

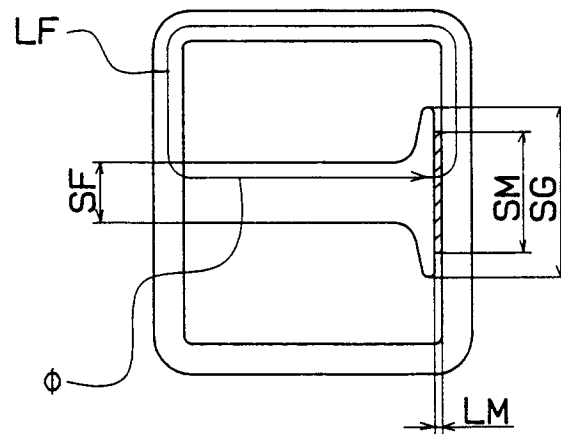


FIG. 7
PRIOR ART

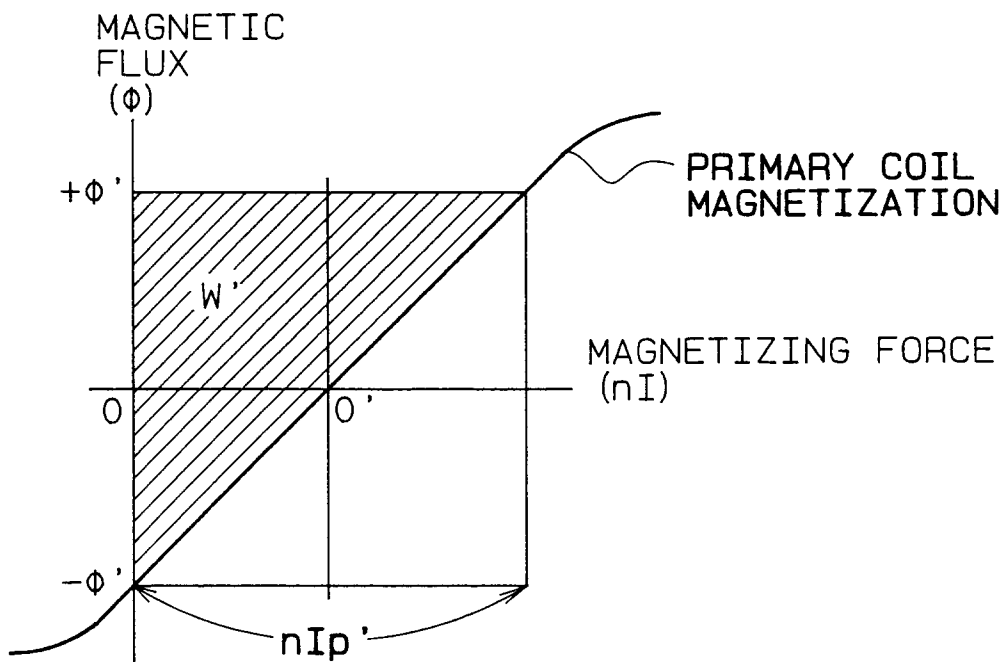


FIG. 8
PRIOR ART

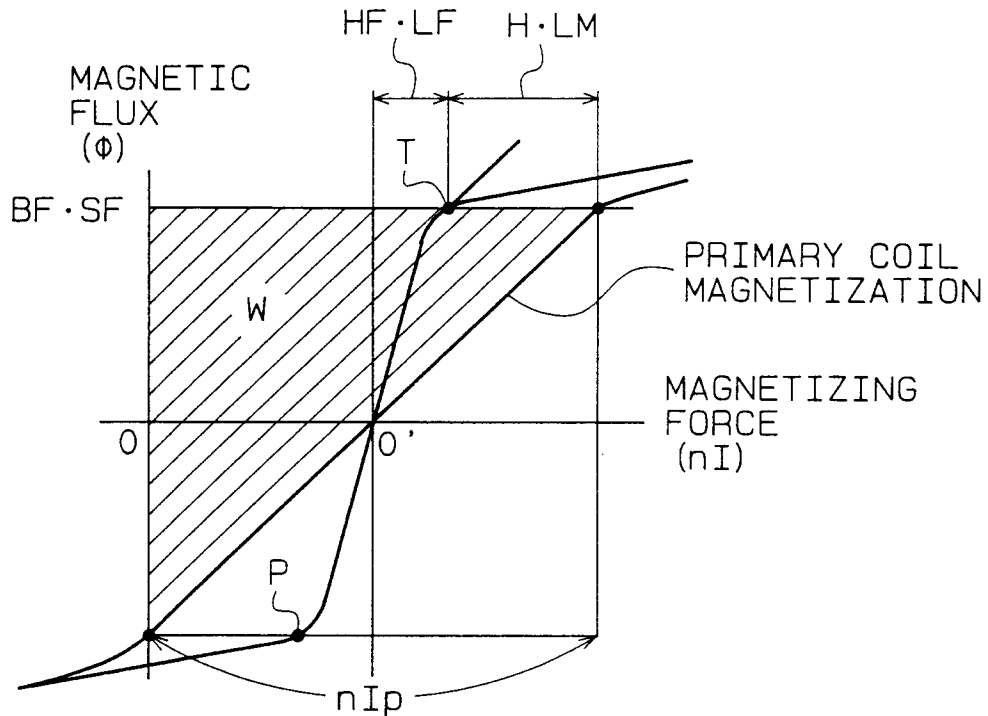


FIG. 9
PRIOR ART

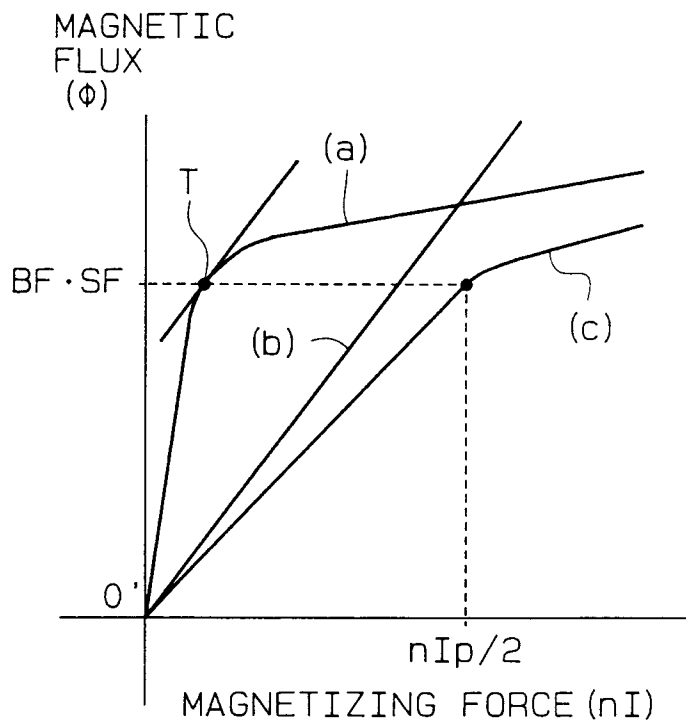


FIG. 10
