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Description

Field of the Invention

[0001] The invention relates to the field of electrical engineering and concerns the basic electrical engineering equipment of electric power stations, substations, power lines, in radio engineering, in devices for measuring, automatic control and regulation.

Background Art

[0002] Transformers are electromagnetic static converters of electrical energy which have two or more inductively coupled windings and are designed for the conversion of an alternating (sinusoidal) current of one voltage into an alternating current of another voltage with the same frequency.

[0003] The principle of operation of a transformer is based on the effect of electromagnetic induction found by M. Faraday in 1831 (B.N. Sergeenko, V.M. Kiselev, N.A. Akimova. Electrical Machines. Transformers. Pub. "Vysshaya Shkola," Moscow, 1989, 350 pages). In accordance with specific features of construction and use, transformers can be divided into power, welding, measuring and special transformers.

[0004] Power transformers, which are a necessary element of an industrial power network, have attained the most widespread use.

[0005] Transformers have two basic parts: a magnetic circuit and windings. Furthermore, high-power transformers have a cooling system.

[0006] The magnetic circuit is the structural base for mounting and fixing windings, taps and other elements of a transformer, and serve for amplification of the magnetic coupling between the windings.

[0007] The part of the magnetic circuit on which the windings are arranged is called the core, the remaining part, closing the magnetic circuit, is called the yoke. The windings of a transformer serve to create a magnetic field by means of which electrical power is delivered. The winding of the transformer to which electrical power is applied is called the primary winding, while the winding from which power is taken is called the secondary winding.

[0008] Known inventions are concerned with the creation of special transformers or with changes of particular structural elements of the transformer: realization of magnetic circuits from certain materials and their structural appearance, connection of magnetic circuits to each other where there is an n number of magnetic circuits, use of different types of insulation and cooling systems, realization of the windings, additional elements in order to enhance noise immunity.

[0009] A transformer is known for vehicles [PCT (WO), 93/14508]. The small-size light transformer comprises a shell-type iron core on which inductively coupled input and output windings are wound. A magnetic element with an air gap is provided between the input and output windings, while a magnetic element creating strong magnetic coupling is located between the output windings. The element is disposed in a gap 5d surrounded by the core and consists of a magnetic circuit without gaps and an insulating plate holding the magnetic circuit and insulating it from the core and windings.

[0010] A transformer is known [PCT (WO), 93/16479], in which the core is made from ferromagnetic wire. A spirally wound core from ferromagnetic wire is proposed. The core is used in a differential current sensor in a switch to open a circuit, which operates when there is a short circuit to ground. The ferromagnetic wire is wound in a spiral, the turns of which are parallel to each other and extend over the whole length of the core. The latter is positioned near current lines, with monitoring of a short circuit therein, wherein both lines are connected to a power source. The currents in them flow in opposite directions. The core interacts with a magnetic field created by those currents. Where a ferromagnetic wire is used, it is possible to substantially increase the surface area of the core without increasing its cross section, and consequently, size.

[0011] A transformer is known [RU, C1, 2041514] consisting of one or several strip cores made from a magnetic alloy comprising silicon, boron, iron and several windings inductively coupled to the core, wherein the magnetic alloy additionally comprises copper and one or several components selected from the group consisting of niobium, tantalum, tungsten, molybdenum, chromium, and vanadium, with the following ratio of alloy components, atom percent: copper - 0.5-2.0; one or several components from the group consisting of niobium, tantalum, tungsten, molybdenum, chromium, vanadium - 2-5; silicon - 5-18; boron - 4-12; iron - balance.

[0012] A transformer is known [PCT (WO), 93/18529] comprising 3 or 4 types of insulation units with one winding. Transformers of this type are easily assembled with small expenditure of time.

[0013] A current transformer with strip insulation is known [RU, C1, 2046425] comprising a single-turn or multiturn primary winding and secondary windings which are placed in a damping screen and have terminals. Wherein the aforesaid windings are secured by means of insertion support and connecting bushings and are covered with epoxy compounds. The transformer is additionally provided with insulation bushings, a screen which is placed on the primary winding, and support clamps. Insulation bushings are mounted in semi-oval slots of the clamps, the damping screen is made open and consists of two parts, with an insulating pad mounted in the gap between the two parts, and the insertion support

bushings are mounted on the insulating bushings in a manner adaptable for securing the damping screen.

[0014] A high-voltage transformer is known [RU, C1, 2035776] comprising a porcelain housing mounted on a socket on which an active portion enclosed in the housing is positioned on compressing posts. The active portion consists of a mixed rectangular magnetic circuit with yokes, upper and lower horizontal cores on which windings are positioned. In order to reduce the noise immunity the transformer is provided with additional screens - a middle one, upper and lower ones, and a capacitive screen.

[0015] A winding for a high-voltage transformer is known [PCT (WO), 93/18528]. A connecting element is secured to the conductive portion of the winding to enhance its mechanical properties, and a second connecting element is connected to the aforesaid connecting element by means of insulating elements. Such a winding can be used as a low-voltage winding with a small number of turns in dry transformers with a resin poured over them.

[0016] A heavy-current transformer is known [RU, C1, 2027238] comprising a primary winding disposed on a toroidal core and a secondary winding encompassing the primary winding. Wherein the secondary winding is made by a bundle of flexible conductors placed in the inner cavity of the torus in N sections, and from the outer side of the torus in N-1 sections, where N is the number of turns of the secondary winding, wherein the bundle is arranged in one or more layers on the outer side of the torus.

[0017] Known from US-A-2,519,224 is a transformer according to the preamble of claim 1.

[0018] Known from US-A-3,657,678 is a closed-loop core of laminated transformer iron, with at least two legs and at least three coils; all coils are electrically separated from each other and the core and can be connected in a variety of ways; at least one coil encircles at least two coils each of the latter of which encircles a respective one of said legs; provision of at least one magnetic shunt member having its opposite ends abutting said core.

[0019] However, all the known transformers are built according to one principle, in particular - supplying electrical power to the primary winding and taking electrical power from the secondary winding, and they all have these drawbacks:

- multiturn secondary windings in step-up transformers, which nevertheless operate in a rather narrow frequency range (50-400 Hz); the limited frequency range of the transformers being related to losses in the magnetic circuit at higher frequencies;
- high resistance of the windings, i.e. the necessity that the no-load condition of the transformer be taken into account during calculations of the number of turns in the secondary winding to obtain a predetermined output voltage;
- the complexity of the construction of the transformers when all possible kinds of additional elements, insulation etc. are used to reduce the aforesaid drawbacks.

