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(54) Title: ELECTRONICALLY COMMUTATED MOTOR



(57) **Abrégé(suite)/Abstract(continued):**

interlocking transistor (172) can be controlled at least by the base signal of the first power transistor (124). This prevents the two power transistors (124, 128) from becoming simultaneously conductive during commutation and makes it possible to control the commutation process by activating or deactivating the base discharge resistances (160, 170).



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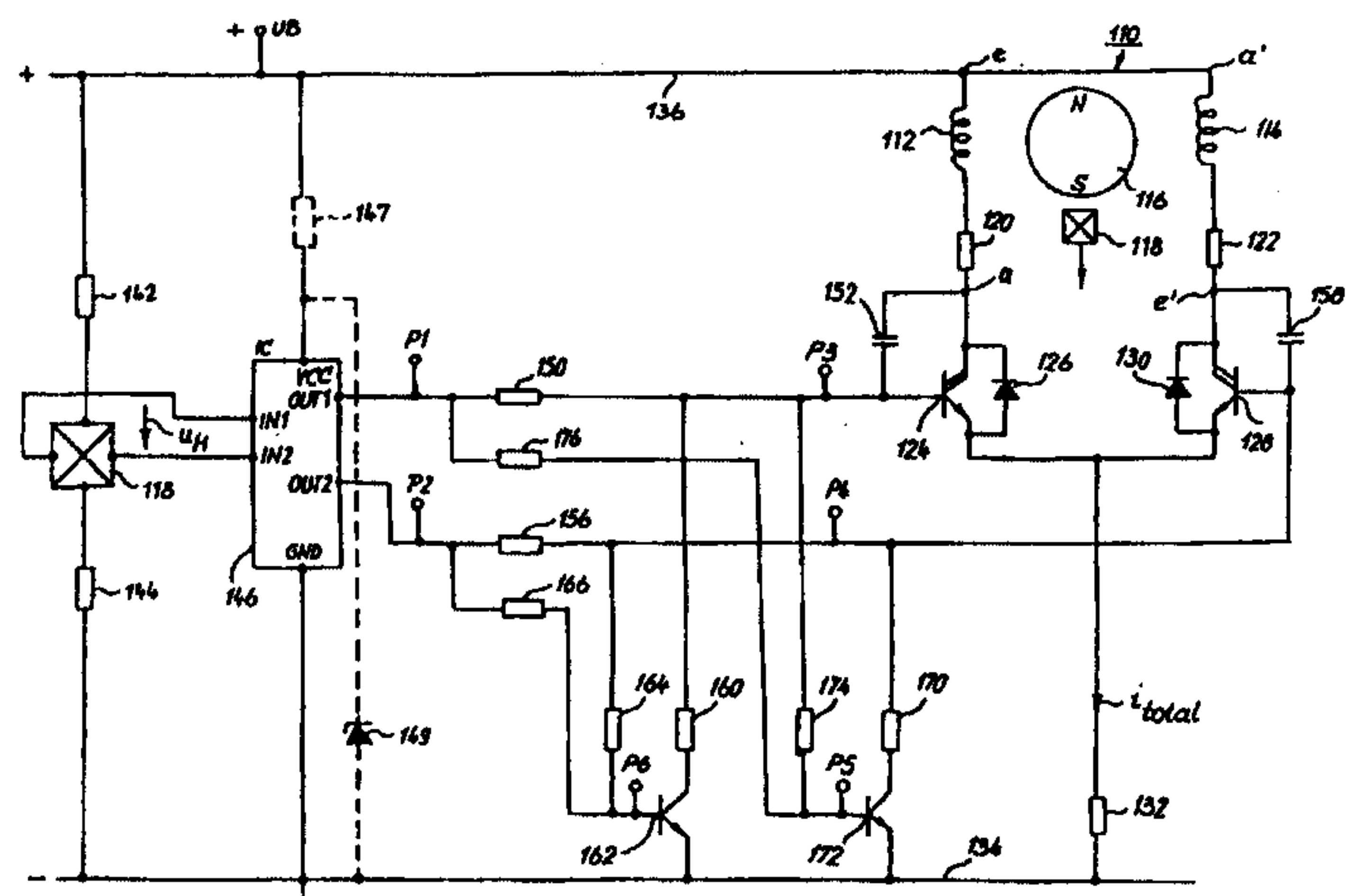
(54) Title: ELECTRONICALLY COMMUTATED MOTOR

(54) Bezeichnung: ELEKTRONISCH KOMMUTIERTER MOTOR

(57) Abstract

An electronically commutated motor comprising a stator and a rotor. The inventive motor also has at least two stator phase windings (112, 114), whereby each winding can be activated by means of an associated power transistor (126, 128) and said windings are controlled in push-pull mode by rotor position signals (OUT1, OUT2) according to the position of the rotor (116). The signals are transmitted to the bases of the power transistors via a resistance (150, 156). A discharge resistance (160) provided for the base of a first power transistor (124) is connected in series to a first interlocking transistor (172). A discharge resistance (170) connected in series to a second interlocking transistor (172) is provided for the base of the other power transistor (128). The first interlocking transistor (162) can be controlled at least by the base signal of the second power transistor (128). The second interlocking transistor (172) can be controlled at least by the base signal of the first power transistor (124).

This prevents the two power transistors (124, 128) from becoming simultaneously conductive during commutation and makes it possible to control the commutation process by activating or deactivating the base discharge resistances (160, 170).



ELECTRONICALLY COMMUTATED MOTOR

FIELD OF THE INVENTION

The invention relates to an electronically commutated motor having at least two stator winding strands or phases, each of which can be actuated by means of an associated power transistor. Such motors are often referred to as "two-phase" motors and are used in great quantities, above all in fans. Fig. 6 shows one of the circuits presently used by the Applicant for controlling such motors.

10

BACKGROUND

Often, such motors must be capable of being operated on very differing voltages, e.g. a fan with a nominal voltage of 24 V is, in practice, operated with voltages ranging between 12 V and 32 V, which represents a voltage deviation range from -50% to +30%. Depending upon voltage, such a fan runs at a desired speed (RPM), i.e. slowly at lower voltages, and fast at higher voltages.

Upon commutation of the motor current from one stator winding phase to another, the switchover can occur in a "hard" or in a "soft" manner. A hard switchover offers good efficiency, but high structure-borne noise levels caused by commutation noise and, additionally, EMC problems (EMC=Electro-Magnetic Compatibility). Further, protective measures must be taken for the end-stage transistors, so that the critical limit values of the components (permissible collector voltages etc.) are not exceeded. This can be accomplished by internal Z-diodes contained in the end-stage transistors or by external Z-diodes (for limiting these voltages) or by recovery diodes which feed back the shutoff energy of the windings to an operating voltage link circuit containing a capacitor capable of receiving this shutoff energy.

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1 Fig. 6 shows a motor 10 with two stator winding strands or
2 phases 12, 14 and a (schematically indicated) permanent magnet
3 rotor 16, in whose vicinity a Hall generator 18 is located.
4 Hall generator 18 is also shown in the left portion of Fig. 6.
5 Ohmic resistors of phases 12 and 14 are designated 20 and 22,
6 respectively. Phase 12 is connected in series with an npn
7 Darlington transistor 24 with built-in recovery diode 26, and
8 phase 14 is connected in series with an npn Darlington transistor
9 28 with built-in recovery diode 30. The emitters of transistors
10 24, 28 are connected via a common emitter resistor 32 to a
11 negative conductor 34. Phases 12, 14 are connected to a positive
12 conductor 36, as shown. Conductors 34, 36 are, during operation,
13 connected to a power supply device 38 which contains a storage
14 capacitor 40. This serves to take up the shutoff energy of
15 phases 12, 14, which is fed back via recovery diodes 26, 30 into
16 this capacitor 40. To the extent that the motor is supplied from
17 an accumulator, the shutoff energy is fed back into the
18 accumulator.

19 Hall generator 18 is connected via a resistor 42 with
20 positive conductor 36 and via a resistor 44 with negative
21 conductor 34. Its output signal U_H (Fig. 7A) is applied to both
22 inputs IN1 and IN2 of an IC (Integrated Circuit) 46 which
23 generates signals OUT1 and OUT2 for controlling transistors 24,
24 26 and simultaneously serves as blocking or stall protection for
25 motor 10, i.e. when it is unable to turn, it is switched off by
26 IC 46.