PRIOR ART

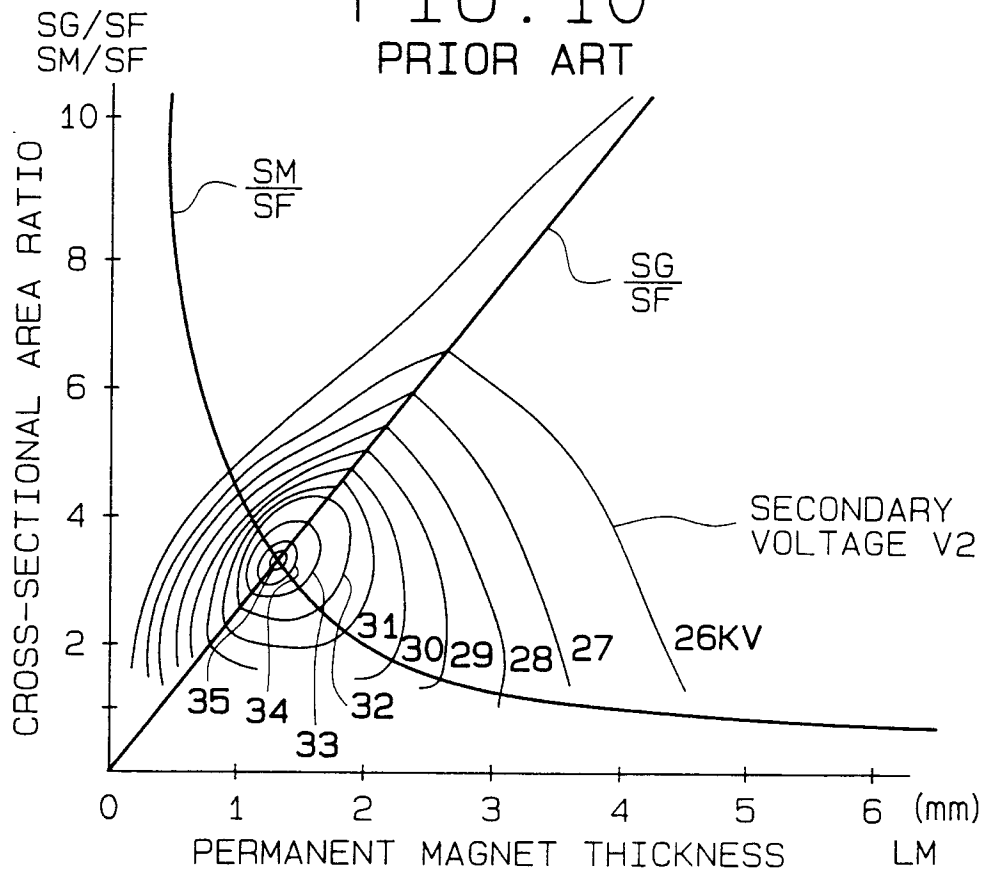


FIG. 11
PRIOR ART

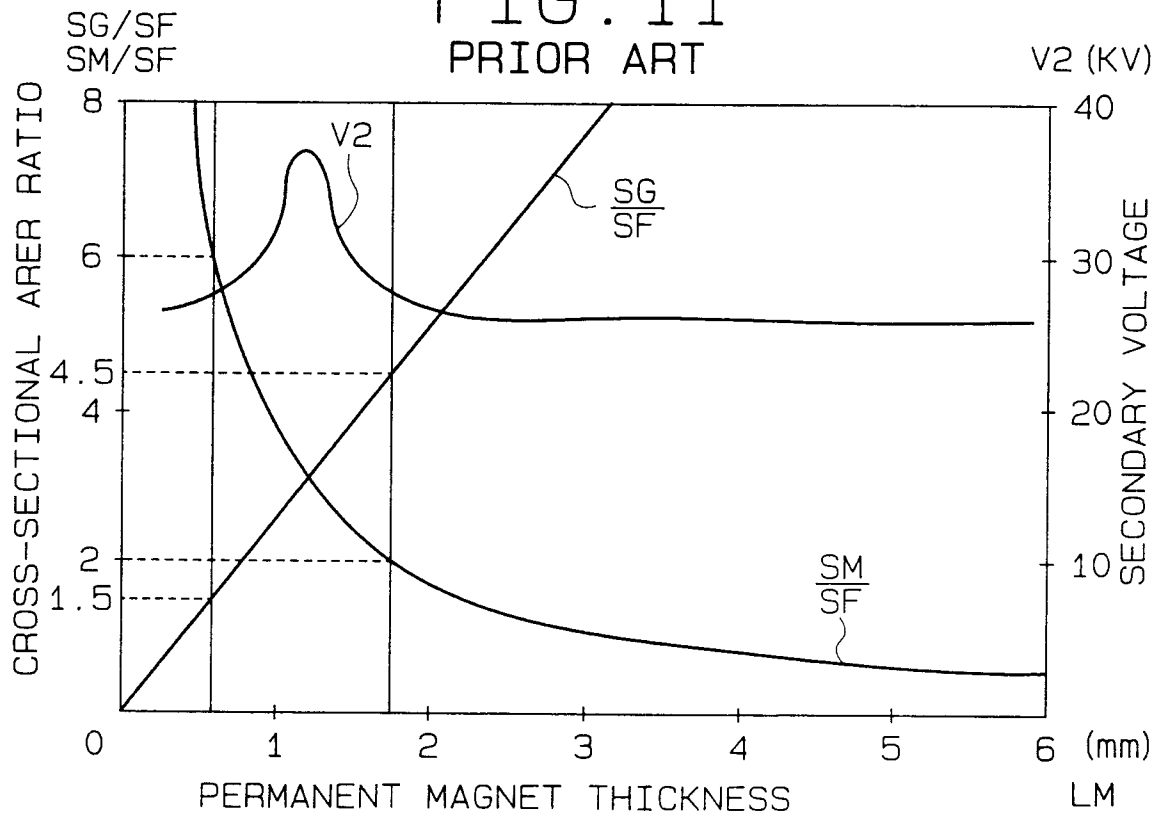


FIG. 12

PRIOR ART

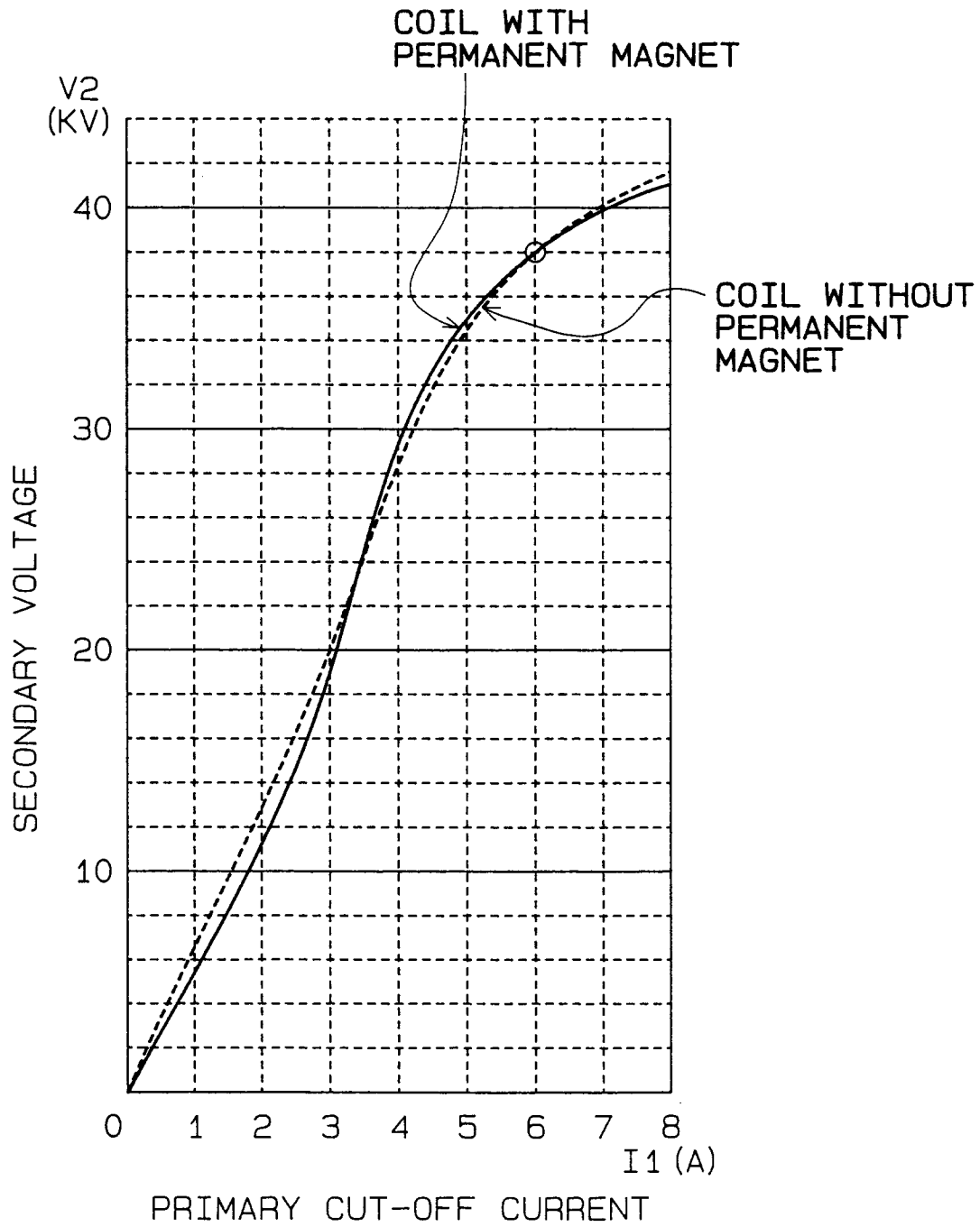


FIG. 13
PRIOR ART

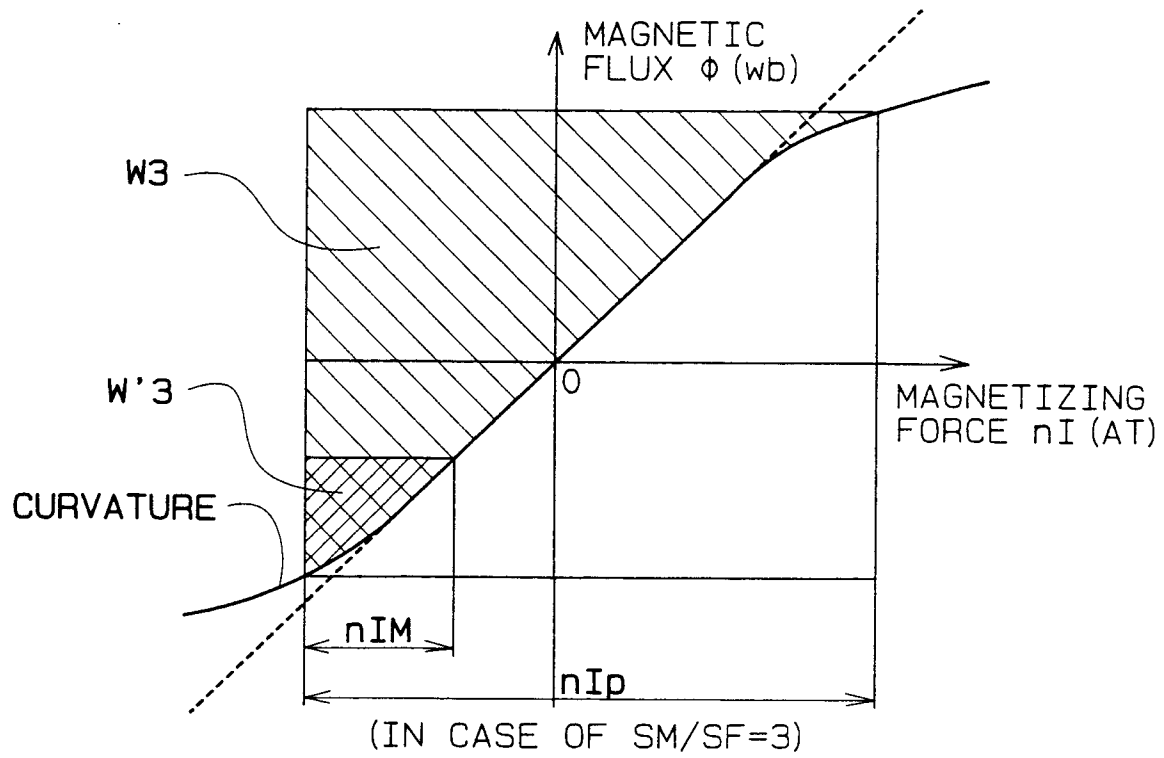


