603382

PATENT APPLICATION FORM

COMMONWEALTH OF AUSTRALIA

Regulation 9

Patents Act 1952

We, LGZ LANDIS & GYR ZUG AG

of CH-6301 ZUG, SWITZERLAND

hereby apply for the grant of a Standard Patent for an invention entitled MEASURING TRANSFORMERS

which is described in the accompanying complete specification.

For a Convention application - details of basic application-

Number	Country	Date of Application
03899/86-7	Switzerland	29th September, 1986

Our address for service is ARTHUR S. CAVE & CO., Patent and Trade Mark Attorneys, 1 Alfred Street, Sydney, New South Wales, Australia 2000.

Dated this 21st day of September, 1987.

LGZ LANDIS & GYR ZUG AG
By Its Patent Attorneys,
ARTHUR S. CAVE & CO.

J.G. SIELY F.I.P.A.A.

To:
Commissioner of Patents

ARTHUR S. CAVE & CO.
PATENT AND TRADE MARK ATTORNEYS
SYDNEY

ACCEPTED AND AMENDMENTS
ALLOWED 16 - 8 - 90

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AUSTRALIA PATENT DECLARATION FORM (NON CONVENTION) Form 7

COMMONWEALTH OF AUSTRALIA

Patents Act 1952–1969

DECLARATION IN SUPPORT OF AN APPLICATION FOR A PATENT OR PATENT OF ADDITION

To be signed by the applicant(s) or in the case of a Company to be signed by a person authorised by the Company.

(a) Insert full name(s) of applicant(s).

In support of the Application by (a) LGZ LANDIS & GYR ZUG AG

(b) Insert title of invention.

for a patent ~~patent of addition~~ for an invention entitled:– (b)

Measuring transformers

(c) Insert full name(s) of declarant(s).

(d) Insert address(es) of declarant(s).

~~I~~/We, (c) Kurt Toniolo Hans Nünlist

of (d) Keltenweg 8 Rigistrasse 45

CH-6312 Steinhausen CH-6314 Unterägeri

do solemnly and sincerely declare as follows:–

~~1. I am/We are the applicant(s) for the patent patent of addition~~

~~(Or, in the case of an application by a body corporate.)~~

(e) Insert name of body corporate.

1. ~~I am~~/We are authorized by (e) LGZ LANDIS & GYR ZUG AG

the applicant for the patent ~~patent of addition~~ to make this declaration on its behalf.

~~2. I am/We are the actual inventor(s) of the invention.~~

(Or, where a person other than the inventor is the applicant)

(f) Insert full name(s) of actual inventor(s).

2. (f) Urs Brandenberg Thomas Seitz

(g) Insert address(es) of actual inventor(s).

of (g) Loretohöhe 3 Hasenbühlweg 7

CH-6300 Zug CH-6300 Zug

Switzerland Switzerland

(h) Set out how applicant(s) derive(s) title from actual inventor(s) i.e. assignee of the invention from the actual inventor(s).

~~is~~/are the actual inventor(s) of the invention and the facts upon which ~~I am/We are~~ the Company is entitled to make the application are as follows:– (h)

The Company is the Assignee of the said invention from the said Urs Brandenberg and Thomas Seitz, by virtue of the Deed of Assignments dated the days of 26th March 1984 and 24th June 1971.

Attestation or legalization not required.

Declared at Zug, Switzerland this 28th day of August 1987

(Signature of Declarant)

LGZ Landis & Gyr Zug AG

i.V. K. Toniolo i/V. Nünlist

To:

The Commissioner of Patents,
COMMONWEALTH OF AUSTRALIA

ARTHUR S. CAVE & CO.
PATENT AND TRADE MARK ATTORNEYS
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A.S.C.–3

(12) PATENT ABRIDGMENT (11) Document No. AU-B-78911/87
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(54) Title
CURRENT MEASURING TRANSFORMER

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(56) Prior Art Documents
US 4473810
US 4742296
US 4559495