Disclosure of the Invention

[0020] At the base of the invention lies the object of creating such a transformer in which the possibility of winding the secondary winding with wire, including wire with a cross-section equal to the cross-section of the primary winding, is realized, reduction of the number of turns in the secondary winding of high-voltage transformers and expansion of the number of variants of existing transformers are attained.

[0021] This object is achieved in that a construction of a transformer is proposed which comprises a magnetic circuit, at least two windings, inlets for a power supply, outlets for a load, wherein the primary winding consists of two sections with an identical number of turns, the sections being connected to each other in a series circuit by one ends of the windings and providing mutual compensation of magnetic fluxes under electric current supplied to the other ends of the sections of the primary winding, wherein the place of connection of the ends of the windings serves as an outlet for the load.

[0022] An embodiment is proposed in which the two sections of a primary winding are wound in one direction on one core of the magnetic circuit, the sections are connected in a series circuit by connection of the outs of the windings, and the point of their connection serves as an outlet for the load, while the ins of the windings of the sections serve as inlets for the power supply.

[0023] In one embodiment, two sections of the primary winding are wound in one direction on one core of the magnetic circuit, the outs of the windings of the sections are connected in a series circuit, while the ins of the section windings serve as inlets for the power supply.

[0024] The secondary winding may be wound on the same core of the magnetic circuit, over the sections of the primary winding.

[0025] In one embodiment, two sections of the primary winding are wound in opposing directions on one core of the magnetic circuit, the out of the winding of the first section and the in of the winding of the second section are connected to each other in a series circuit, while the in of the winding of the first section and the out of the winding of the second section serve as inlets for the power supply.

[0026] The secondary winding may be wound on the same core of the magnetic circuit over the sections of the primary winding.

[0027] In one embodiment, both sections of the primary winding are wound in one direction on two cores of one

magnetic circuit, the out of the winding of the first section and the in of the winding of the second section are connected to each other in a series circuit, while the in of the winding of the first section and the out of the winding of the second section serve as inlets for the power supply. The secondary winding may be wound on both sections of the primary winding, encompassing both cores of the magnetic circuit.

[0028] In one embodiment, both sections of the primary winding are wound in opposing directions on two cores of one magnetic circuit, the outs of the windings of the sections are connected to each other in a series circuit, while the ins of the windings of the sections serve as inlets for the power supply.

[0029] The secondary winding may be wound on both sections of the primary winding, encompassing both cores of the magnetic circuit.

[0030] In one emebodiment, both sections of the primary winding are wound in one direction on two cores of one magnetic circuit, wherein the in of the winding of the first section is connected to the out of the winding of the second section, the out of the winding of the first section is connected to the in of the winding of the second section, the points of their connection serve as inlets for the power supply.

[0031] The secondary winding may be wound on both sections of the primary winding, encompassing both cores of the magnetic circuit.

[0032] In one embodiment, the two sections of the primary winding are wound in opposing directions on two cores of one magnetic circuit, both sections are connected to each other by connection of the ins and outs thereof respectively, and the points of their connection serve as inlets for the power supply.

[0033] The secondary winding may be wound on both sections of the primary winding, encompassing both cores of the magnetic circuit.

[0034] The following lies at the base of the invention: sections of the primary winding are wound and connected to each other in such a manner that the magnetic flux created by one of such sections during operation of the transformer compensates the magnetic flux created by the other section of the primary winding.

[0035] If the two sections of the primary winding of the proposed transformer are connected to an alternating current network having a voltage U_1, then a current i_o will flow therealong. The magnetomotive force of one section of the winding $i_o w_1$ due to the current i_o creates an alternating magnetic flux F_1 in the magnetic circuit of the transformer. Similarly, a magnetomotive force $i_o w_2$, which is equal to the mmf of the first section $i_o w_1$, appears in the second section of the winding. Since the sections are connected to each other in a series circuit, the alternating magnetic flux F_2 appearing in the second section of the primary winding and directed counter to the magnetic flux F_1 will compensate the magnetic flux of the first section F_1. However, due to the induction of the mmf the permeability of the magnetic circuit changes. When the network current drops during half-cycles, restoration of the permeability occurs in the magnetic circuit, and consequently, an electromotive force (emf) is induced in the primary and secondary windings. Wherein, during a half-cycle of current in the primary winding, the voltage in the secondary winding passes through a whole period.

[0036] In the case where both windings are wound in opposing directions with an identical number of turns, but are connected to each other in a series circuit by opposing leads (the out of the winding of the first section and the in of the winding of the second section), the magnetic flux in the primary winding i_o will also be equal to zero, i.e. the same technical result can be attained as in the case where the windings of both sections are wound in one direction. When R_H is connected to the secondary winding, the form of the voltage does not change. The output voltage depends on an increase of the number of turns in the secondary winding as compared with the number of turns in the primary winding.

[0037] Such a realization of the proposed transformer results in:

1) a reduction in the number of turns in the secondary winding by 10-20 times, and consequently, the dimensions of the transformer are reduced;
2) the possibility of winding the secondary winding with a thick wire having a cross section equal to the cross section of the wire in the primary winding;
3) the secondary winding having a number of turns either greater or less than the number of turns in the primary winding, depending on the necessity of a high voltage at the output of the transformer.

Brief Description of the Drawings

[0038] Further the invention will be explained by a description of concrete examples of its embodiment and the accompanying drawings in which:

Fig. 1 shows the device being patented - a transformer in accordance with the invention (circuit);
Fig. 2 shows another embodiment of the transformer in accordance with the invention (circuit);
Fig. 3 shows one of the embodiments of the transformer in accordance with the invention (circuit);
Fig. 4 shows one more embodiment of the transformer in accordance with the invention (circuit);
Fig. 5 shows one more embodiment of the transformer in accordance with the invention (circuit);

Fig. 6 shows one of the embodiments of the transformer in accordance with the invention (circuit);
Fig. 7 shows one of the embodiments of the transformer in accordance with the invention (circuit);
Fig. 8 shows a stylized dependence of the increase of current and voltage in the primary and secondary windings of a transformer with a ferrite magnetic circuit;
Fig. 9 shows a stylized dependence of the increase of current and voltage in primary and secondary windings of sheet steel.

Best Variants of Carrying Out the Invention

[0039] A comprehensive description of embodiments of the transformer being patented in accordance with the invention is given below.