This IC is preferably the ROHM BA6406. Fig. 7A shows the signal U_H , Fig. 7B shows the signal OUT1 of IC 46 and Fig. 7C shows the signal OUT2. Signals OUT1 and OUT2 run in phase opposition to each other. Fig. OUT1 is fed via a resistor 50
 5 (e.g. 8.2 k Ω) to the base of transistor 24, which is connected via a capacitor 52 (e.g. 1 Nf) to the collector and via a base drain-off resistor 54 (e.g. 1.2 k Ω) to negative conductor 34. In the same manner, signal OUT2 is fed via a resistor 56 to the base of transistor 28, which is connected via a capacitor
 10 58 with its collector and via a base drain-off resistor 60 with negative conductor 34.

During operation, transistors 24, 28 are alternately switched on by signals OUT1, OUT2. Through the combination of resistor 50 and capacitor 52 and the common resistor 32, a
 15 soft switching of transistor 24 is achieved. Similarly, resistor 56, in combination with capacitor 58 and common resistor 32, effects a soft switching of transistor 28. However, these measures cause an increased warming of transistors 24, 28 and therefore a reduction in efficiency.
 20 Furthermore, the circuit can be optimally configured only for a single operating point, i.e. for a specified RPM and a specified torque. This results in many compromises, especially with respect to voltage overruns and temperature overruns. One also obtains, in practice, a voltage range only of $\pm 15\%$.

25 SUMMARY OF THE INVENTION

It is therefore an object of the invention to provide a new electronically commutated motor.

In accordance with the invention, this object is achieved by an electronically commutated motor comprising: a stator and
 30 a rotor (116), at least one rotor position sensing means (118), a commutation controller (146), responsive to signals from the rotor position sensing means, for generating rotor position signals (OUT1, OUT2), at least first and second power transistors (124, 128), at least two stator winding phases
 35 (112, 114), each adapted to be energized via a respective one of the power transistors (124, 128) and being controllable, as

a function of position of the rotor (116), by oppositely phased ones of the rotor position signals (OUT1, OUT2), the signals being applied to the bases of the power transistors via a respective resistor (150, 156), a base drain resistor (160) for the base of the first power transistor (124), which resistor (160) is connected in series with a first latching transistor (162), a base drain resistor (170) for the base of the second power transistor (128), which resistor (170) is connected in series with a second latching transistor (172), the first latching transistor (162) being controllable at least by the base signal of the second power transistor (128) and the second latching transistor (172) being controllable at least by the base signal of the first power transistor (124), in order to prevent, during commutation, simultaneous conduction of both power transistors, and in order to control commutation by activation and deactivation of the base drain resistors (160, 170).

By the alternate biasing of the power transistors, one achieves that such a motor is usable over a large range of its operating voltage U_B ; and further, that, during commutation, both power transistors are briefly blocked, which minimizes braking torques and improves efficiency, and that the kind of commutation can be adapted to the rotation speed (soft commutation at low RPM, hard commutation at higher RPM).

This can be achieved by making the kind of ascent and descent of the commutation signal dependent upon the RPM. Such a solution is also very economical.

BRIEF FIGURE DESCRIPTION

5 Further details and advantageous features of the invention will be apparent from the embodiment described below and illustrated in the drawings, which is not to be understood as limiting the invention, as well as from the dependent claims. Shown are:

10 FIG. 1 illustrates a preferred embodiment of an electronically commutated motor according to the invention;

FIG. 2 is a graph showing the course of commutation during operation at a 50% undervoltage (12 V), the normal operating voltage being 24 V in this example;

15 FIG. 3 is a graph, analogous to FIG. 2, for the prior art motor shown in FIG. 6;

FIG. 4 is a graph showing the course of commutation, in a motor according to FIG. 1, during operation at a 16.5% overvoltage (28 V);

20 FIG. 5 is a graph, analogous to FIG. 4, for the prior art motor shown in FIG. 6;

FIG. 6 is a schematic diagram of a motor according to the prior art;

25 FIG. 7 is a signal diagram illustrating the operation of the motors shown in FIGS. 1 and 6;

FIG. 8 is a schematic diagram illustrating a first embodiment of the stator winding; and

FIG. 9 is a schematic diagram illustrating a second embodiment of the stator winding.

DETAILED DESCRIPTION

The electronically commutated motor 110 according to FIG. 1 has two stator winding phases 112, 114 and a (schematically illustrated) permanent magnet rotor 116, in whose vicinity a Hall generator 118 is located, as also shown on the left side of FIG. 1. Respective ohmic resistances of the windings 112 and 114 are designated 120 and 122.

As shown in FIG. 8, by way of example, the two phases 112, 114 are preferably coupled with each other by making the winding with two parallel wires, i.e. as a so-called "bifilar" winding. The terminals of phase 112 are designated a and e, and the terminals of phase 114 are designated a' and b' as shown in FIGS. 8 and 9. In phase 112, current flows from a to e, while in phase 114, current flows from e' to a', so that these two phases create opposing magnetic fluxes. Motor 110 can, for example, be constructed as shown in DE 23 46 380.

Alternatively, phases 112, 114 may be inductively coupled together via the metal lamination stack of the stator. FIG. 9 shows this, on a two-pole stator 210 of an external rotor motor. Phase 112 is wound on the upper stator pole 214, and phase 114 is wound on the lower stator pole 216. Part 218 of the lamination stack between poles 214, 216 effects a close magnetic coupling of the winding phases 112, 114. The preferred rotation direction of the motor of FIG. 9 is designated 220. In FIG. 9, the internal stator 210 remains still, and the two-pole rotor 116 rotates around it.

Phase 112 is, as shown in FIG. 1, in series with an npn Darlington transistor 124 with built-in recovery or free-running diode 126, and phase 114 is in series with an npn Darlington transistor 128 with built-in recovery or free-running diode 130. The emitters of transistors 124, 128 are, in the illustrated embodiment, connected in an advantageous manner via a common emitter resistor 132 to a negative conductor 134. Optionally, each of transistors 124, 128 can have its own emitter resistor.

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1 Phases 112, 114 are, as shown, connected to a positive conductor
2 136. Conductors 134, 136 are, during operation, usually
3 connected to a power supply 38 (FIG. 6) which includes a storage
4 capacitor 40. It serves the purpose of absorbing the shut-off
5 energy of stator phases 112, 114, which is fed back via recovery
6 diodes 126, 130 into this capacitor 40.

7 Depending upon how "softly" the end-stage transistors 124,
8 128 are switched during commutation, there is a reduction in the
9 shut-off energy, which must be fed back into capacitor 40 during
10 the commutation. In the most favorable scenario, such a
11 capacitor becomes unnecessary, since a slow shut-off of
12 transistors 124, 128 means that this energy can be completely
13 converted into heat in the end stages.

14 Hall generator 118 is connected via a resistor 142 to the
15 positive conductor 136 and via a resistor 144 to the negative
16 conductor 134. The generator output signal U_H (FIG. 7A) is
17 applied to both inputs IN1 and IN2 of an IC 146, which generates
18 the signals OUT1 and OUT2 for control of transistors 124, 128 and
19 which simultaneously provides protection against stalling of
20 motor 110; that is, when rotor 116 cannot turn, the motor is
21 turned off by IC 146. FIG. 7A shows this signal U_H, FIG. 7B
22 shows signal OUT1 of IC 146, and FIG. 7B [sic] shows signal OUT2.
23 The two last-mentioned signals are phased oppositely to each
24 other. Signal OUT1 is fed via a resistor 150 to the base of
25 transistor 124, which is connected via a capacitor 152 (Miller
26 capacitor) to the collector of transistor 124. In the same
27 manner, signal OUT2 is fed via a resistor 156 to the base of
28 transistor 128, which is connected via a capacitor 158 (Miller
29 capacitor) to its collector.

30 IC 146 is, as shown, connected via its terminal VCC to the
31 positive conductor 136 and via its terminal GND to the ground or
32 negative conductor 134. Optionally, a resistor 147 can be placed
33 in the connection to positive conductor 136, and terminal VCC can

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1 be connected via a Z-diode 149 to negative conductor 134. The
2 Zener voltage of diode 149 can be selected to be above the
3 nominal operating voltage U_B , e.g. 28 V if the motor is designed
4 for 24 V. Thereby, the amplitudes of signals OUT1, OUT2 rise to a
5 voltage of 28 V and then remain constant, even if U_B rises still
6 higher. In FIG. 7B, the variable amplitude of signal OUT1 is
7 indicated by the double-ended arrow 151. The same applies for
8 the signal OUT2, but this is not shown.