FIG. 14
PRIOR ART

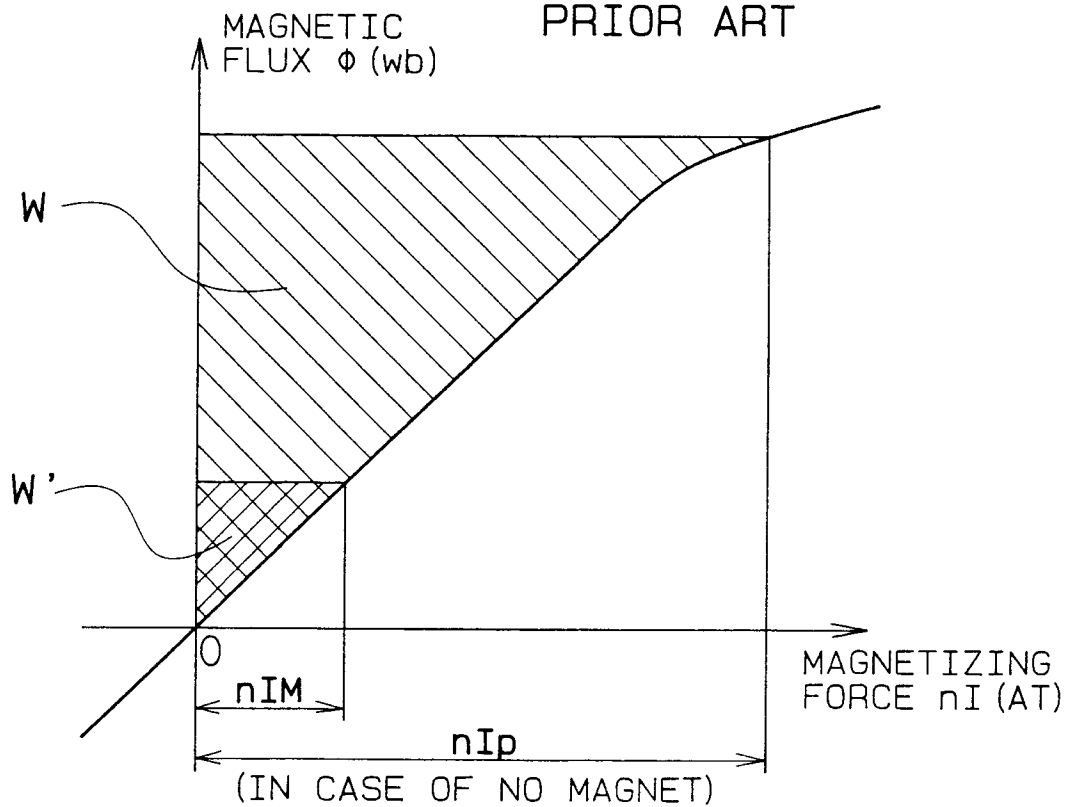


FIG. 15
PRIOR ART

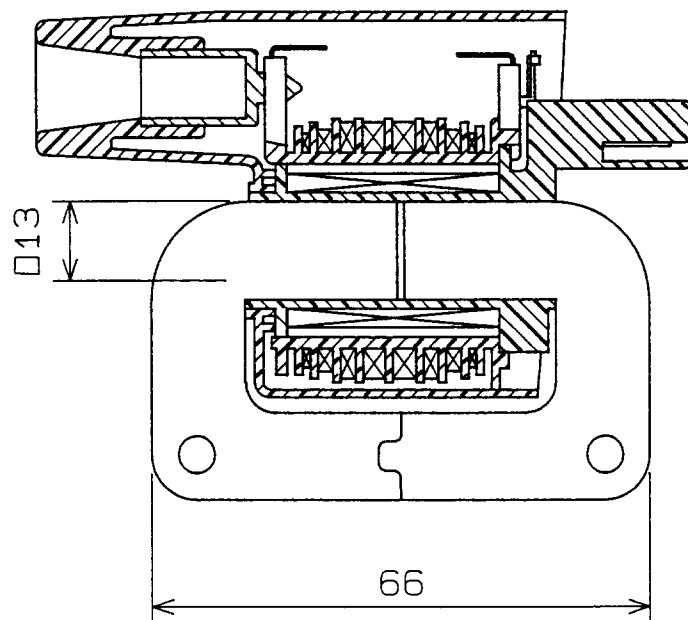


FIG. 16
PRIOR ART

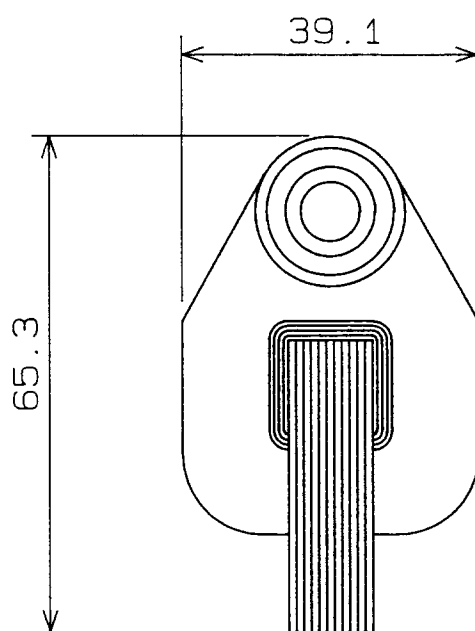


FIG. 17
PRIOR ART