[0040] A transformer in accordance with the invention (according to the embodiment shown in Fig. 1) comprises a magnetic circuit 1, a first section 2 of a primary winding, a second section 3 of the primary winding, a_1 and x_1 - the in and out of the winding of the first section, a_2 and x_2 - the in and out of the winding of the second section of the primary winding, R_{H1} - the resistance of a load connected to the first section, R_{H2} - the resistance of a load connected to the second section of the primary winding. The two sections of the primary winding are wound on the magnetic circuit 1: the first section 2, the second section 3 thereon in one direction, and they have an identical number of turns. The outs x_1 and x_2 of the windings are connected to each other in a series circuit, while the ins a_1 and a_2 of the windings are separately connected to a power supply. A load resistance is connected parallel to each section of the winding: R_{H1} in the path of the current from the power supply to the first section of the winding and to the point of connection of the windings of the sections, and R_{H2} correspondingly to the second section of the primary winding.

[0041] A transformer in accordance with the invention according to the embodiment shown in Fig. 2 is made similar to the transformer according to the embodiment shown in Fig. 1. A distinction is in the presence of secondary winding 4, which is wound in a third layer on the sections 2 and 3 of the primary winding on the same core of the magnetic circuit 1. A and X designate the inlet and outlet (in and out of the phase) of the secondary winding, R_H - the resistance of the load connected to the leads A and X of the secondary winding.

[0042] A transformer in accordance with the invention according to the embodiment according to Fig. 3 is made similar to the transformer according to the embodiment shown in Fig. 2. A distinction is that the sections of the primary winding are wound in opposing directions. The out of the winding of the first section x_1 and the in of the winding of the second section a_2 are connected to each other in a series circuit, the other leads of the sections a_1 and x_2 serve as inlets for the power supply.

[0043] A transformer in accordance with the invention according to the embodiment shown in Fig. 4 is made similar to the transformer according to the embodiment shown in Fig. 2. A distinction is that the sections of the primary winding 2 and 3 are wound on two cores of the magnetic circuit 1. The sections are connected to each other via opposite leads - the out of the winding of the first section and the in of the winding of the second section. Secondary winding 4 is wound on both sections of the primary winding and encompasses both cores of the magnetic circuit.

[0044] A transformer in accordance with the invention according to the embodiment shown in Fig. 5 is made similar to the transformer according to the embodiment shown in Fig. 4. A distinction is that the two sections of the primary winding are wound in opposing directions, the outs x_1 and x_2 of the windings of the sections are connected to each other in a series circuit, while the ins a_1 and a_2 of the windings of the sections serve as inlets for the power supply.

[0045] A transformer according to the embodiment shown in Fig. 6, in accordance with the invention, is made similar to the transformer according to the embodiment shown in Fig. 4. A distinction is that the in of the first section a_1 and the out of the second section x_2, and also the out of the first section x_1 and the in of the second section a_2 are connected to each other, and the points of their connection serve as inlets for the power supply.

[0046] A transformer according to the embodiment shown in Fig. 7, in accordance with the invention, is made similar to the transformer according to the embodiment shown in Fig. 6. A distinction is that the sections are wound in opposing directions, by the ins a_1 and a_2 and by the outs x_1 and x_2 the windings of the sections are connected to each other, and the points of their connection serve as inlets for the power supply.

[0047] The principle of operation of the proposed transformer according to the embodiment shown in Fig. 1 is as follows.

I. Open circuit (no-load conditions)

[0048] The ins a_1 and a_2 of the windings of sections 2 and 3 are separately connected to a power supply U, the outs x_1 and x_2 of the windings of those same sections are connected to each other in a series circuit. Wherein a current i flows through the windings of those sections, this current causing the occurrence of a magnetomotive force mmf in each section of the winding which is equal to iw. Since the fluxes in each section are equal and directed in opposing directions they are mutually compensated and reversal of magnetization of the core does not occur, but as a consequence of maintenance of the principle of superposition of magnetic fields in a magnetic circuit, the latter interacts with the fields

on a microscopic level which results in stressed interaction of a domain structure and a change in the magnetic permeability of the material of the magnetic circuit. Thus, a change of the current passing through the sections of the primary winding in time results in a change of the permeability, while a change of the latter causes an emf to appear in those windings between the point of connection of the sections and the ins of the windings, but shifted by phase in time relative to the current passing from the supply source. Due to this, the voltage at the output of the transformer is increased by 10-20 times with actually just one primary winding.

II. Operating mode (with a load connected)

[0049] The load resistance R_{H1} is connected in the path of the current i from the power supply U to the first section 2 of the winding and to the point of connection of the outs of the sections, the load resistance R_{H2} is connected accordingly to the second section 3 of the winding. The current i from the power supply is passed through the formed closed loop, wherein the primary current i is increased in each loop proportionally to the load R_H, which results in a change of the emf in the loop - an increase of the emf.

[0050] At a low load resistance (equal to the resistance of the winding) the voltage U will be equal to the voltage drop on the winding, when the load resistance tends to increase to infinity, the secondary voltage U will increase proportionally, as a result of which the emf at the output of the transformer will increase dozens of times when there is one primary winding.

[0051] The principle of operation of the transformer according to the embodiments shown in Figs. 2-7 is similar to the principle of operation of the transformer according to the embodiment shown in Fig. 1.

[0052] A distinction lies in the presence of a secondary winding 4. Since the primary winding for the mmf in those embodiments remains open, a no-load emf is always induced therein, i.e. a self-inductance current is not created in the winding and all the mmf energy is provided as an emf of the secondary winding. Under such conditions, the intensity of the electric field per unit of length of the conductor of the winding in the secondary winding can exceed by ten times the intensity of the electric field in the primary winding, which is set by the power supply. As a result the secondary winding can have a fewer number of turns as compared with the primary winding, while the voltage is dozens of times greater than the mains voltage. Wherein the form of the voltage and current in the secondary winding repeats the form of the voltage and current in the primary winding.

[0053] Fig. 8 shows a stylized dependence of the increase of current and voltage in the primary and secondary windings of a transformer with a ferrite magnetic circuit.

[0054] It should be noted that the permeability μ of the magnetic circuit changes in time in the following manner with a sinusoidal form of current: it increases from 0 to $\pi/4$, then from $\pi/4$ to $\pi/2$ it drops, and from $\pi/2$ to $\pi 3/4$ the speed of restoration of the permeability again increases and from $\pi 3/4$ to π the restoration of μ is slower. As a result of such a change of the magnetic permeability, an emf is induced in the secondary winding at a doubled frequency and there is a complete period of the secondary current for one half-period of the current in the primary winding.

[0055] Fig. 9 shows a stylized dependence of an increase of current and voltage in the primary and secondary windings of a transformer with a magnetic circuit of sheet steel. With this type of magnetic circuit there is a shift of the form of the primary and secondary current curve from $\pi/6$ to $\pi/4$ while the form of the current is maintained.

