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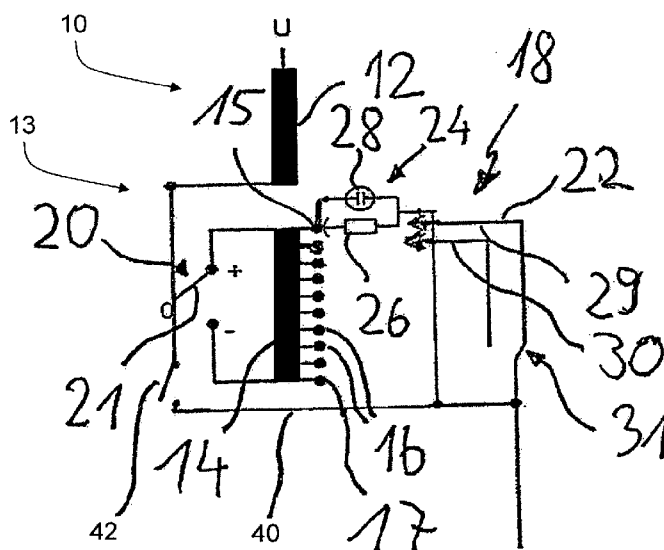
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[Continued on next page]

(54) Title: TAP CHANGER FOR A TRANSFORMER

FIG. 1



(57) Abstract: The invention relates to a tap changer for a power transformer comprising at least one main and one regulating winding, with a preselector (20) and a fine selector (18), which comprises at least one fine selector contact (29, 30). Besides the fine selector contact (29, 30), the fine selector (18) has at least one auxiliary switch (24), which is actuable independently of the fine selector contact (29, 30) and has at least one auxiliary switching component (26, 28), which contacts taps of the regulating winding in an at least largely arc-free manner. This makes it possible to perform switchover processes of the tap changer in a largely gas-free manner.



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TAP CHANGER FOR A TRANSFORMER

The present invention relates to a tap changer for a transformer, in particular a fine selector for a tap changer of a regulating transformer with a regulating winding comprising multiple taps, which are connectible by the fine selector. The tap changer according to the invention, however, also makes it possible to switch multiple windings of a transformer, for instance, multiple main windings. Tap changers are known for the purpose of changing the transmission ratio of the transformer under load, and thus allowing to adjust voltage and active and reactive power in electrical power networks. A fine selector for a tap changer is described in DE 23 59 628 A1, for instance. Regulating transformers are used in public power supply systems and in the industry, in particular for high-current applications such as aluminum production. The switchover processes, in particular switchover of the preselector, can involve the occurrence of electric switching arcs, which can cause gases to be released into a surrounding cooling and insulation medium, for instance an oil bath, thus polluting the medium and impairing its insulation and cooling effect.

The object of the present invention is to create a durable, maintenance-friendly tap changer for a transformer in which the switching processes do not release any gases into the transformer oil.

According to the invention, this object is fulfilled by a tap changer according to claim 1. The object of the invention is also fulfilled by a regulating transformer according to claim 9 and by a method according to claim 11. Advantageous developments of the invention are specified in the respective subclaims.

According to the invention, the tap changer comprises a preselector and a fine selector, which has at least one fine selector contact. Besides the fine selector contact, the fine selector has at least one auxiliary switch, which is actuatable independently of the fine selector contact and which has at least one auxiliary switching component, by which switching is at least largely arc-free.

The auxiliary switch can be used for switchover processes between the taps, in particular in the context of switchover of the preselector. After the switchover process is completed, the preselector and the fine selector contact of the fine selector reassume the task of electrical contacting.

The auxiliary switching component is designed to enable switchover between the various taps in an at least largely gas-free manner, i.e. without the occurrence of an electric arc. Such auxiliary switches that allow "smooth" or largely arc-free switching can include or be formed by vacuum switches, for instance vacuum switching tubes, transition resistors and/or semiconductor switches and also varistors and thermistors. In vacuum switches, electric arcs are prevented by the vacuum in the switch, and when using electronic components, this effect is achieved by their ability to limit current or voltage during the switching process, for instance by means of thermistors and varistors.

In a preferred embodiment, the auxiliary switch of the fine selector is connectible with the preselector via a coupling switch. In this instance, the auxiliary switch can be used very efficiently for gas-free switchover of the preselector.

The auxiliary switch preferably includes a vacuum switch, for instance a vacuum switching tube, as an auxiliary switching component. This isolates the electric arc from the surrounding medium and reduces the gas release into the oil. A vacuum switch can be produced at a low cost and allows switching high currents and voltages, such as are common in power transformers. As the auxiliary switch is used only for switchover, the service life of the auxiliary switch is very long.

The auxiliary switching components of the auxiliary switch are preferably constructed as vacuum switch and transition resistor, which are arranged such that always at least one of the two auxiliary switching components contacts one of the taps of the regulating winding. It is in this manner that uninterrupted switchover between the taps of various windings or of a regulating winding is made possible. The vacuum switch and transition resistor are preferably in an open parallel connection, with the open ends of the parallel connection forming switch contacts, which interact with the taps of the regulating winding.

Preferably, the transition resistor is arranged in switching direction upstream of the vacuum switch so that the vacuum switch still contacts the one tap while the transition resistor already contacts the next tap until the vacuum switching tube opens and disconnects from the tap and also contacts the next tap. In this way, the current flow is never completely interrupted, thus counteracting the occurrence of electric arcs during switchover. During the short transition phase when both auxiliary switching components contact two adjacent taps, a bridge current flows via the transition resistor between the two contacted taps.