(57) Claim

1. A measuring transformer for current measurement, the measuring transformer comprising:

an electric conductor having first and second conductor portions, the first conductor portion being arranged to conduct an electric current to be measured in one direction and the second conductor portion being arranged to conduct the electric current in the opposite direction;

at least one air coil being formed of a wire-wound coil wound on a coil body, being flattened so that the axis of the coil extends between and is substantially parallel to an opposed pair of flat sides of the coil, and being sandwiched between the two conductor portions of the electric conductor with each flat side of the coil facing a respective one of the

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conductor portions such that the axis of the air coil extends substantially parallel to the direction of magnetic fields produced by current flowing through the two conductor portions of the electric conductor, wherein the distance between the outer circumferential surface of the air coil and the two conductor portions of the electric conductor is equal to a minimum distance for maximising the magnetic coupling between the two conductor portions and the air coil while avoiding voltage breakdown for a predetermined current in the conductor;

at least one ferromagnetic shield surrounding the first and second conductor portions for shielding the air coil from external magnetic fields, the ferromagnetic shield being in the form of a ring of sheet metal electrically insulated from the first and second conductor portions; and

a housing made of electrically insulating material around the air coil, the housing having walls which electrically insulate the air coil from the first and second conductor portions, and including a bottom portion which comprises a carrier for the air coil.

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COMPLETE SPECIFICATION

(ORIGINAL)

FOR OFFICE USE

Application Number:
Lodged:

Complete Specification Lodged:
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Related Art:

This document contains the amendments made under Section 49 and is correct for printing.

TO BE COMPLETED BY APPLICANT

Name of Applicant: LGZ LANDIS & GYR ZUG AG

Address of Applicant: CH-6301 SWITZERLAND

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AUSTRALIA

Complete Specification for the invention entitled MEASURING TRANSFORMERS.

The following statement is a full description of this invention including the best method of performing it known to me:-

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ASC 49

MEASURING TRANSFORMERS

This invention relates to measuring transformers for measuring the current flowing in an electric conductor.

Measuring transformers may be used, for example, in electricity meters to determine a momentary value of electric power delivered to a consumer. In such cases, the momentary value of electric current is measured by means of the arrangement and is then multiplied by the momentary value of a supply voltage.

W. German Patent Publication Auslegeschrift No. 1 079 192 discloses a measuring transformer provided with a ferromagnetic shield and with at least one air coil insulated from an electric conductor through which the current to be measured is passed, the air coil being wound on a coil body. Such a measuring transformer as disclosed is not easy to assemble and is dependent on close mechanical tolerances being maintained.

According to the present invention there is provided a measuring transformer for current measurement, the measuring transformer comprising:

an electric conductor having first and second conductor portions, the first conductor portion being arranged to conduct an electric current to be measured in one direction and the second conductor portion being arranged to conduct the electric current in the opposite direction;

at least one air coil being formed of a wire-wound coil wound on a coil body, being flattened so that the axis of the coil extends between and is substantially parallel to an opposed pair of flat sides of the coil, and being sandwiched between the two conductor portions of the electric conductor with each flat side of the coil facing a respective one of the conductor portions such that the axis of the air coil extends substantially parallel to the direction of magnetic fields produced by current flowing through the two conductor portions of the electric conductor, wherein the distance between the outer circumferential surface of the air coil and the two conductor portions of the electric conductor is equal to a minimum distance for maximising the magnetic coupling between the two conductor portions and the air coil while avoiding voltage breakdown for a predetermined current in the conductor;

at least one ferromagnetic shield surrounding the first and second conductor portions for shielding the air coil from external magnetic fields, the ferromagnetic shield being in the form of a ring of sheet metal electrically insulated from the first and second conductor portions; and

a housing made of electrically insulating material around the air coil, the housing having walls which electrically insulate the air coil from the first and second conductor portions, and including a bottom portion which comprises a carrier for the air coil.

Preferred embodiments of the invention, to be described in greater detail hereinafter, provide measuring transformers, the assembly of which is very simple and non-critical with respect to mechanical tolerances, which are insensitive to interfering magnetic fields, which are particularly precise, simple and reliable and which provide strong output signals.

The invention will now be described by way of example with reference to the accompanying drawings, throughout which like parts are referred to by like references, and in which:

Figure 1 is a first cross-sectional view A-B of the schematic design of a measuring transformer according to a first embodiment of the invention;

Figure 2 is a second cross-sectional view C-D of the design of the measuring transformer shown in Figure 1;

Figure 3 is a schematic perspective view of a measuring transformer according to a second embodiment of the invention; and

Figure 4 is a schematic perspective view of a measuring transformer according to a third embodiment of the invention.