[0056] The transformation ratio for each type of transformer was experimentally determined.

[0057] Concrete examples of operation of different types of transformers are given below in order to better understand the invention. The same results were obtained with embodiments of transformers for which examples are not provided.

[0058] Example 1. M600HH-8 K100-60-15 ferrite rings were used as the magnetic circuit. Two sections of the primary winding, one over the other, were wound on a core of the magnetic circuit assembled from four rings. The outs of the windings of both sections were connected in a series circuit, a load resistance R_H was connected parallel to each section - one end to the point of connection of the sections, the other - to the ins of the sections, the ins of the windings of each section were connected to the power supply. The number of turns in the sections was identical and equal to 60. The transformation ratio for this transformer was 11. The results of measurement of the voltage at the output of the transformer are presented in Table 1, example 1.

[0059] Similar results were obtained when the transformer was made with a ferrite U-shaped magnetic circuit.

[0060] Example 2. A ring-type magnetic circuit made from sheet steel and designed for a power of 2.5 kW was used as the magnetic circuit. Two sections of the primary winding were wound on the core of the magnetic circuit, wherein both sections were wound in one direction with their outs connected in a series circuit, the ins of the sections connected to the power supply. A secondary winding was wound on the primary winding (the direction in which it is wound does not affect the operation of the transformer).

[0061] The transformation ratio was determined experimentally and was equal to 5.

[0062] The number of turns of one section of the primary winding was 110, the number of turns of the secondary winding was also equal to 110, the diameter of the wires in the primary and secondary windings was identical and equal to 1.2 mm. A load was connected to the leads of the secondary winding. The voltage was measured at the input of the primary winding and at the output of the secondary winding, i.e. on the load. The results of measurements are presented

in Table 1, example 2.

[0063] Example 3. U-shaped ferrites were used as the magnetic circuit. The magnetic circuit was assembled from four units. Two sections of the primary winding were wound on the two cores of the magnetic circuit, each section on one core. The sections were wound in opposing directions, but with an identical number of turns. The total number of turns in the primary winding was 120. The outs of the windings of the sections were connected in a series circuit, the ins were connected to a power supply. A secondary winding, encompassing both cores, was wound on the primary winding. The number of turns in the secondary winding was 120. The transformation ratio was determined and found equal to 10. The results are presented in Table 1, example 3.

[0064] Example 4. A U-shaped magnetic circuit made from sheet steel was used as the magnetic circuit. Two sections of the primary winding were wound on both cores of the magnetic circuit, each section on one core. The sections were wound in one direction, the number of turns in each section was 120. The out of the winding of the first section and the in of the winding of the second section, and also the in of the winding of the first section and the out of the winding of the second section were connected to each other, and the points of their connection were connected to the power supply. The secondary winding was wound on the primary winding, the number of turns in the secondary winding was 120.

[0065] The transformation ratio of this transformer was 8.5. The results of measurement are presented in Table 1, example 4.

Table 1

Voltage at the output of the transformer

$U_{primary}$, V $U_{secondary}$, V	100	200	300	400	500	600	700	800	900
Example 1	1100	2200	3300	4400	5500	6600	7700	8800	9900
Example 2	500	1000	1500	2000	2500	3000	3500	4000	4500
Example 3	1000	2000	3000	4000	5000	6000	7000	8000	9000
Example 4	850	1700	2550	3400	4250	5100	5050	6800	7650

Industrial Applicability

[0066] Samples of all types of transformers were made and have been working for from three to five years. All these samples were tested and can serve as electrical engineering equipment in laboratory practice and in industrial enterprises.

Claims

1. A transformer comprising a magnetic circuit (1) with at least two windings wound on one or both cores of the magnetic circuit, inlets for a power supply, and outlets for a load, **characterized in that** the primary winding consists of two sections (2, 3) with identical number of turns, the sections (2, 3) being connected to each other in a series circuit by one ends (x_1, x_2; a_1, a_2) of the windings and providing mutual compensation of magnetic fluxes under electric current supplied to the other ends (x_1, x_2; a_1, a_2) of the sections (2, 3) of the primary winding, wherein the place of connection of the ends of the windings serves as an outlet for the load.

2. A transformer according to claim 1, **characterized in that** the two sections (2, 3) of the primary winding are wound in one direction on one core of the magnetic circuit (1), the sections (2, 3) are connected in a series circuit by connection of the outs (x_1, x_2) of the windings, and the point of their connection serves as an outlet for the load, the ins (a_1, a_2) of the windings of the sections (2, 3) serve as inlets for the power supply.

3. A transformer according to claim 1, **characterized in that** the two sections (2, 3) of the primary winding are wound in one direction on one core of the magnetic circuit (1), the sections (2, 3) are connected in a series circuit by connection of the outs (x_1, x_2) of the windings, the ins (a_1, a_2) of the windings of the sections (2, 3) serve as inlets for the power supply.

4. A transformer according to claim 1, **characterized in that** the two sections (2, 3) of the primary winding are wound in opposing directions on one core of the magnetic circuit (1), the out (x_1) of the winding of the first section (2) and the in (a_2) of the winding of the second section (3) are connected to each other in a series circuit, while the in (a_1) of the winding of the first section (2) and the out (x_2) of the winding of the second section (3) serve as inlets for the power supply.

5. A transformer according to claim 3 or 4, **characterized in that** the secondary winding (4) is wound on the same core of the magnetic circuit (1) over the sections (2, 3) of the primary winding.

6. A transformer according to claim 1, **characterized in that** the two sections (2, 3) of the primary winding are wound in one direction on two cores of one magnetic circuit (1), the out (x_1) of the winding of the first section (2) and the in (a_2) of the winding of the second section (3) are connected to each other in a series circuit, while the in (a_1) of the winding of the first section (2) and the out (x_2) of the winding of the second section (3) serve as inlets for the power supply.

7. A transformer according to claim 1, **characterized in that** the two sections (2, 3) of the primary winding are wound in opposing directions on two cores of one magnetic circuit (1), the outs (x_1, x_2) of the windings of the sections (2, 3) are connected to each other in a series circuit, while the ins (a_1, a_2) of the windings serve as inlets for the power supply.

8. A transformer according to claim 1, **characterized in that** the two sections (2, 3) of the primary winding are wound in one direction on two cores of one magnetic circuit (1), wherein the in (a_1) of the winding of the first section (2) is connected to the out (x_2) of the winding of the second section (3), the out (x_1) of the winding of the first section (2) is connected to the in (a_2) of the winding of the second section (3), the points of connection of the sections (2, 3) serve as inlets for the power supply.