The vacuum switch and the transition resistor are preferably disposed movably in relation to the taps of the regulating winding and in relation to each other. This allows a switching

geometry in which both auxiliary switching components selectively contact two taps of the regulating winding during the switchover process, thus enabling an uninterrupted current flow during switchover.

5 The auxiliary switching component of the auxiliary switch can take the form of a snap switch, in which the auxiliary switching component switches (snaps) onto a new winding contact under mechanical preload. This results in short switching times. If using a vacuum switch and a transition resistor as auxiliary switching components, first the transition resistor preferably snaps onto a new winding contact, for instance onto a tap of a regulating winding, and then, after having been opened, the vacuum switching tube snaps onto it.
10 This can be carried out by means of a spring mechanism, for instance. Snap switches as such are known from the prior art and their mode of operation does not need to be explained in detail here.

15 The tap changer preferably takes the form of a rotary switch, with the auxiliary switch and the fine selector also being formed as rotary switches. The fine selector contacts and the auxiliary switching components have a common axis of rotation and the taps of the regulating winding are arranged on a circular path around the axis of rotation. This structure allows a good integration of the auxiliary switch into the customary rotation switching geometry of a tap changer.

20 The preselector preferably takes the form of a change-over selector, which is connected with the main winding at its center tap and the switch of which contacts, in dependence on the switch position, one of the both ends of the regulating winding. Such a tap changer is cost-efficient and reliable.

25 If the auxiliary switch is connected with the preselector via a coupling switch in a preferable embodiment of the invention, the preselector can be switched over by means of the auxiliary switch without gas being released.

30 The invention also relates to a regulating transformer with a main winding and a regulating winding, which comprises multiple taps, the taps being switchable by a fine selector of a tap changer according to the previous explanations. The regulating transformer furthermore has a preselector, by means of which alternatively one of the both ends of the regulating winding is connectible with the main winding.

According to a particularly preferable embodiment of the invention, the main winding is connected with the auxiliary switch via a coupling switch. This allows using the auxiliary

switch of the fine selector for switchover of the preselector. This has the advantage that the preselector can be switched over in a completely potential-free and thus gas-free manner and because the switchover of the connection of the main winding with one of the both end contacts of the regulating winding is carried out by the auxiliary switch of the fine selector, which is enabled in a gas-free manner by means of the auxiliary switch. This embodiment is therefore particularly well suited for realizing gas-free switching of all switches of a tap changer in a power transformer, for instance the preselector and the fine selector of a tap changer. It should also be noted that switchover of the preselector is performed in a load-free manner. The capacitive coupling between main winding, regulating winding, and transformer housing leads to electric arcs and gas release into the surrounding oil medium on actuating the preselector. The switchover according to the invention by means of the auxiliary switch now allows switchover of the preselector in an uninterrupted and gas-free manner.

The invention furthermore relates to a method for switchover between multiple taps in a transformer using a tap changer with main switch and auxiliary switch as described above. According to the invention, only the auxiliary switch is used for switchover between the taps of regulating windings. In normal transformer operation, the taps are contacted by the main switch, for instance by the preselector or the main switch of the fine selector. This has the advantage that the auxiliary switch can be designed specifically for gas-free switchover and the main switch or the main switches can be designed solely for contacting during normal operation. These main switches have a very low resistance and are designed for conducting high currents.

The invention also relates to a method for switchover of a preselector in a regulating transformer of the previously mentioned type, in which the fine selector, i.e. its auxiliary switch, is connected with the main winding via a coupling switch. In this method, the auxiliary switch (24) is used for switchover of the preselector (20) between the end contacts (15, 17) of the regulating winding (14), wherein the auxiliary switch (24) is connected with the main winding via the coupling switch. The auxiliary switch switches over between the end contacts (15, 17) of the regulating winding, while the preselector (20) is switched to a non-contacting neutral position. In this manner, gas-free switchover of the preselector is ensured.

For switchover of the preselector, it is possible to proceed, for instance, as detailed in the following:

If not already switched to that position, the auxiliary switch of the fine selector can be switched selectively to the end contact of the change-over selector at the regulating winding. The coupling switch between the auxiliary switch of the fine selector and the main winding is then switched from the open normal position to a closed switchover position.

5 This results in the regulating winding then being connected both by the preselector and by the auxiliary switch of the fine selector with the same end contact of the regulating winding. In this context, both branches of the auxiliary switch contact the end contact of the regulating winding at the same time. During this switchover process, the fine selector contact or contacts of the fine selector can be switched to a non-contacting neutral position.

10 The change-over selector is then switched to a non-contacting neutral position, thus resulting in the corresponding end contact of the regulating winding to be connected with the main winding only by the auxiliary switch (via both branches). The auxiliary switch is now switched onto the other end contact at the regulating winding, for instance via all taps of the regulating winding, or (in the instance of a rotary switch) in the opposite sense, where-
15 in the other end contact, which the preselector is to be connected with, is removed by only one switching position. This switchover process is performed in an at least largely arc-free and gas-free manner by means of the auxiliary switching components.

The preselector, for instance the change-over selector, is then switched onto the corresponding end position of the regulating winding, and the coupling switch can be opened
20 again. After this switchover of the preselector, the other end of the regulating winding is thus connected with the main winding, without any gas released during the switching process. After switchover, the fine selector contact of the fine selector is moved onto the corresponding end contact and the auxiliary switch can be switched to a neutral, non-contacting position until it is again required for a switching process.