9 Thus, below the Zener voltage, one has a dependence of
10 signal amplitudes upon U_B , but not above the Zener voltage.
11 Without the Z-diode 149, there is this dependence over the entire
12 range of U_B .

13 The base of transistor 124 is connected via a base drain
14 resistor 160 and the collector-emitter path of an npn transistor
15 162 to the negative conductor 134. The base of transistor 162 is
16 connected via a resistor 164 to the base of transistor 128 and
17 via a resistor 166 to the output OUT2 of IC 146. The value ratio
18 of resistor 164 to resistor 166 is about, for example, 3:100,
19 i.e. the influence of the signal on the base of transistor 124 is
20 stronger than that of signal OUT1 [sic].

21 In a fully symmetrical manner, the base of transistor 128 is
22 connected via a base drain resistor 170 and via the collector-
23 emitter path of an npn transistor 172 to the negative conductor
24 134. The base of transistor 172 is connected via a resistor 174
25 to the base of transistor 124, and via a resistor 176 to the
26 output OUT1 of IC 146. The values of resistors 174, 176
27 correspond to those of resistors 164, 166.

28 The transistors 162, 172 can, on the one hand, be called
29 "safety or latching" transistors, since they latch the two power
30 transistors 124, 128 with respect to each other, and prevent them
31 from both being conductive (ON) at the same time. On the other
32 hand, these transistors do not simply switch ON or OFF; rather,
33 they activate, during the commutation interval, the base drain

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1 resistors 160 and 170, respectively, while in the time ranges
2 outside the commutation, these resistors 160, 170 are not active.

3 According to the prior art circuit shown in FIG. 6, the base
4 drain resistors 54, 60 are continuously active. This is
5 particularly disadvantageous during an undervoltage condition,
6 since, for example, in FIG. 6 the resistor 60 and resistor 56
7 together form a voltage divider which, if there is a low
8 operating voltage U_B , may prevent transistor 28 from receiving an
9 adequate base current.

10 However, since in the circuit according to FIG. 1, the base
11 drain resistors 160, 170 are only active in the interval of the
12 commutation process, and not active in the time interval between
13 two commutations, problems in the latter time interval arising
14 from resistors 160, 170 are avoided, even in case of low
15 operating voltage U_B , since they are not then active, as already
16 described.

17 In the circuit, various monitoring points P1 to P6 are
18 shown. If, for example, power transistor 124 is conductive,
19 monitoring points P1 and P3 have differing potentials, since a
20 base current flows via resistor 150 from the positive (high)
21 output OUT1 to the base of transistor 124, and upon shut-off of
22 transistor 124, the signal OUT1 is indeed low, but the shut-off
23 voltage of winding 112 is transmitted via capacitor 152 to the
24 base of transistor 124, and has the effect that this base
25 receives base current for a little while longer. Due to the
26 symmetry of the circuit, the relationships at transistor 128 are
27 identical.

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1 PREFERRED VALUES OF COMPONENTS

2 Motor 110 is, in this example, designed for an operating
3 voltage of 24 V direct current, and has a power draw of 2.4 W
4 at this nominal voltage.

5	Hall generator 118	HWA 101
6	IC 146	ROHM BA6406
7	Resistor 132	1 Ω
8	Resistors 150, 156	8.2 k Ω
9	Resistors 160, 170	560 Ω
10	Resistors 164, 174	1.5 k Ω
11	Resistors 166, 176	47 k Ω
12	Capacitors 152, 158	3.3 nF
13	Transistors 124, 128	ZTX600
14	Transistors 162, 172	BC847A

15 MODE OF OPERATION

16 Since the arrangement is symmetrical, it suffices to
17 describe the processes involved in the switching of current from
18 phase 114 to phase 112, since the processes in the reverse
19 direction, ie. from phase 112 to phase 114, take the same course.

20 Whenever phase 114 is carrying current, the signal OUT1 is
21 low and the signal OUT2 is high. This corresponds to instant t_1
22 in FIG. 7. Thus, transistor 124 is blocked, and transistor 128 is
23 conducting, as is transistor 162, since its base is subjected to
24 the high signal OUT2. However, since OUT1 is low, no current
25 flows over its collector-emitter path, i.e. in this state,
26 transistor 162 has no influence on the function of the motor and
27 also does not influence its efficiency.

28 Upon commutation at instant t_2 (FIG. 7), signal OUT1 goes
29 high and signal OUT2 goes low. Transistor 162 continues to
30 conduct, since it receives, as before, a base current from the
31 base of transistor 128, and thereby transistor 124 remains
32 initially blocked, although signal OUT1 is high, since its base

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1 current is drained away via resistor 160. Transistor 128, in
2 this state, is still conductive, since it is still receiving a
3 base current, via capacitor 158.

4 At monitoring point P3, one obtains a potential which is
5 determined by the resistors 150, 160 and the capacitor 152.
6 Point P1 is, as previously described (arrow 151 in FIG. 7B),
7 at a potential which is dependent upon the potential of positive
8 conductor 136. The potential at point P3, due to capacitor 152,
9 is delayed in reaching its end value, which is determined by
10 resistors 150, 160. At this time, transistor 172 is still not
11 conducting. The potential on the base of transistor 172 is
12 determined by the signal OUT1, which in this case is high, and by
13 the voltage divider 176, 174, connected to the base of transistor
14 174, which at this instant still has a low potential. Thus,
15 transistor 172 remains temporarily blocked.

16 Due to the increase in charge on capacitor 152, the
17 potential at P3 rises, so that transistor 172 begins to conduct,
18 which assures blocking of transistor 128. Upon blocking of
19 transistor 128, the time constant of elements 158 (capacitor) and
20 170 (resistor) becomes effective. The current amplification of
21 transistors 162, 172 has little influence on the time delay. As
22 soon as transistor 172 becomes conductive, this removes the base
23 current from transistor 162, which hitherto had been supplied via
24 resistor 164. Thereby the current over the base drain resistor
25 160 stops, and transistor 124 is released and can turn on
26 according to a time constant which is determined by the resistor
27 150 and the capacitor 152. Transistor 128 is, at this instant,
28 currentless, i.e. between the shut-off of transistor 128 and the
29 turn-on of transistor 124 [126] [sic], a current gap is created,
30 in which neither transistor 124 nor transistor 128 is conductive.

31 These processes are supported by the inductive coupling
32 between phases 112 and 114, examples of which are shown in FIGS.
33 8 and 9.

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FIG. 2 illustrates the voltage courses at a low voltage U_B of 12 V. The curves U_{C128} , U_{C124} show the collector voltages of transistors 128, 124, respectively.

At instant t_2 , signals OUT1 and OUT2 change. During a transition phase until instant t_3 , voltage U_{C124} decreases and voltage U_{C128} increases, because transistor 128 starts to block. Due to the inductive coupling (FIG. 8) of windings 112, 114, the increase in U_{C128} between t_2 and t_3 corresponds essentially to the decrease in U_{C124} , without transistor 124 being conductive yet. In the interval from t_3 to t_4 , the shut-off voltage of phase 114 causes a rise 180 in U_{C128} and thus a recovery current through diode 130. This keeps transistor 162 conductive, so that a portion of the base current of transistor 124 flows via resistor 160, and transistor 124 can first switch on at instant t_4 , at which time its base voltage U_{B124} has become sufficiently positive because transistor 162 has blocked.

Transistor 128 is thus switched off at instant t_3 , and transistor 124 is first switched on at t_4 , thereby producing, between t_3 and t_4 , a current gap. The shut-off and turn-on processes run gently, so that the motor produces little structure-borne noise during the commutation. This is important in a fan, because at low RPM the fan noises should be minimized.

FIG. 3 shows the analogous processes in the motor according to FIG. 6, also at a low voltage of 12 V. There, transistor 28 shuts off about at instant t_5 , and at instant t_6 , transistor 24 is turned on, i.e. the current gap is shorter here. Furthermore, as previously mentioned, the resistors 54 and 60 are continuously active, which is unfavorable for the operation of the motor at low voltages.

FIG. 4 shows the processes in the motor of FIG. 1, when it is operated at an overvoltage of 28 V. Rotor 16 here rotates significantly faster, i.e. the processes of commutation must be executed faster, so that the power of the motor will be

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1 sufficiently large and that it can achieve a high rotation speed.

2 At instant t_7 , the signals OUT1, OUT2 change, which means,
3 due to the inductive coupling of phases 112, 114, that the
4 voltage U_{C124} on the collector of transistor 124 decreases and the
5 voltage U_{C128} of transistor 128 increases until instant t_8 , in such
6 a way that the decrease and the increase correspond. This
7 inductive (transformer) coupling of the windings (cf. FIG. 8) is
8 indicated by an arrow 184.