9. A transformer according to claim 1, **characterized in that** the two sections (2, 3) of the primary winding are wound in opposing directions on two cores of one magnetic circuit (1), both sections (2, 3) of the winding are connected to each other by their ins (a_1, a_2) and outs (x_1, x_2), and the points of their connection serve as inlets for the power supply.

10. A transformer according to any of claims 6-9, **characterized in that** the secondary winding (4) is wound on both sections (2, 3) of the primary winding, encompassing both cores of the magnetic circuit (1).

Patentansprüche

1. Transformator, der einen Magnetkreis (1) mit wenigstens zwei Wicklungen, die um einen oder um beide Kerne des Magnetkreises gewickelt sind, Eingänge für eine Leistungsversorgung und Ausgänge für eine Last umfasst, **dadurch gekennzeichnet, dass** die Primärwicklung aus zwei Abschnitten (2, 3) mit der gleichen Anzahl von Windungen besteht, wobei die Abschnitte (2, 3) durch Enden (x_1, x_2; a_1, a_2) der Wicklungen in einer Reihenschaltung miteinander verbunden sind und eine gegenseitige Kompensation magnetischer Flüsse bei einem zu den jeweils anderen Enden (x_1, x_2; a_1, a_2) der Abschnitte (2, 3) der Primärwicklung gelieferten elektrischen Strom schaffen, wobei der Ort der Verbindung der Enden der Wicklungen als ein Ausgang für die Last dient.

2. Transformator nach Anspruch 1, **dadurch gekennzeichnet, dass** die zwei Abschnitte (2, 3) der Primärwicklung in einer Richtung auf einen Kern des Magnetkreises (1) gewickelt sind, wobei die Abschnitte (2, 3) durch Verbinden der Ausgänge (x_1, x_2) der Wicklungen in einer Reihenschaltung verbunden sind und wobei der Punkt ihrer Verbindung als ein Ausgang für die Last dient, während die Eingänge (a_1, a_2) der Wicklungen der Abschnitte (2, 3) als Eingänge für die Leistungsversorgung dienen.

3. Transformator nach Anspruch 1, **dadurch gekennzeichnet, dass** die zwei Abschnitte (2, 3) der Primärwicklung in einer Richtung auf einen Kern des Magnetkreises (1) gewickelt sind, wobei die Abschnitte (2, 3) durch Verbinden der Ausgänge (x_1, x_2) der Wicklungen in einer Reihenschaltung verbunden sind, wobei die Eingänge (a_1, a_2) der Wicklungen der Abschnitte (2, 3) als Eingänge für die Leistungsversorgung dienen.

4. Transformator nach Anspruch 1, **dadurch gekennzeichnet, dass** die zwei Abschnitte (2, 3) der Primärwicklung in entgegengesetzten Richtungen auf einen Kern des Magnetkreises (1) gewickelt sind, wobei der Ausgang (x_1) der Wicklung des ersten Abschnitts (2) und der Eingang (a_2) der Wicklung des zweiten Abschnitts (3) in einer Reihenschaltung miteinander verbunden sind, während der Eingang (a_1) der Wicklung des ersten Abschnitts (2) und der Ausgang (x_2) der Wicklung des zweiten Abschnitts (3) als Eingänge für die Leistungsversorgung dienen.

5. Transformator nach Anspruch 3 oder 4, **dadurch gekennzeichnet, dass** die Sekundärwicklung (4) über den Abschnitten (2, 3) der Primärwicklung auf denselben Kern des Magnetkreises (1) gewickelt ist.

6. Transformator nach Anspruch 1, **dadurch gekennzeichnet, dass** die zwei Abschnitte (2, 3) der Primärwicklung in einer Richtung auf beide Kerne eines Magnetkreises (1) gewickelt sind, wobei der Ausgang (x_1) der Wicklung des ersten Abschnitts (2) und der Eingang (a_2) der Wicklung des zweiten Abschnitts (3) in einer Reihenschaltung miteinander verbunden sind, während der Eingang (a_1) der Wicklung des ersten Abschnitts (2) und der Ausgang (x_2) der Wicklung des zweiten Abschnitts (3) als Eingänge für die Leistungsversorgung dienen.

7. Transformator nach Anspruch 1, **dadurch gekennzeichnet, dass** die zwei Abschnitte (2, 3) der Primärwicklung in entgegengesetzten Richtungen auf beide Kerne eines Magnetkreises (1) gewickelt sind, wobei die Ausgänge (x_1, x_2) der Wicklungen der Abschnitte (2, 3) in einer Reihenschaltung miteinander verbunden sind, während die Eingänge (a_1, a_2) der Wicklungen als Eingänge für die Leistungsversorgung dienen.

8. Transformator nach Anspruch 1, **dadurch gekennzeichnet, dass** die zwei Abschnitte (2, 3) der Primärwicklung in einer Richtung auf beide Kerne eines Magnetkreises (1) gewickelt sind, wobei der Eingang (a_1) der Wicklung des ersten Abschnitts (2) mit dem Ausgang (x_2) der Wicklung des zweiten Abschnitts (3) verbunden ist, der Ausgang (x_1) der Wicklung des ersten Abschnitts (2) mit dem Eingang (a_2) der Wicklung des zweiten Abschnitts (3) verbunden ist und die Verbindungspunkte der Abschnitte (2, 3) als Eingänge für die Leistungsversorgung dienen.

9. Transformator nach Anspruch 1, **dadurch gekennzeichnet, dass** die zwei Abschnitte (2, 3) der Primärwicklung in entgegengesetzten Richtungen auf beide Kerne eines Magnetkreises (1) gewickelt sind, wobei beide Abschnitte (2, 3) der Wicklung durch ihre Eingänge (a_1, a_2) und ihre Ausgänge (x_1, x_2) miteinander verbunden sind und ihre Verbindungspunkte als Eingänge für die Leistungsversorgung dienen.

10. Transformator nach einem der Ansprüche 6-9, **dadurch gekennzeichnet, dass** die Sekundärwicklung (4) auf beide Abschnitte (2, 3) der Primärwicklung gewickelt ist und beide Kerne des Magnetkreises (1) umgibt.

Revendications

1. Transformateur comprenant un circuit magnétique (1) avec au moins deux enroulements enroulés sur l'un des noyaux du circuit magnétique ou les deux, des entrées pour une source d'alimentation, et des sorties pour une charge, **caractérisé en ce que** l'enroulement primaire consiste en deux sections (2, 3) avec des nombres de spires identiques, les sections (2, 3) étant raccordées l'une à l'autre en un circuit en série par des premières extrémités (x_1, x_2 ; a_1, a_2) des enroulements et assurant une compensation mutuelle des flux magnétiques sous le courant électrique délivré aux autres extrémités (x_1, x_2 ; a_1, a_2) des sections (2, 3) de l'enroulement primaire, dans lequel l'emplacement du raccordement des extrémités des enroulements sert de borne de sortie pour la charge.