25 By using an auxiliary switch that performs switchover in a gas-free manner at the fine selector and by using the coupling switch in this switchover process, a solution is achieved with a technical element. The switchover process of the preselector on switchover of the regulating winding is performed in a gas-free manner.

In the following passages, the invention will be exemplarily described by way of the schematic drawing, in which:
30

FIG. 1 shows a circuit diagram of a regulating transformer with main winding, regulating winding, and a tap changer with preselector and fine selector,

FIG. 2 shows an illustration of the fine selector from FIG. 1 designed as rotary

switch,

FIG. 3a-h show a sequence of the switching statuses in the tap changer of a regulating transformer, in which the switchover of the preselector is performed by means of the auxiliary switch of the fine selector.

5 FIG. 1 shows a regulating transformer 10, such as is employed as power transformer in the area of energy supply. The regulating transformer 10 has a main winding 12 and a regulating winding 14 with a multitude of taps 16. The regulating transformer further comprises a tap changer 13 with a preselector designed, in particular, as change-over selector 20, which selectively connects the main winding 12 with one of the both end contacts 15, 17 of the regulating winding 14, and a fine selector 18 for connecting the taps, i.e. the taps of the regulating winding 14. The preselector can also take the form of a coarse tap selector. In this instance, the coarse tap selector connects or disconnects a section at the main winding. The change-over selector 20 has a switch 21, which is fixedly connected on one side with the main winding 12, and of which the switch contacts either contact the upper end contact 15 or the lower end contact 17 of the regulating winding 14. A load current typically flows via the main winding 12, the change-over selector 20, the regulating winding 12, and subsequently via the main switch 22 to the load dissipation.

The fine selector 18 comprises a main switch 22 with, for instance, two fine selector contacts 29, 30 and an auxiliary switch 24 with two auxiliary switching components 26, 28, wherein the first auxiliary switching component 26 is a transition resistor and the second auxiliary switching component 28 is a vacuum switch, for instance a vacuum switching tube. Using a load diverter switch, the fine selector contacts 29, 30 are alternatingly switched to the taps 16 of the regulating winding 14, as is known from DE 10 2009 060 132 A1, for instance. The auxiliary switch 24 is connectible with the tap of the change-over selector 20 and with the main winding 12 via a connection 40 and a coupling contact 42.

Such a fine selector according to FIG. 1 is typically designed as rotary switch, as can be seen in FIG. 2. Those parts which are identical or functionally equivalent to the parts in FIG. 1 are designated by identical reference characters. Regarding the arrangement of the transition resistor 26 and the vacuum switch 28 of the auxiliary switch 24, it must be added that with the switching direction of the auxiliary switch as it is indicated by the arrow direction, the distance of the two auxiliary switching components 26, 28 is adjusted or adjustable by means of a spring mechanism in such a manner that for a short moment both auxiliary switching components 26, 28 contact two adjacent taps 16 on one switching lev-

el, while a corresponding current flows between the taps 16 via the transition resistor 26 and the vacuum switch 28. Due to the construction of the fine selector 18, the taps of a regulating winding 14 are distributed on two levels. The even-numbered taps (2, 4, 6,...) are located on the first level, and the uneven-numbered taps (1, 2, 3, 5,...) on the second level.

The vacuum switch 28 is constructed as a pressure-actuable vacuum switching tube, which contacts as soon as the switch contact 32 of the vacuum switch 28 glides by a certain distance onto a tap 16, wherein the two switch contacts 32, 34 of the vacuum switch 28 are pressed onto one another and contact. The auxiliary switch in the present context is designed for gas-free switchover and configured for a great number of switching processes. A reliably operating, low-maintenance fine selector with a long lifetime is thus realized. Contacting of the vacuum switch 28 with a tap 16 is performed via a simple contact. The branch with the auxiliary switching component 26, ergo the transition resistor, contacts the tap 16 via a snap arrangement.

The tap changer 13 illustrated in FIG. 1 and 2 is advantageous in particular because, by coupling the auxiliary switch 24 with the main winding 12 via the coupling switch 42 during switchover of the preselector 20, the actual switchover process can be performed by means of the auxiliary switch 24, while the preselector 20, i.e. its switching component 21, is switched to a non-contacting neutral position.

FIG. 3 illustrates a preselector 20 being switched over in a gas-free manner, i.e. without creating an electric arc at the preselector, using the fine selector 18 from FIG. 1 and 2. The corresponding circuit diagrams in FIG. 3b to 3h respectively illustrate the corresponding switching position of a fine selector designed as rotary switch.

During regular operation, i.e. with the preselector not being switched over as shown in FIG. 3a, the coupling switch 42 is open.

For switchover of the change-over selector 20, the coupling switch 42 is closed, as shown in FIG. 3b. The change-over selector 20 is switched over currentless so that the only problems during switchover result from capacitive coupling between main winding, regulating winding, and housing (earth). This can lead to an electric arc and thus to gas formation when switching over the change-over selector 20. By closing the coupling switch according to FIG. 3, the upper end contact 15 of the regulating winding 14 is, however, now connected with both the change-over selector 20 and the fine selector contact 29 of the fine selector 18. The auxiliary switch 24 with the two auxiliary switching components 26, 28 is

then brought into contact with the upper end contact 15 of the regulating winding 14 (FIG. 3d). After that, the change-over selector 20 can be switched to a non-contacting neutral position, as is shown in FIG. 3e. Due to the upper end contact 15 of the regulating winding 14 being connected with the coupling switch 42 with main winding 12 by means of the auxiliary switch 24, in particular by means of the auxiliary switching component 28 with closed vacuum switching tube, the switch 21 of the change-over selector 20 remains at the same potential as the upper end contact 15 of the regulating winding 14 so that no electric arc will occur on opening the switch 21 of the change-over selector 20. The auxiliary switch 24 of the fine selector 18 is subsequently moved, for instance via all taps 16 of the regulating winding 14, onto the lower end contact 17 of the regulating winding, as illustrated in the Figures 3e and 3f. As the taps 16 are distributed on two levels, the auxiliary switch 24 always skips one respective tap 16 on moving toward the lower end contact.