Referring to Figures 1 and 2, a measuring transformer for measuring the current i flowing in an electric conductor 1 contains at least one ferromagnetic screen or shield 2 and at least one air coil 3,4 insulated from the electric conductor 1, the air coil consisting of a wire-wound coil 3 wound on a coil body 4. An air coil is herein defined generally as a coil not having a ferromagnetic core. The air coil 3,4 (not shown to scale in the drawing) is installed in such a manner between a conductor 1a providing a current path in one direction and a conductor 1b providing a current path in the opposite direction with conductors 1a,1b extending parallel to each other, that its axis is substantially parallel to the direction of magnetic fields $\vec{H}_a$ and $\vec{H}_b$. The magnetic field $\vec{H}_a$ is produced by the current i flowing through the conductor 1a in the one direction, while the magnetic field $\vec{H}_b$ is produced by the current i flowing through the conductor 1b in the opposite direction. In the space between the conductor 1a and the conductor 1b, the two magnetic fields $\vec{H}_a$ and $\vec{H}_b$ are parallel to each other in the same direction, in the vicinity of the air coil 3,4. The air coil 3,4 is preferably a flat coil as shown, and the distance between the circumferential surface of the air coil 3,4 and the two conductors 1a and 1b is always equal to the minimum distance dictated by a required insulation voltage, typically about one millimetre. Due to this fact, the magnetic coupling between the conductor 1 and the air coil 3,4 is very large, since the magnetic flow of the magnetic fields $\overrightarrow{H_a}$ and $\overrightarrow{H_b}$ produced by the current i is taken up as completely as possible by the air coil 3,4, and because the air coil extends over the shortest possible partial length of the magnetic field line produced by the current i.

The air coil 3,4 is located in a housing 10 made of electrically insulating material, the walls of which in turn electrically insulate the air coil 3,4 from the conductors 1a and 1b. The housing 10 is preferably made of a ceramic material and provided with a bottom portion 10b and a housing cover 10a. The air coil 3,4 is located on a carrier made of an insulating material on which additional electronic structural elements may be located, whereby the bottom portion 10a of the housing 10 constitutes this carrier. A preferred material for the ferromagnetic shield 2, due to its high permeability, is an iron-nickel alloy such as, for example, permenorm, vacoperm, trafoperm, permax, ultraperm or mu-metal. The ferromagnetic shield 2 consists of a ring which is made of at least one piece of sheet-metal bent in the shape of a ring, as this greatly simplifies its fabrication, while allowing for electrical insulation of the conductor 1a and the conductor 1b. The width L of the ring is greater than its widest clear opening, so that it shields the air coil 3,4 very effectively against the influence of external interfering magnetic fields. The electric conductor 1 can have a rectangular cross-section, for example, and in that case the ring is also preferably rectangular in shape. The electrical conductor 1 is preferably constituted by a U-shaped loop 11, the opposite sense or back-and-forth conductors of which are the mutually parallel conductors 1a and 1b of the electric conductor 1. The rectangular cross-section of the electric conductor 1 can measure 2 mm by 10 mm, for example, for a current i of about 100A. Additional electronic structural elements (not shown), such as for instance parts of the wiring electronics of the measuring transformer, can be additionally installed on the carrier, inside or outside the housing 10.

It has been assumed in Figure 1 that the width of the housing 10 is greater than the width of the electric conductor 1. In that case, in the cross-section A-B the housing 10 would completely fill the space between the two conductors 1a and 1b and the loop 11. However, the width of the housing 10 can also be equal to or smaller than the width of the electric conductor 1. In the latter case, in the cross-section A-B, the housing

10 will fill the space between the two conductors 1a and 1b only partially. The two conductors 1a and 1b of the loop 11 cross the cavity between the housing 10 and the ring, for example, in such manner that they are in spacial contact with the housing 10 as well as in electrically-insulating spacial contact with the ring. Between the ring on the one hand and the two conductors 1a and 1b on the other hand, an insulation layer 13a thus exists, as shown in Figures 1 and 2.