2. Transformateur selon la revendication 1, **caractérisé en ce que** les deux sections (2, 3) de l'enroulement primaire sont enroulées dans un premier sens sur un premier noyau du circuit magnétique (1), les sections (2, 3) sont raccordées en un circuit en série par raccordement des sorties (x_1, x_2) des enroulements, et leur point de raccordement sert de borne de sortie pour la charge, les entrées (a_1, a_2) des enroulements des sections (2, 3) servent de bornes d'entrée pour la source d'alimentation.

3. Transformateur selon la revendication 1, **caractérisé en ce que** les deux sections (2, 3) de l'enroulement primaire sont enroulées dans un premier sens sur un premier noyau du circuit magnétique (1), les sections (2, 3) sont raccordées en un circuit en série par le raccordement des sorties (x_1, x_2) des enroulements, les entrées (a_1, a_2) des enroulements des sections (2, 3) servent de bornes d'entrée pour la source d'alimentation.

4. Transformateur selon la revendication 1, **caractérisé en ce que** les deux sections (2, 3) de l'enroulement primaire sont enroulées dans des sens opposés sur un premier noyau du circuit magnétique (1), la sortie (x_1) de l'enroulement de la première section (2) et l'entrée (a_2) de l'enroulement de la seconde section (3) sont raccordées l'une à l'autre en un circuit en série, alors que l'entrée (a_1) de l'enroulement de la première section (2) et la sortie (x_2) de l'enroulement de la seconde section (3) servent de bornes d'entrée pour la source d'alimentation.

5. Transformateur selon la revendication 3 ou 4, **caractérisé en ce que** l'enroulement secondaire (4) est enroulé sur le même noyau du circuit magnétique (1) au-dessus des sections (2, 3) de l'enroulement primaire.

6. Transformateur selon la revendication 1, **caractérisé en ce que** les deux sections (2, 3) de l'enroulement primaire sont enroulées dans un premier sens sur deux noyaux du premier circuit magnétique (1), la sortie (x_1) de l'enroulement

de la première section (2) et l'entrée (a_2) de l'enroulement de la seconde section (3) sont raccordées l'une à l'autre en un circuit en série, alors que l'entrée (a_1) de l'enroulement de la première section (2) et la sortie (x_2) de l'enroulement de la seconde section (3) servent de bornes d'entrée pour la source d'alimentation.

7. Transformateur selon la revendication 1, **caractérisé en ce que** les deux sections (2, 3) de l'enroulement primaire sont enroulées dans des sens opposés sur deux noyaux d'un premier circuit magnétique (1), les sorties (x_1, x_2) des enroulements des sections (2, 3) sont raccordées l'une à l'autre en un circuit en série, alors que les entrées (a_1, a_2) des enroulements servent de bornes d'entrée pour la source d'alimentation.

8. Transformateur selon la revendication 1, **caractérisé en ce que** les deux sections (2, 3) de l'enroulement primaire sont enroulées dans un premier sens sur deux noyaux d'un premier circuit magnétique (1), dans lequel l'entrée (a_1) de l'enroulement de la première section (2) est raccordée à la sortie (x_2) de l'enroulement de la seconde section (3), la sortie (x_1) de l'enroulement de la première section (2) est raccordée à l'entrée (a_2) de l'enroulement de la seconde section (3), les points de raccordement des sections (2, 3) servent de bornes d'entrée pour la source d'alimentation.

9. Transformateur selon la revendication 1, **caractérisé en ce que** les deux sections (2, 3) de l'enroulement primaire sont enroulées dans des sens opposés sur deux noyaux d'un circuit magnétique (1), les deux sections (2, 3) de l'enroulement sont raccordées l'une à l'autre par leurs entrées (a_1, a_2) et sorties (x_1, x_2), et leurs points de raccordement servent de bornes d'entrée pour la source d'alimentation.

10. Transformateur selon l'une quelconque des revendications 6 à 9, **caractérisé en ce que** l'enroulement secondaire (4) est enroulé sur deux sections (2, 3) de l'enroulement primaire, entourant les deux noyaux du circuit magnétique (1).