Switchover in this context is performed as follows:

The auxiliary switching component 26 with the transition resistor jumps onto the next tap to be switched. Due to the snap contact at its end and to the fact that this snap contact disconnects from the tap extremely rapidly, switchover will not produce an electric arc. A circular current then flows between the taps via the auxiliary switching components 26, 28. This circular current is interrupted by opening the vacuum switching tube, and the auxiliary switching component 28 with the vacuum switch can subsequently be switched in an arc-free manner onto the tap, which is also contacted by the auxiliary switching element 26 with transition resistor.

As soon as the auxiliary switch 24 has contacted the lower end contact 17 of the regulating winding 14, the switch 21 of the change-over selector 20 can be switched onto this end contact 17, which switching can be accomplished, again, without producing an electric arc and thus in a gas-free manner, because the auxiliary switch 24, in particular the auxiliary switching component 28 with the closed vacuum switching tube is at the same potential as the switching component of the change-over selector 20. In an optional sequence, it is then possible to open the coupling switch 42 again, and the fine selector contact 29 of the fine selector 18 can be contacted with the lower end 46 of the regulating winding 14, thus completing the switchover process.

As is shown in FIG. 3h, contacting of the taps 16 by means of the fine selector contact 29 of the fine selector 18 can already be performed before opening the coupling switch 42.

The above-described exemplary embodiments have shown that the construction of the

fine selector 18 according to the invention with an auxiliary switch 24 enables the change-over selector 20 to be switched over in a gas-free manner.

The invention is not limited to the disclosed exemplary embodiments, but can rather be varied within the scope of the following claims.

CLAIMS

1. A tap changer for a power transformer comprising at least one main winding and one regulating winding, with
 - 5 – a preselector (20) and
 - a fine selector (18), which comprises at least one fine selector contact (29, 30), characterized in that
 - the fine selector (18) comprises, besides the fine selector contact (29, 30), at least one auxiliary switch (24) with at least one auxiliary switching component (26, 28),
10 the auxiliary switch (24) being actuatable independently of said fine selector contact (29, 30).
2. Tap changer according to claim 1, wherein the auxiliary switching component (28) comprises a vacuum switch.
3. Tap changer according to claim 1 or 2, wherein the auxiliary switch (24) comprises a
15 vacuum switch (28) and a transition resistor (26) as auxiliary switching components.
4. Tap changer according to claim 3, wherein the auxiliary switch (24) contacts the transition resistor (26) in switching direction upstream of the vacuum switch (28).
5. Tap changer according to one of the previous claims, wherein the auxiliary switch (24) is constructed as snap switch.
- 20 6. Tap changer according to one of the previous claims, wherein
 - the auxiliary switch (24) is constructed as rotary switch in the fine selector (18),
 - the fine selector contacts (29, 30) and the auxiliary switching components (26, 28) have a common axis of rotation and
 - the taps (16) are arranged on a circular path around the axis of rotation.
- 25 7. Tap changer according to one of the previous claims, wherein the preselector (20) is constructed as change-over selector or coarse tap selector.
8. Tap changer according to one of the previous claims, wherein the auxiliary switch (24) is connected with the preselector (29) via a coupling switch (42).
9. A regulating transformer (10) with at least one main winding (12) and at least one
30 regulating winding (14) having multiple taps (16), which regulating transformer has a tap

changer (17) according to one of the previous claims.

10. Regulating transformer (10) according to claim 9, wherein the auxiliary switch (24) is connected with the main winding (12) via a coupling switch (42)

5 11. A method for switchover of the preselector in a regulating transformer by way of using a tap changer according to one of the claims 1 to 8, characterized in that

- the auxiliary switch (24) is used for switchover of the preselector (20) between the end contacts (15, 17) of the regulating winding (14),
- the auxiliary switch (24) is connected via a coupling switch (42) with the main winding (12) and performs switchover between the end contacts (15, 17) of the regulating winding, while the preselector (20) is switched to a non-contacting neutral position.

12. Method according to claim 11 for switchover of a preselector in a regulating transformer according to claim 9 or 10, characterized by the following steps,

- 15 (a) the auxiliary switch (24) of the fine selector (18), or at least one auxiliary switching component (28), is connected with an end contact (15, 17) of the regulating winding (14) prior to switchover of the preselector (22),
- (b) the auxiliary switch (24) is switched onto that end contact (15, 17) of the regulating winding which is contacted by the preselector (20),
- 20 (c) the preselector is switched into a non-contacting neutral position,
- (d) the end contact (15, 17) to be switched and located at the opposite end of the regulating winding (14) is contacted by the auxiliary switch (24) of the fine selector (18),
- (e) the fine selector (20) is switched over onto that end contact (15, 17) of the regulating winding that is to be switched, and
- 25 (f) the connection between the auxiliary switch (24) and the regulating winding (14) is disconnected again.