The ring is preferably surrounded completely on its circumferential surface by a substantially parallel, ring-shaped and wider outer shield 12. An insulation layer 13b, for instance, can be located between the ring and the outer shield 12. The outer shield 12 has a width Z which is greater than the width L of the ring, so that the latter's frontal surfaces are also shielded in part. This width Z can for example be 30 mm. The outer shield 12 is preferably made of deep-draw steel or of an iron-nickel alloy. The insulating layer 13b between the ring and the outer shield 12 also serves to increase the spacial distance between the two in this case, thus improving the shielding effect of the outer shield 12. This spacial distance can be about .05 mm, for example. It is the role of the outer shield 12 to relieve the highly permeable but easily saturated ring, which in fact acts as a shield, when strong external interfering magnetic fields are present. The ring and the outer shield 12 thus act as a double shield. Without the outer shield 12, the shield formed by the ring would remain unsaturated up to a value of the external interfering magnetic field of approximately 50A/cm. However, when the double shield is present, the shield constituted by the ring remains unsaturated up to a value of the external interfering magnetic field of approximately 200A/cm. The voltage induced in the air coil 3,4 is proportional to $d(\vec{H_a} + \vec{H_b})/dt$, that is for sinusoidal magnetic fields $\vec{H_a}$ and $\vec{H_b}$, in proportion to the total $(\vec{H_a} + \vec{H_b}) = 2\vec{H_a}$, since the magnetic fields $\vec{H_a}$ and $\vec{H_b}$ are of equal size and of the same orientation. When the magnetic fields $\vec{H_a}$ and $\vec{H_b}$ are not sinusoidal, the two connections of the air coil 3,4 must be connected to a bipolar input of an integrator (not shown in the drawings). The output signal of this integrator is then in every instance proportional to $(\vec{H_a} + \vec{H_b}) = 2\vec{H_a}$. The integrator can be a Miller integrator, for instance, which consists of an operational amplifier, the output of which is fed back via a capacitor to the inverting input of the operational amplifier. The two poles of the input of the integrator are in this case connected to the inverting or to the non-inverting input of the operational amplifier within the integrator, each via a resistance.

Due to the particularly narrow or concentrated magnetic coupling between the two conductors 1a and 1b comprising the conductor 1 and the air coil 3,4, the measuring transformer is particularly precise and reliable. The shield 2 and, if installed, the outer shield 12, render it insensitive to magnetic fields.

The second and third embodiments differ from the first embodiment only in the configuration of the electric conductor 1.

In the arrangement shown in Figure 3 illustrating the second embodiment, the electric conductor 1 forms at least two U-shaped loops 11a and 11b which are installed side by side and parallel to each other, and are electrically connected in series. Also, each of two conductors 16 and 17 or 18 and 19 is attributed to each loop 11a or 11b, one above the other and in parallel to each other. The two conductors 16 and 18 leading away, on the one hand, and the two conductors 17 and 19 leading back, on the other hand, of the two loops 11a and 11b, are each arranged in the same plane next to each other. The housing 10, and thereby also the air coil 3,4, is installed between the two conductors 16 and 18 leading away, on the one hand, and the two conductors 17 and 19 leading back on the other hand, whereby all of these back-and-forth conductors run in proximity of the housing. The ring, and if present the outer shield 12, surround the two U-shaped loops 11a and 11b laterally while being insulated from them electrically. This arrangement makes it possible to excite the measuring transformer with half the current, for example with 50A, without altering the configuration of the ferromagnetic shield 2 and of the housing 10. This half current produces an equally large magnetic field with the two loops 11a and 11b as does the current *i* with the single loop 11.

It is possible for the U-shaped loops 11a and 11b to be telescoped into each other so as to cover each other. In this case, the two conductors 16 and 18 leading away, on the one hand, and the two conductors 17 and 19 leading back, on the other side, are arranged above each other in a covering manner instead of next to each other. The back-and-forth conductors 16 to 19 can then be nearly twice as wide and half as thick as those previously described.