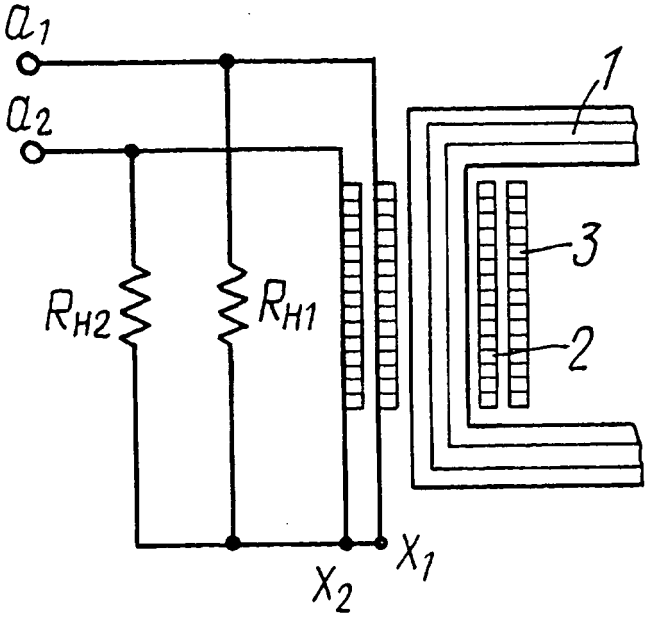


FIG. 1

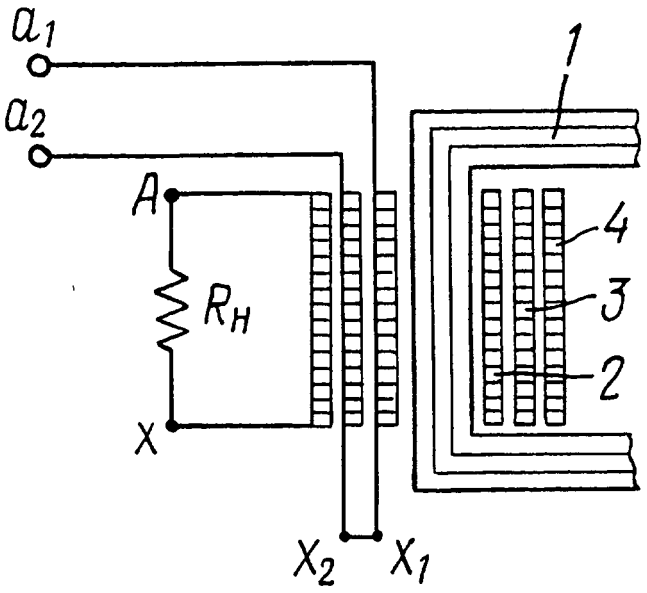


FIG. 2

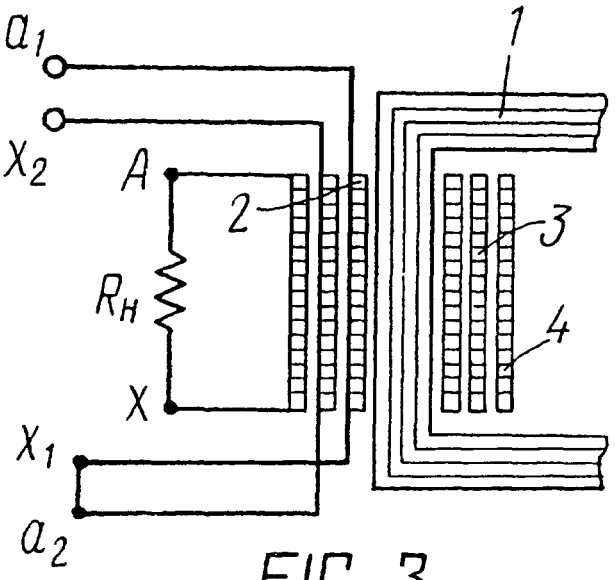


FIG. 3

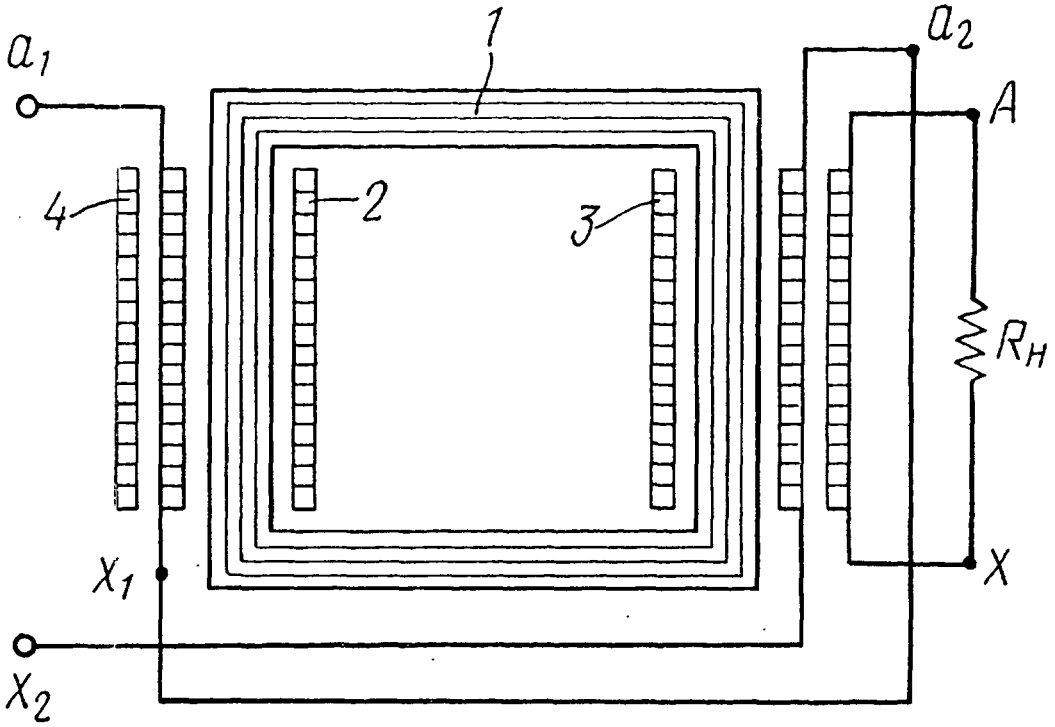


FIG. 4

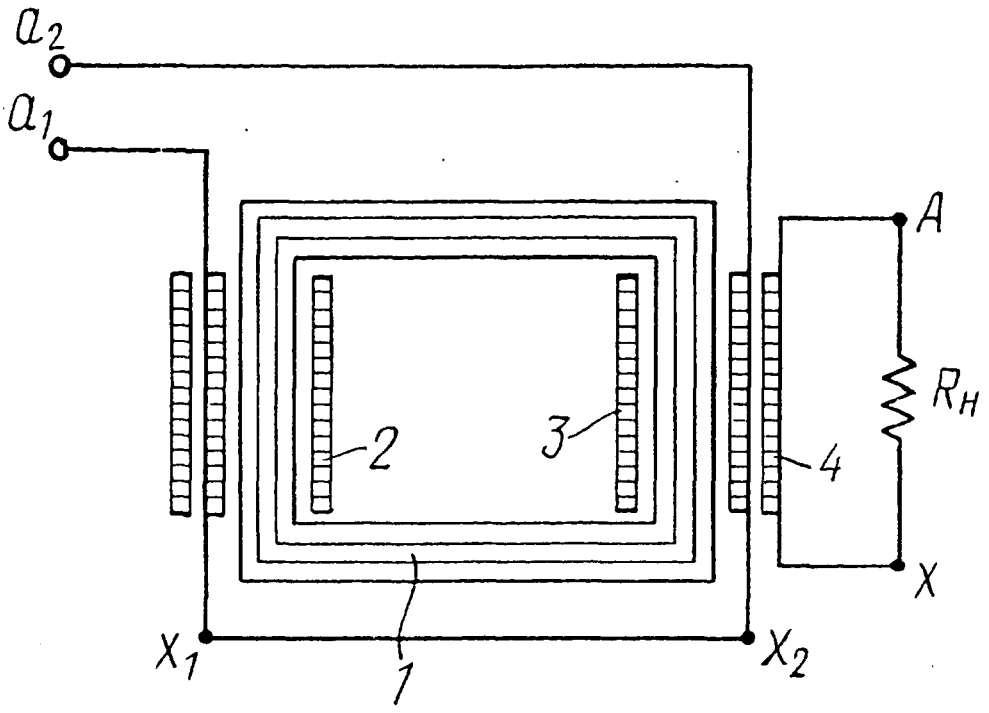


FIG. 5