13. Method according to claim 12, characterized by a chronological sequence of the process steps a) to f).

14. Method according to one of the claims 11 to 13, characterized in that the fine selector contact (29, 30) is disconnected from the taps (16) of the regulating winding (14) during switchover of the auxiliary switch (24).

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FIG. 1

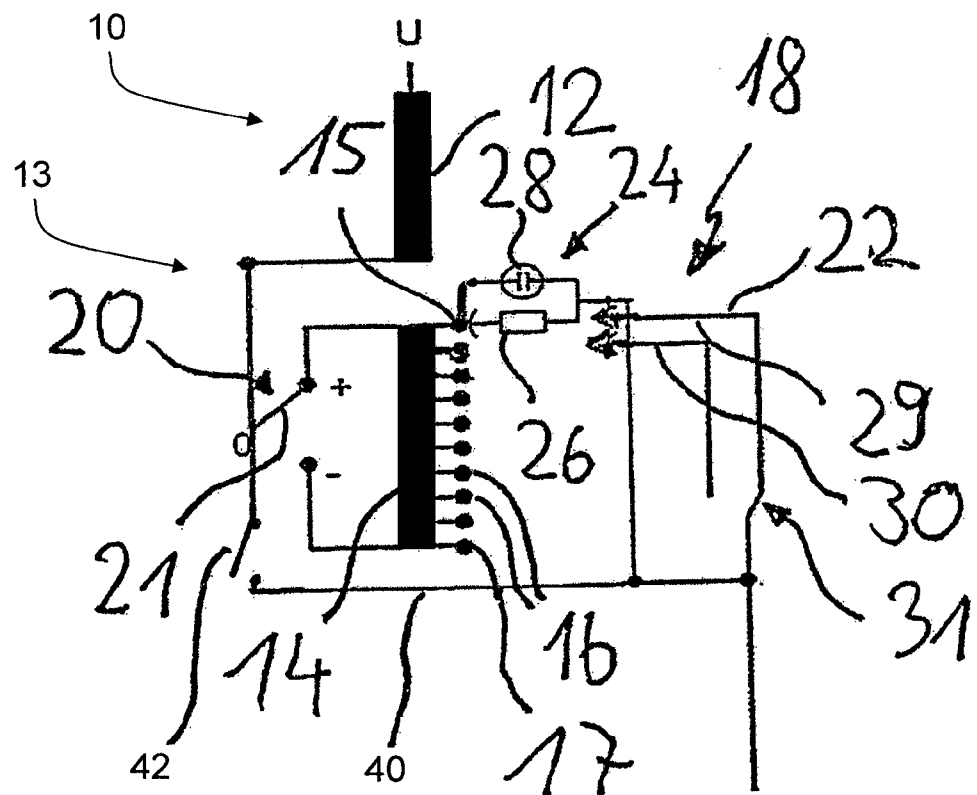
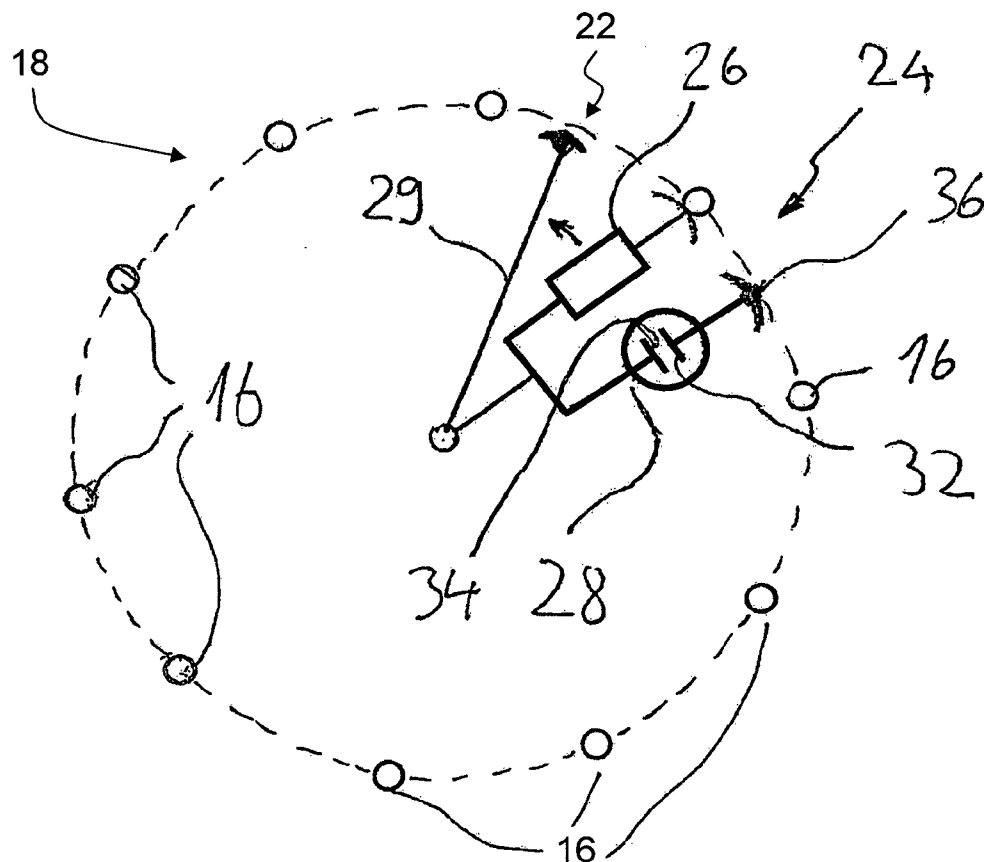