In the third embodiment shown in Figure 4, the electric conductor 1 consists of two conductors 20 and 21 which are parallel at least within the ring and which are arranged at least once in such a manner that they initially cross the ring in one direction, then cross each other while being electrically insulated, and then again cross the ring in the opposite direction. In that case, the housing 10, and thereby also the air coil 3,4, is arranged for both directions between the two conductors 20 and 21. The two conductors 20 and 21 can for example be installed parallel to each other and one above the other. An outer shield 12 surrounds the ring advantageously from the side as well. This arrangement can be used in electricity meters in the USA for example, and makes it possible to excite the measuring transformer with two independent single-phase currents $\underline{i}_1$ and $\underline{i}_2$ of 200A each, for example, without altering the configurations of the housing 10 and of the ferromagnetic shield 2, whereby one of the two currents $\underline{i}_1$ and $\underline{i}_2$ can be zero in an extreme case. Such an overall design of the conductors 20 and 21 makes it possible to keep the transfer constants of the two currents $\underline{i}_1$ and $\underline{i}_2$ exactly equal.

The claims defining the invention are as follows:

1. A measuring transformer for current measurement, the measuring transformer comprising:

an electric conductor having first and second conductor portions, the first conductor portion being arranged to conduct an electric current to be measured in one direction and the second conductor portion being arranged to conduct the electric current in the opposite direction;

at least one air coil being formed of a wire-wound coil wound on a coil body, being flattened so that the axis of the coil extends between and is substantially parallel to an opposed pair of flat sides of the coil, and being sandwiched between the two conductor portions of the electric conductor with each flat side of the coil facing a respective one of the conductor portions such that the axis of the air coil extends substantially parallel to the direction of magnetic fields produced by current flowing through the two conductor portions of the electric conductor, wherein the distance between the outer circumferential surface of the air coil and the two conductor portions of the electric conductor is equal to a minimum distance for maximising the magnetic coupling between the two conductor portions and the air coil while avoiding voltage breakdown for a predetermined current in the conductor;

at least one ferromagnetic shield surrounding the first and second conductor portions for shielding the air coil from external magnetic fields, the ferromagnetic shield being in the form of a ring of sheet metal electrically insulated from the first and second conductor portions; and

a housing made of electrically insulating material around the air coil, the housing having walls which electrically insulate the air coil from the first and second conductor portions, and including a bottom portion which comprises a carrier for the air coil.

2. A measuring transformer according to claim 1, wherein the length of the ring between its open ends is greater than its widest clear opening.

3. A measuring transformer according to claim 1 or claim 2, wherein the ring is rectangular and the cross-section of the electric conductor is rectangular.

4. A measuring transformer according to claim 1, claim 2 or claim 3, wherein the electric conductor forms a U-shaped loop whose parallel limbs form the first and second conductor portions.

5. A measuring transformer according to claim 1, claim 2 or claim 3, wherein the electric conductor forms at least two mutually adjacent and parallel U-shaped loops which are electrically connected in series, one of

the U-shaped loops comprising the first and second conductor portions and the other U-shaped loop comprising third and fourth conductor portions, all of the conductor portions being substantially parallel to each other, the first and second conductor portions being arranged one above the other, the third and fourth conductor portions being arranged one above the other and to conduct electric current in opposite directions, the first and third conductor portions being arranged in one plane, the second and fourth conductor portions being arranged in another plane, the electric conductor including a conductive path connecting the second and third conductor portions, and the air coil being positioned between the first and third conductor portions and between the second and fourth conductor portions.

6. A measuring transformer according to claim 1, claim 2 or claim 3, wherein the electric conductor forms at least two U-shaped loops which are telescoped into each other so as to cover each other and are electrically connected in series, one of the U-shaped loops comprising the first and second conductor portions and the other U-shaped loop comprising third and fourth conductor portions, all of the conductor portions being substantially parallel to each other, the first and third conductor portions being arranged one above the other and to conduct electric current in one direction, the second

and fourth conductor portions being arranged one above the other and to conduct electric current in the opposite direction, the electric conductor including a conductive path connecting the second and third conductor portions, and the air coil being positioned between the first and third conductor portions and between the second and fourth conductor portions.

7. A measuring transformer according to claim 1, claim 2 or claim 3, wherein the electric conductor comprises two mutually parallel conductor parts at least partially within the ring which are arranged such that they cross the ring initially in one direction, then cross each other in an electrically insulating manner, and then cross the ring again in the opposite direction, and wherein the air coil is wholly located between the two conductor parts.