9 Subsequently, the shut-off current spike on winding 114
10 causes (at 186) an increase in voltage U_{C128} , which lengthens the
11 current gap further up to an instant t_9 , at which, due to the
12 blocking of transistor 162, the base voltage U_{B124} rises so far
13 that this transistor becomes conductive. The increase of U_{B124} is
14 designated 188. Thus, at high voltages and high RPM, the current
15 gap lasts from t_8 to t_9 .

16 Upon comparison of FIGS. 2 and 4, it is significant that the
17 steepness 192 of the rise of collector voltage U_{C128} in FIG. 2 is
18 low, and this steepness 194 in FIG. 4 is high. This is a result
19 of the fact that the amplitudes of signals OUT1, OUT2, in the
20 high state, are approximately proportional to the operating
21 voltage U_B , so that the charging of capacitor 152 (or 158) and
22 the switching of transistor 172 (or 162) occurs faster at high
23 U_B . This is a result of the voltage divider 166, 164 between
24 points P2 and P4 and the voltage divider 176, 174 between points
25 P1 and P3. Due to the higher input voltage at P1 or P2, at
26 points P5 or P6 the necessary turn-on voltage is achieved sooner,
27 if the voltage U_B is higher.

28 FIG. 5 shows that, in the motor of FIG. 6, the steepness 196
29 of the increase in U_{C28} is not much changed from that of FIG. 3
30 and that, already at instant t_{10} , at which the signals OUT2, OUT1
31 change, the signal U_{B24} goes so high that transistor 24 turns on,
32 so that for a while both transistors 24 and 28 conduct, which
33 leads (at 198) to an increase in total current i_{total} .

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1 At instant t_{11} , transistor 24 blocks again and at t_{12} , it
2 becomes conductive again, which leads (at 200) to a corresponding
3 reduction in the total current i_{total} . The shut-off between t_{11} and
4 t_{12} , leads to corresponding heating up of transistor 24 (due to
5 the unnecessary switching processes) and to a reduced efficiency
6 of the motor.

7 By practicing the invention, one thus achieves, at all
8 rotation speeds, a sufficiently large switching pause during the
9 commutation. At low voltage U_B , during the commutation, the
10 current in a winding rises and falls only relatively slowly, i.e.
11 one obtains a switching signal edge with a lower slope, which
12 results in a quiet running of the motor. At higher operating
13 voltage U_B , during the commutation, the current rises and falls
14 in a winding quickly. This improves the efficiency and increases
15 the maximum attainable RPM, at which, however, the structure-
16 borne noise of the motor rises. At high RPM, that is not
17 disturbing, since all the noises are rising anyway.

18 The base drain resistors 160, 170, which are turned on and
19 off by the transistors 162, 172, respectively, are only effective
20 during the commutation, as already described, so that they do not
21 degrade the efficiency of the motor. This permits dimensioning
22 for a large voltage range.
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1 The signal at the base of power transistor 124 controls, via
2 the resistor 174, the transistor 172. The signal at the base of
3 power transistor 128 controls, via the resistor 164, the
4 transistor 162. The transistors 162, 172 are so latched with
5 respect to each other that only one of the two can conduct at a
6 given time, and this excludes the possibility that both
7 transistors 124, 128 would conduct at the same time, and a
8 defined current gap is created at commutation, which is a
9 precondition for obtaining a "soft" switching of transistors 124,
10 128. Comparison of FIGS. 4 and 5 shows this. According to FIG.
11 5, for a time both transistors 24, 28 conduct simultaneously,
12 whereas by contrast in FIG. 4, a sufficiently long "switching
13 pause" is created.

14 Naturally, within the scope of the present invention,
15 numerous variations and modifications are possible. In
16 particular, the various functions of latching transistors 162,
17 172 could be performed by a larger number of transistors,
18 to the extent that the cost thereof is not a factor.

CLAIMS

1. An electronically commutated motor comprising:
a stator and a rotor (116),
at least one rotor position sensing means (118),
a commutation controller (146), responsive to signals from
said rotor position sensing means, for generating rotor
position signals (OUT1, OUT2),
at least first and second power transistors (124, 128),
at least two stator winding phases (112, 114), each adapted to
be energized via a respective one of said power
transistors (124, 128) and being controllable, as a
function of position of the rotor (116), by oppositely
phased ones of said rotor position signals (OUT1, OUT2),
said signals being applied to the bases of the power
transistors via a respective resistor (150, 156),
a base drain resistor (160) for the base of the first power
transistor (124), which resistor (160) is connected in
series with a first latching transistor (162),
a base drain resistor (170) for the base of the second power
transistor (128), which resistor (170) is connected in
series with a second latching transistor (172),
the first latching transistor (162) being controllable at
least by the base signal of the second power transistor
(128) and the second latching transistor (172) being
controllable at least by the base signal of the first
power transistor (124), in order to prevent, during
commutation, simultaneous conduction of both power
transistors, and in order to control commutation by
activation and deactivation of the base drain resistors
(160, 170).

2. The motor according to claim 1, wherein the first latching transistor (162) is controllable by a combination of the rotor position signal (OUT2) for the second power transistor (128) and the base signal thereof, and the second latching transistor (172) is controllable by a combination of the rotor position signal (OUT1) for the first power transistor (124) and the base signal thereof.
3. The motor according to claim 1, wherein both base drain resistors (160, 170) are disabled outside a commutation process time interval.
4. The motor according to claim 1, wherein said winding phases which are adapted to be controlled in phase opposition are coupled inductively.
5. The motor according to claim 4, wherein said winding phases are bifilar wound.
6. The motor according to claim 1, wherein said first power transistor (124) and said second power transistor (128) have a common emitter resistor (132).
7. The motor according to claim 1, wherein a respective Miller capacitor (152, 158) is associated with each power transistor (124, 128).
8. The motor according to claim 1, wherein the amplitude of a rotor position signal (OUT1, OUT2) increases, at least in a range, as operating voltage (U_B) of the motor (110) increases.

9. The motor according to claim 1, further comprising, for generation of the rotor position signals (OUT1, OUT2), a controller (146), whose operating voltage (U_B) is, above a predetermined value, held essentially constant, in order, upon overshooting of this predetermined value, to hold constant the amplitudes of the rotor position signals.
10. The motor according to claim 8, wherein changes in the collector voltages of the power transistors during commutation occur as a function of the operating voltage (U_B).
11. The motor according to claim 2, wherein both base drain resistors (160, 170) are disabled outside a commutation process time interval.
12. The motor according to claim 2, wherein said winding phases, which are adapted to be controlled in phase opposition, are inductively coupled.
13. The motor according to claim 4, wherein said winding phases are inductively coupled with each other via a lamination stack forming part of the stator.
14. The motor according to claim 2, wherein said first power transistor (124) and said second power transistor (128) have a common emitter resistor (132).
15. The motor according to claim 2, wherein a respective Miller capacitor (152, 158) is associated with each power transistor (124, 128).

16. The motor according to claim 2, wherein the amplitude of a rotor position signal (OUT1, OUT2) increases, at least in a range, as operating voltage (U_B) of the motor (110) increases.
17. The motor according to claim 2, further comprising, for generation of the rotor position signals (OUT1, OUT2), a controller (146), whose operating voltage (U_B) is, above a predetermined value, held essentially constant, in order, upon overshooting of this predetermined value, to hold constant the amplitudes of the rotor position signals.