FIG. 2



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FIG. 3a

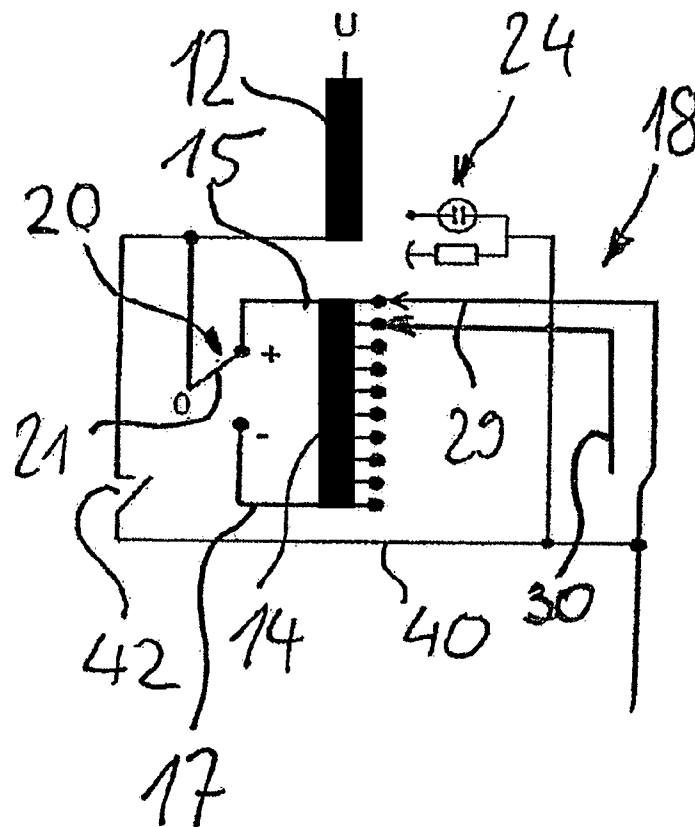
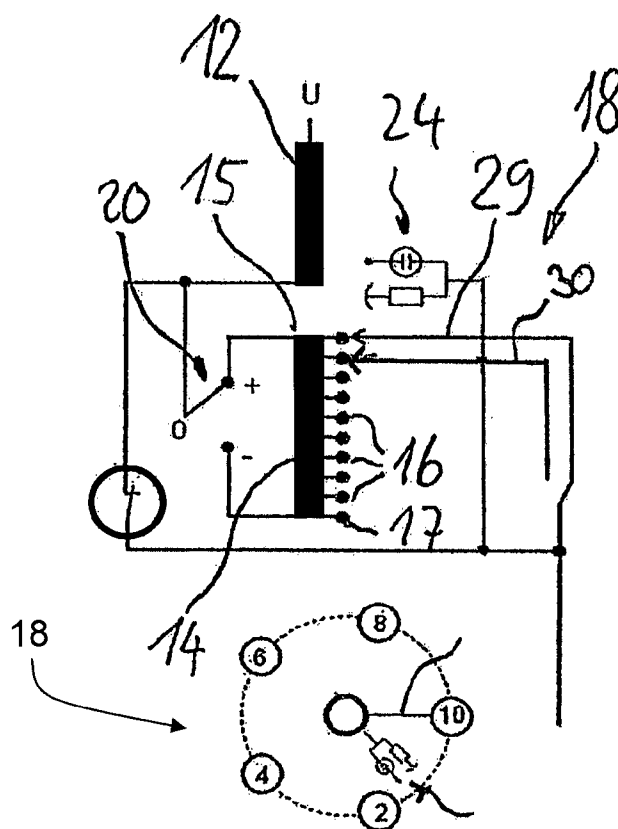