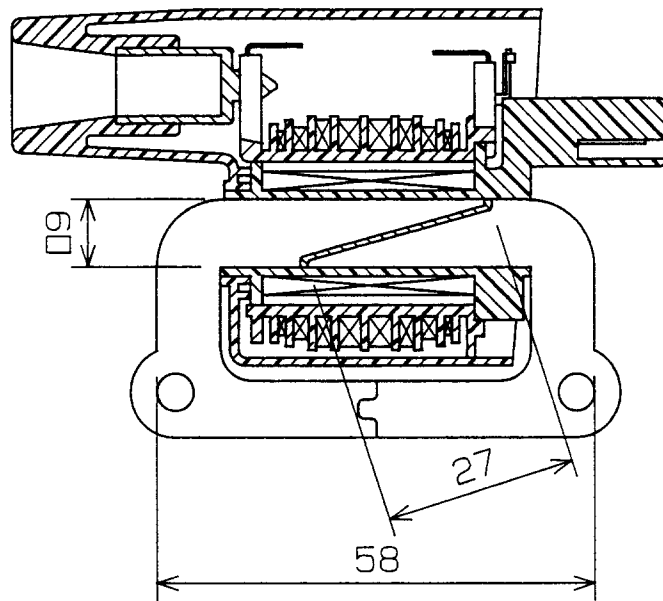
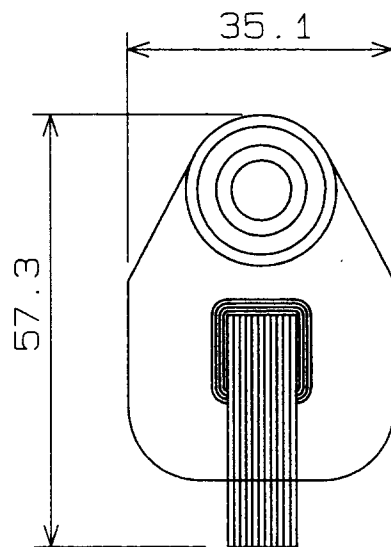


FIG. 18
PRIOR ART





European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 94 10 9288

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.5)
D,X	EP-A-0 352 453 (NIPPONDENSO CO) * page 6 - page 8 *	1-3,6-8	H01F38/12
A	---	4,5,10	
A	DE-C-656 392 (SOCIETE DES MAGNETOS R.B.) * page 2, line 63 - line 67 *	4,9	
A	---		
A	FR-A-2 464 543 (BROWN BOVERI & CIE)		
A	---		
A	EP-A-0 043 744 (DUCELLIER & CIE)		
A	---		
A	EP-A-0 431 322 (NIPPONDENSO CO)		
A	---		
A	DE-A-14 64 202 (LICENTIA) -----		
The present search report has been drawn up for all claims			TECHNICAL FIELDS SEARCHED (Int.Cl.5)
			H01F
Place of search		Date of completion of the search	Examiner
THE HAGUE		21 September 1994	Vanhulle, R
CATEGORY OF CITED DOCUMENTS			
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document			
T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			