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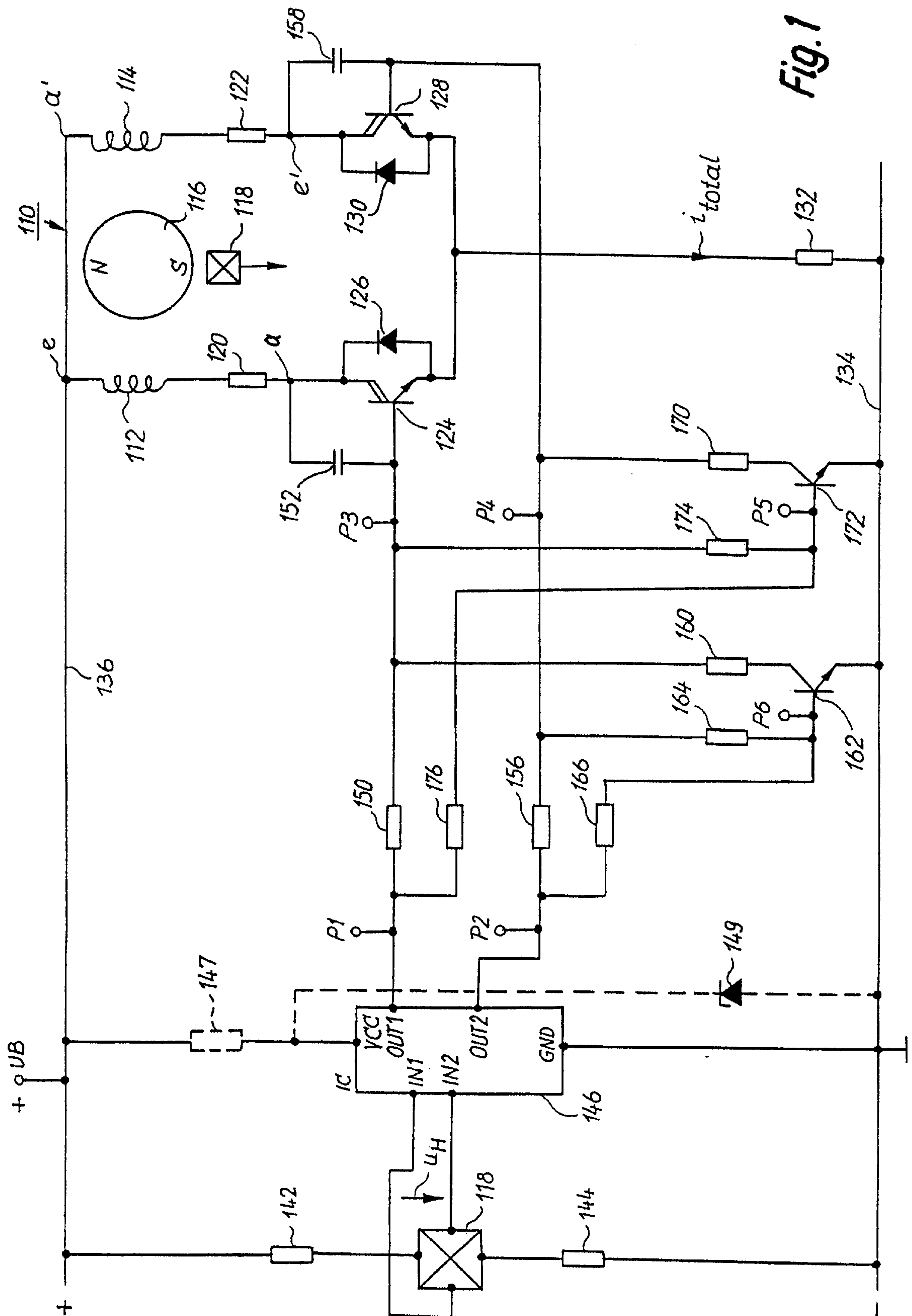