8. A measuring transformer according to any one of the preceding claims, wherein the housing is made of a ceramic material.

9. A measuring transformer according to any one of the preceding claims, wherein additional electronic elements are also located on the carrier for the air coil.

10. A measuring transformer according to any one of the preceding claims, wherein the ferromagnetic shield is made of an iron-nickel alloy.

11. A measuring transformer according to any one of the preceding claims, wherein the ferromagnetic shield is surrounded on its circumferential surface by a substantially parallel, ring-shaped and wider outer shield.

12. A measuring transformer according to claim 11, wherein the outer shield is made of deep-drawn steel.

13. A measuring transformer according to claim 11, wherein the outer shield is made of an iron-nickel alloy.

14. A measuring transformer according to claim 11, claim 12 or claim 13, wherein there is a space between the ferromagnetic shield and the outer shield.

15. A measuring transformer for current measurement, the measuring transformer being substantially as herein described with reference to Figures 1 and 2, Figure 3 or Figure 4 of the accompanying drawings.

DATED this 2nd day of April, 1990.

LGZ LANDIS & GYR ZUG AG
By Its Patent Attorneys
ARTHUR S CAVE & CO

Fig.1

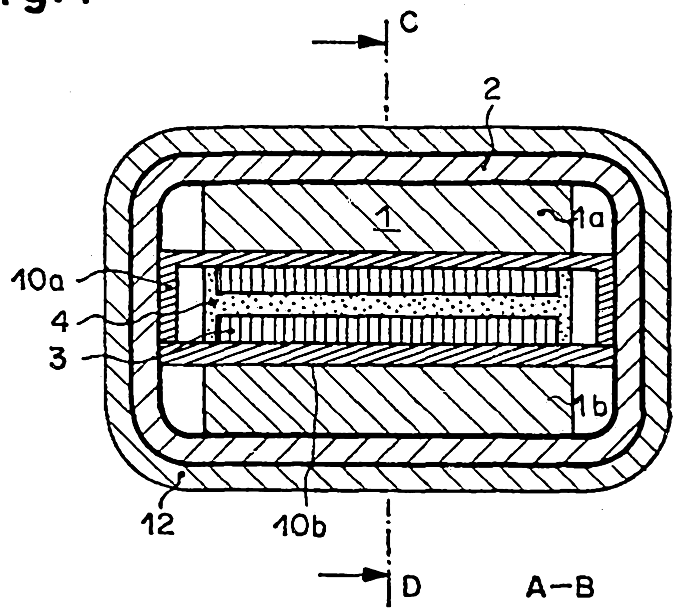
C
2
1
1a
10a
4
3
1b
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Fig.2

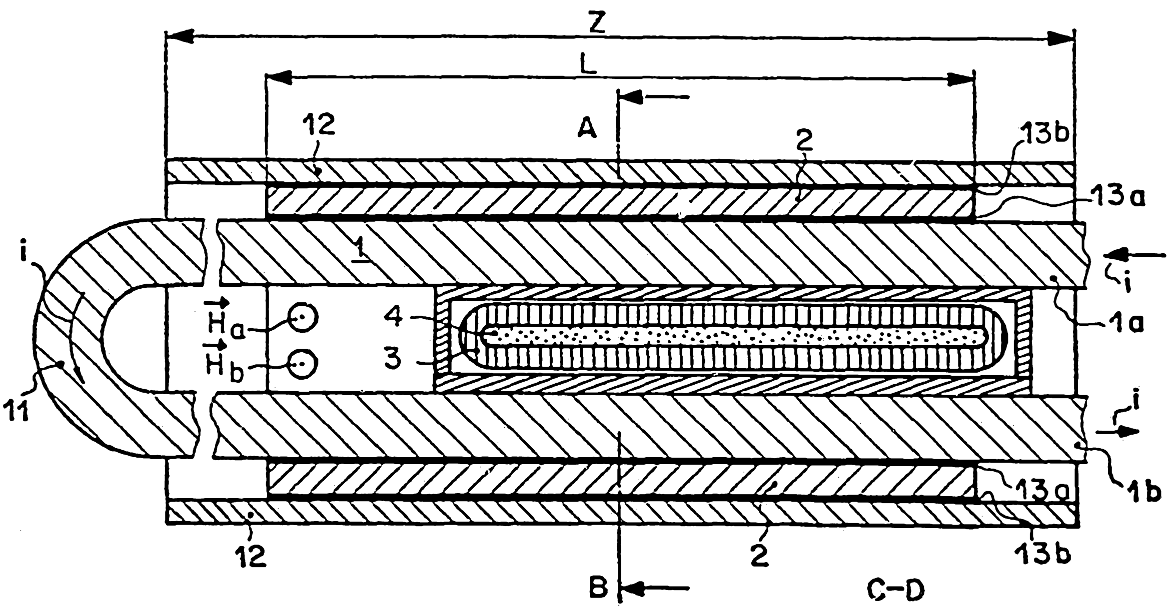
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Fig.3