FIG. 3b



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FIG. 3c

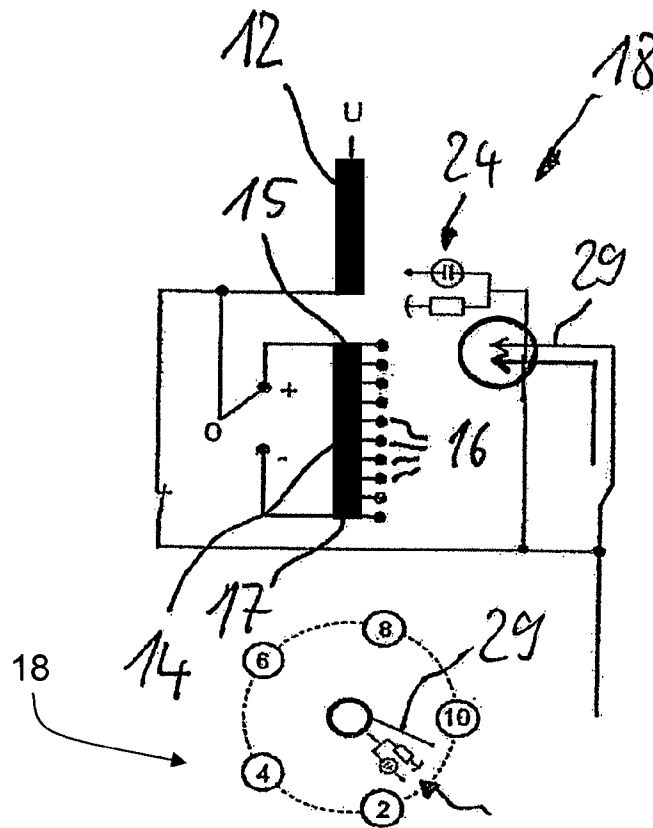
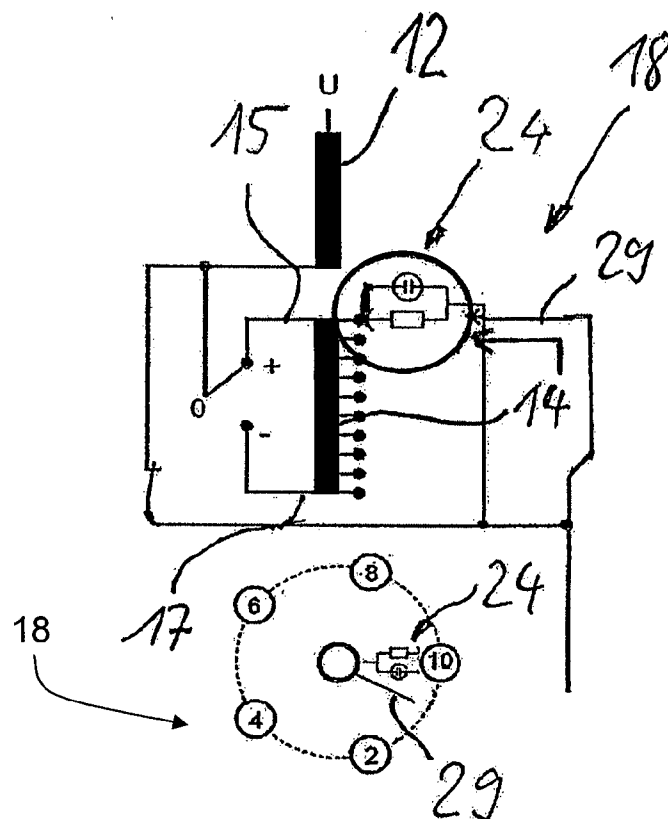


FIG. 3d



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FIG. 3e

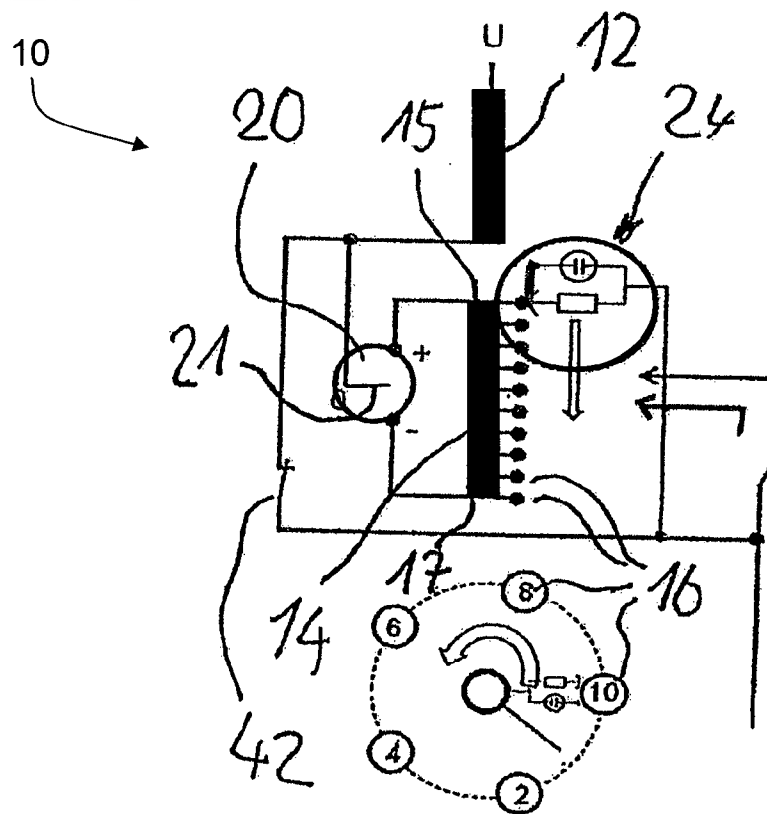
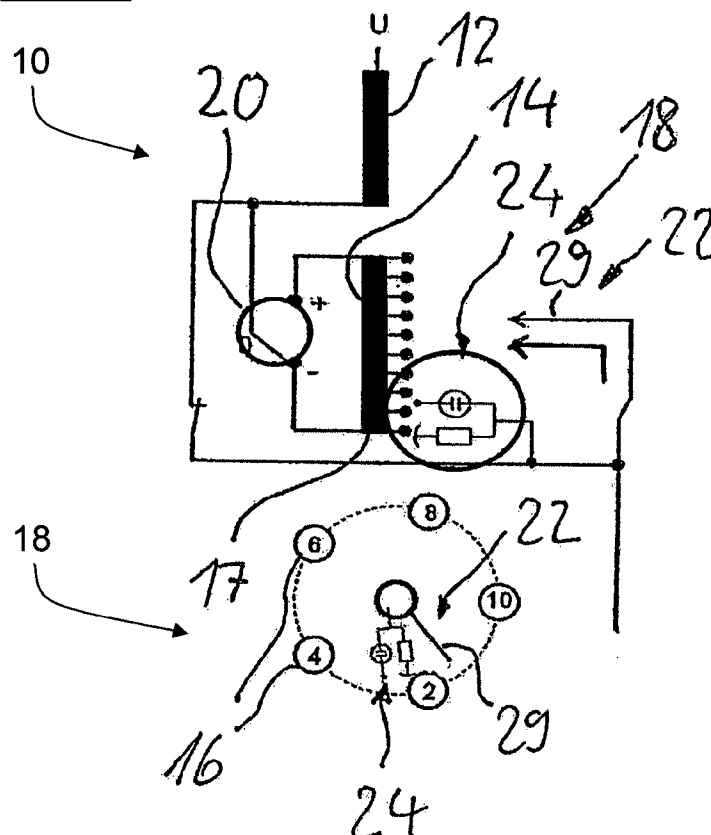