Fig. 1

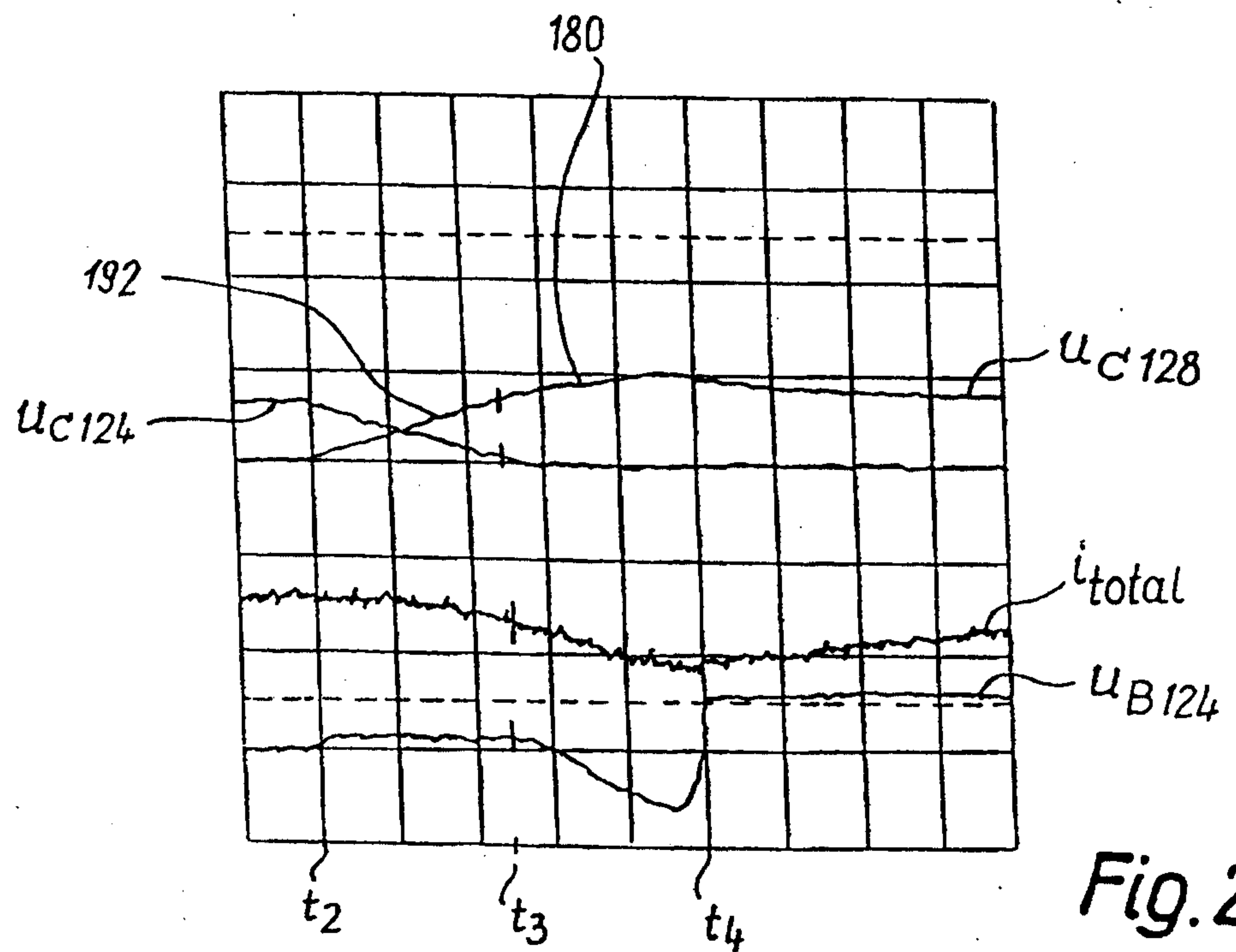


Fig. 2

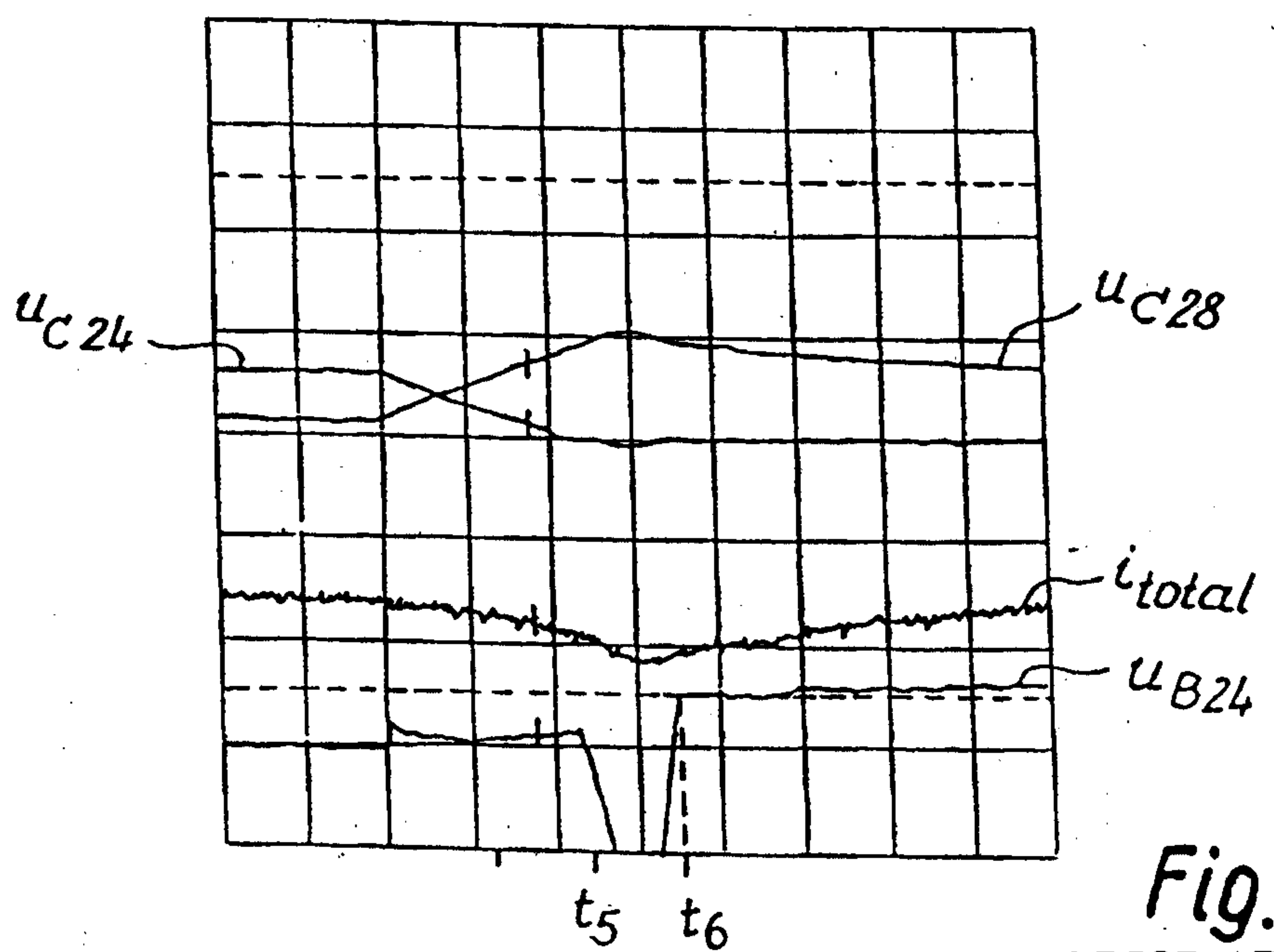


Fig. 3

PRIOR ART

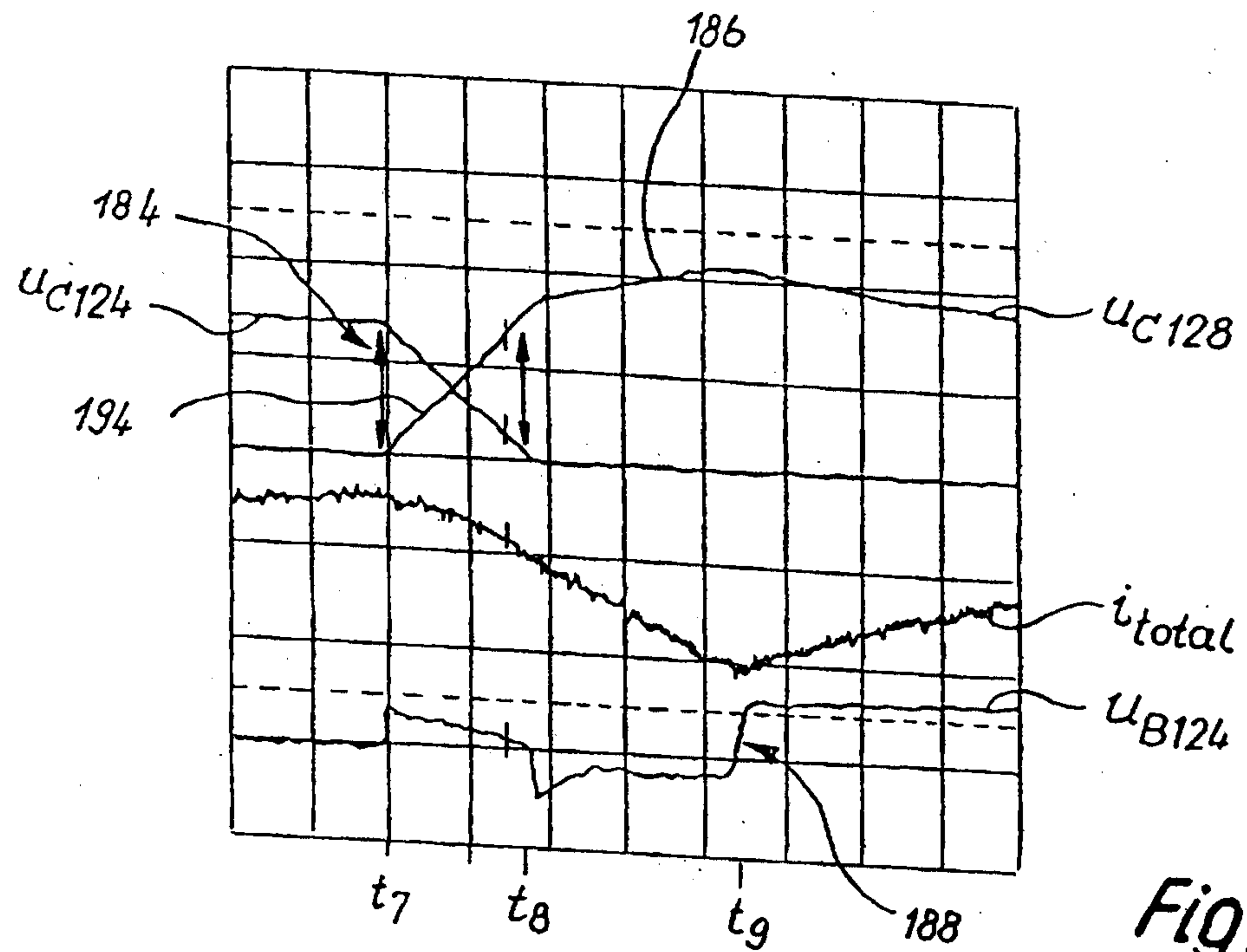


Fig. 4