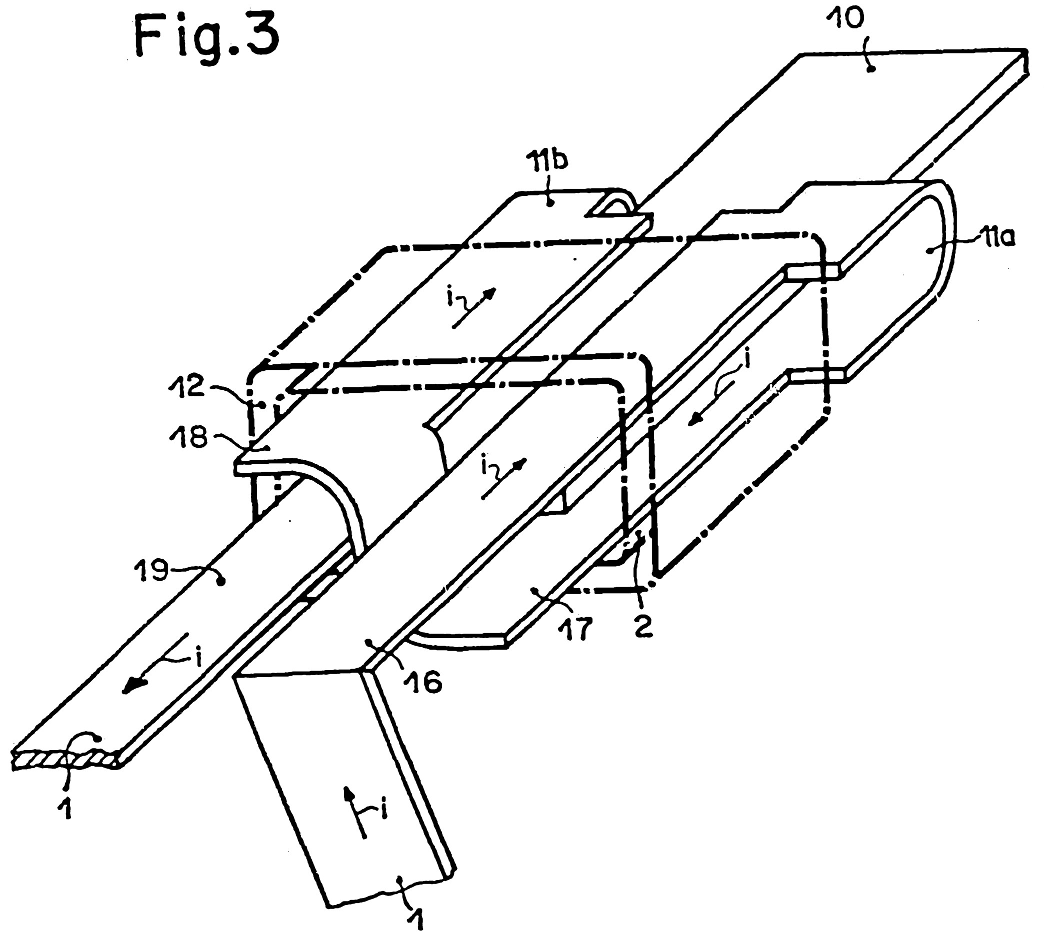

Fig.4