FIG. 3f



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FIG. 3g

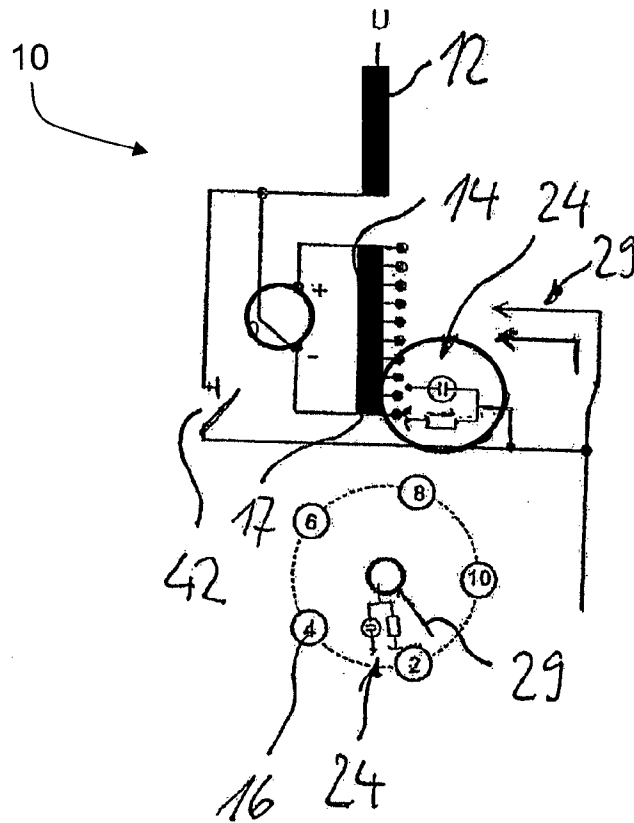
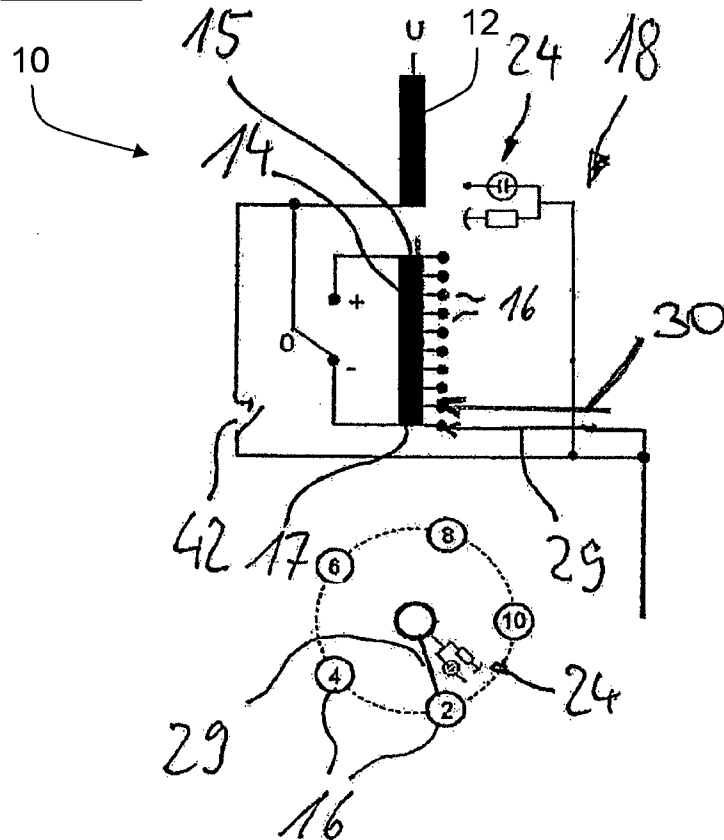


FIG. 3h



INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2014/070639

A. CLASSIFICATION OF SUBJECT MATTER
INV. H01H9/00 H01F29/04
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H01H H01F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DE 10 2009 060132 B3 (REINHAUSEN MASCHF SCHEUBECK [DE]) 12 May 2011 (2011-05-12) cited in the application	1,7-14
Y	paragraphs [0021], [0022]; claims; figures 2,3	2-6
Y	----- DE 195 01 529 C1 (REINHAUSEN MASCHF SCHEUBECK [DE]) 20 June 1996 (1996-06-20) column 2, line 43 - column 3, line 42; figures	2-6
A	----- WO 2013/053510 A1 (REINHAUSEN MASCHF SCHEUBECK [DE]; BISGES MICHAEL [DE]) 18 April 2013 (2013-04-18) abstract; figure 2 -----	1



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

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Date of the actual completion of the international search

19 November 2014

Date of mailing of the international search report

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Findeli, Luc

INTERNATIONAL SEARCH REPORT

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