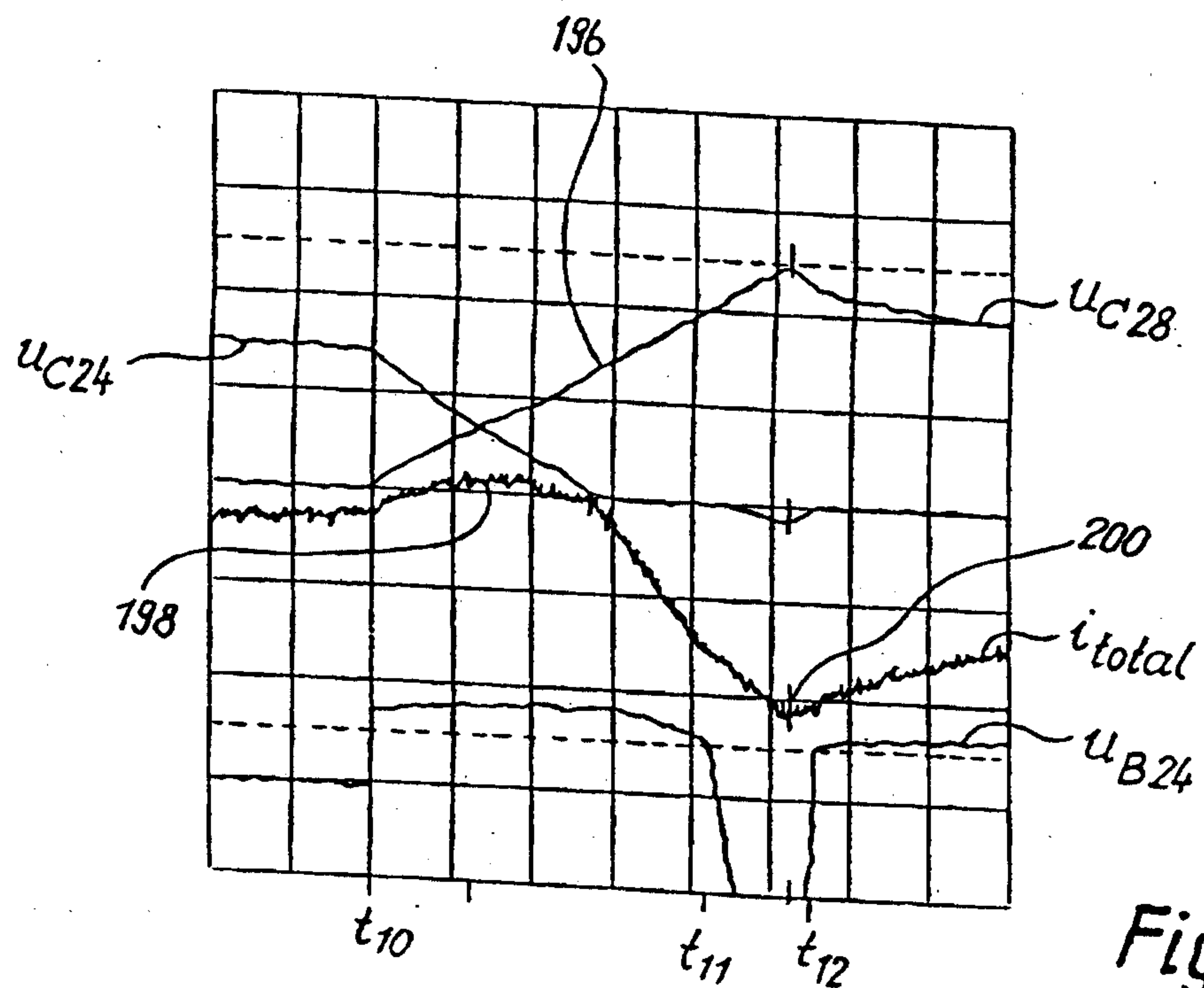


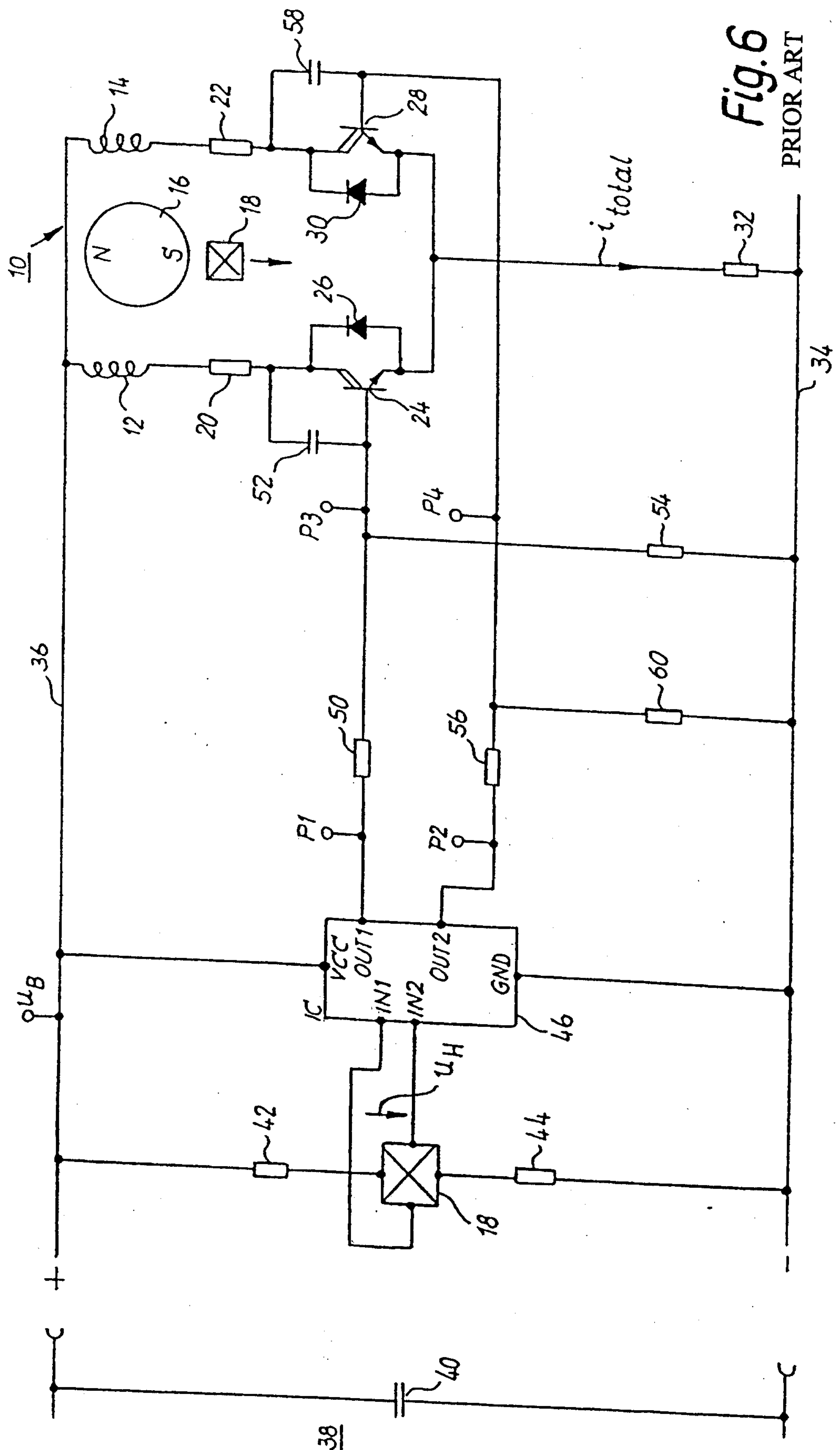
Fig. 5

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Fig. 6