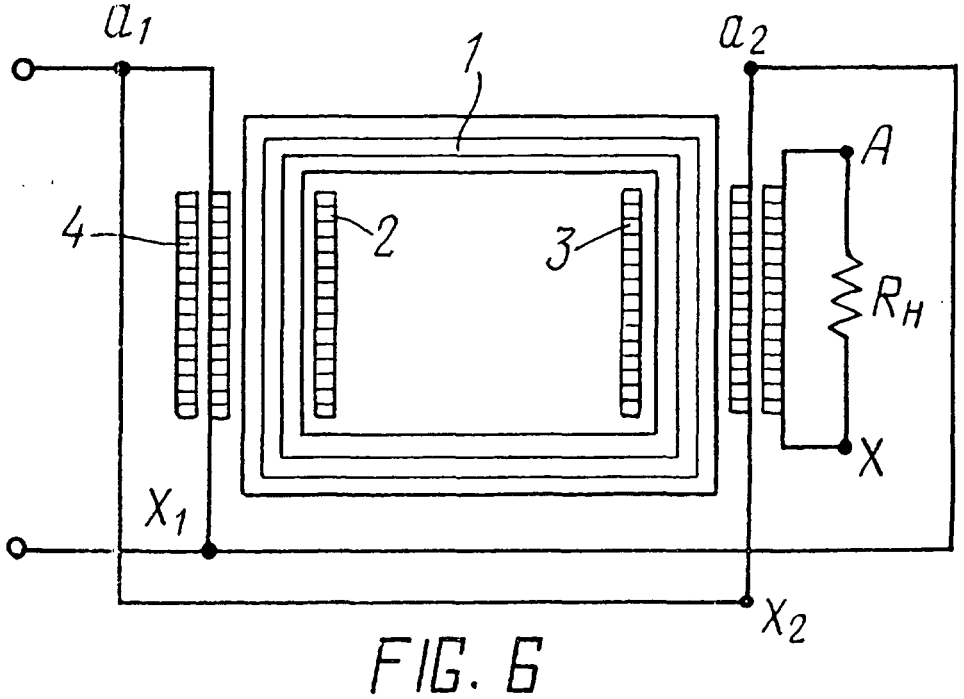


FIG. 6

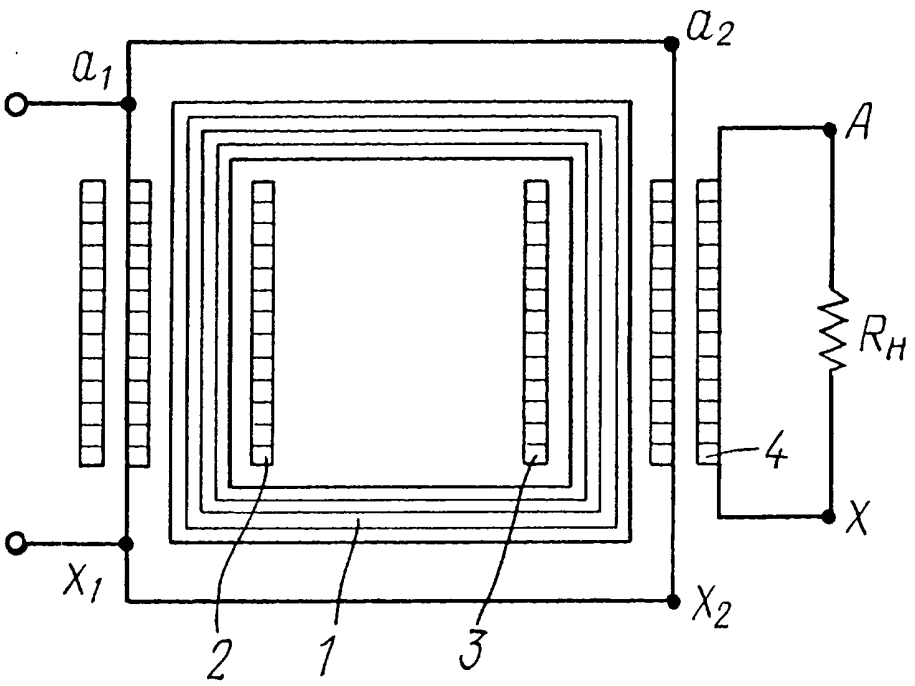


FIG. 7

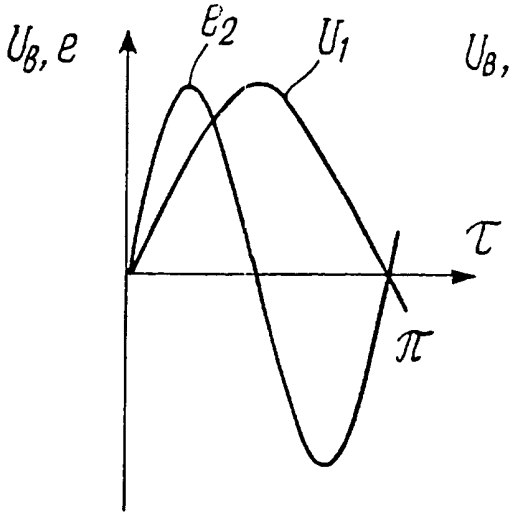


FIG. 8

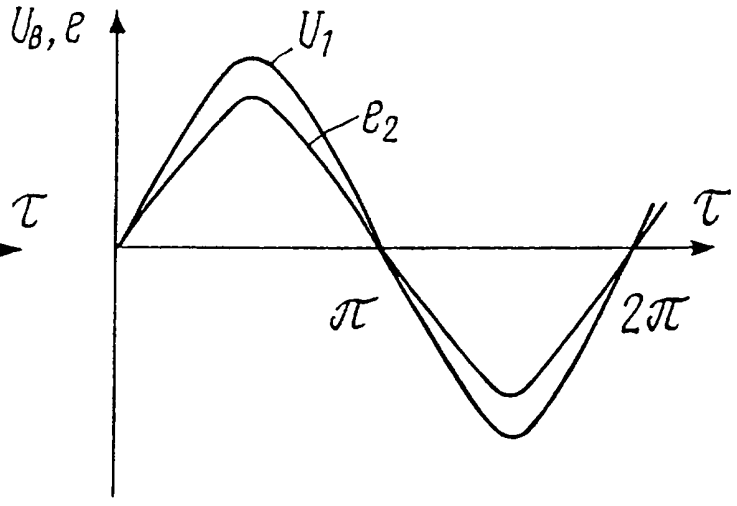


FIG. 9

REFERENCES CITED IN THE DESCRIPTION

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