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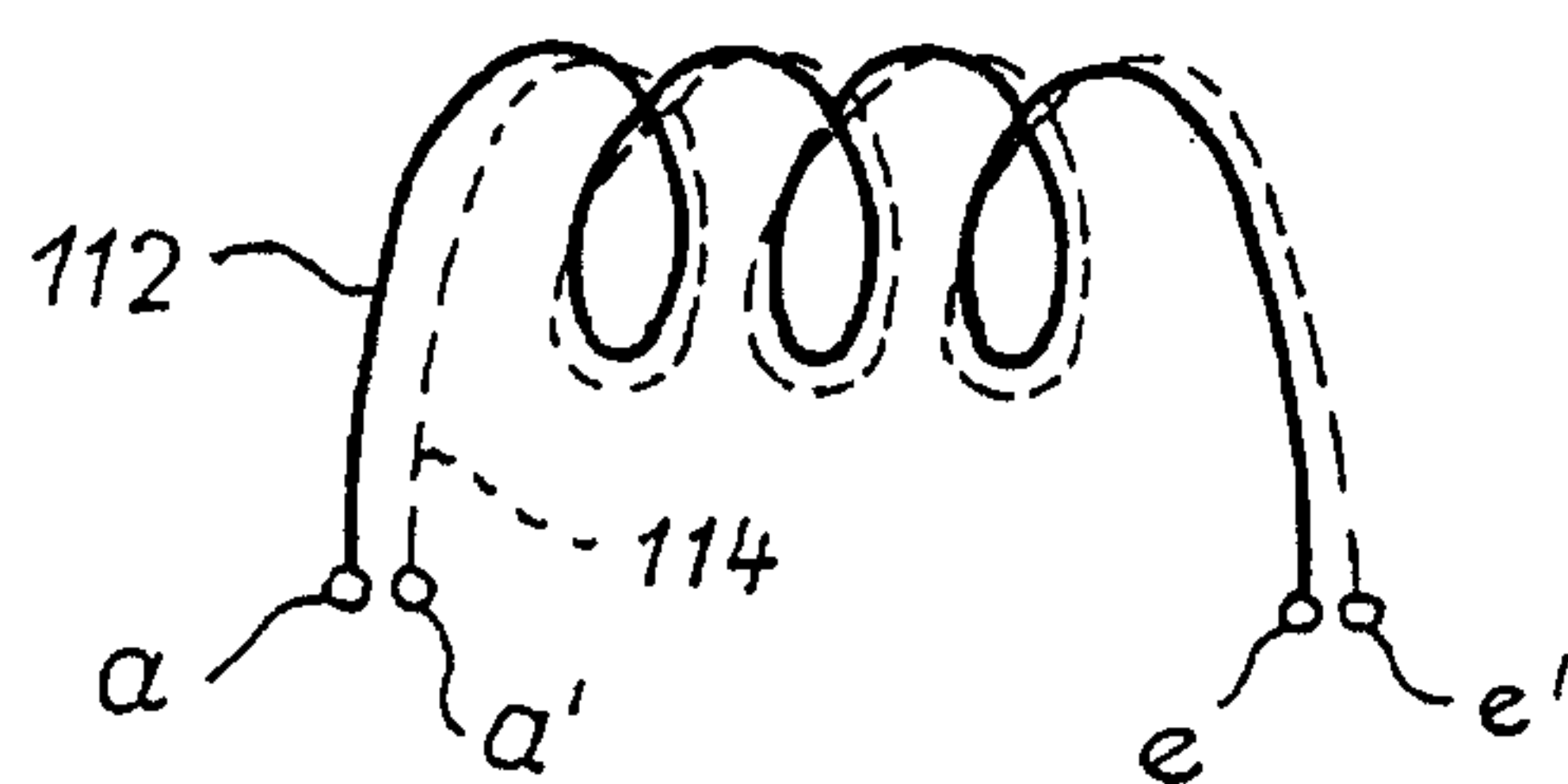
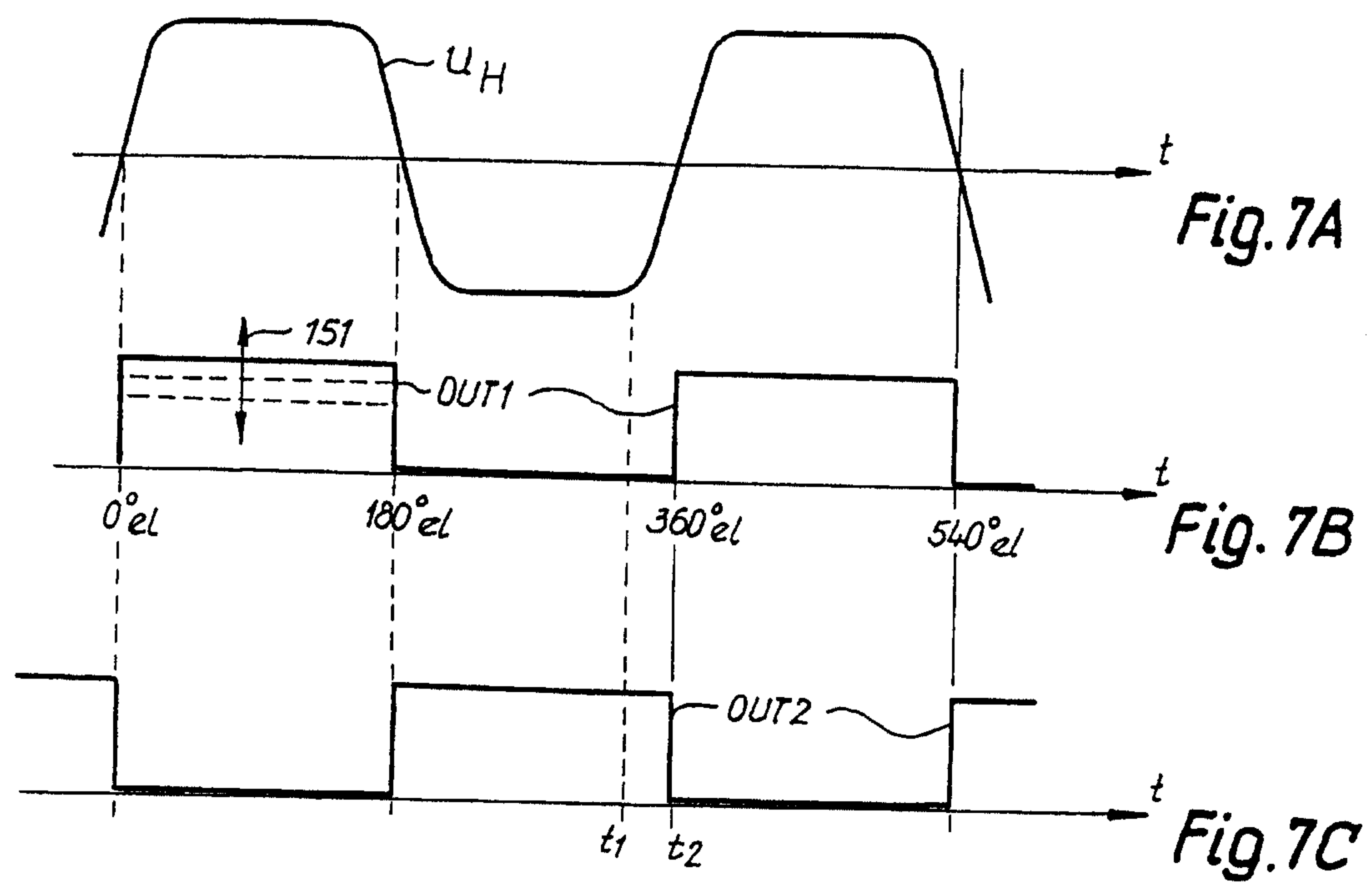


Fig. 8

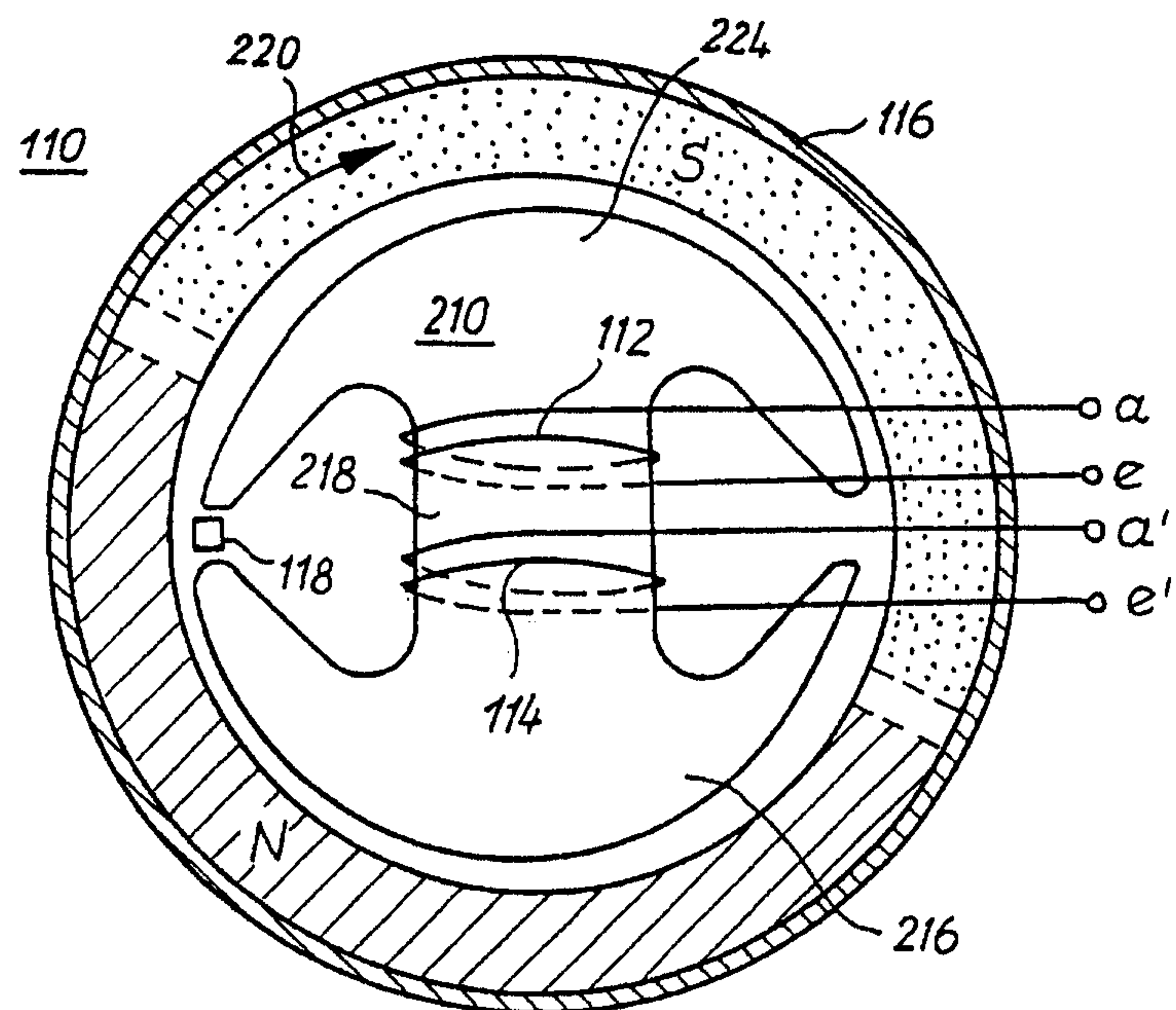


Fig. 9

