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(54) Benævnelse: **AKSELGENERATORANORDNING PÅ ET SKIB**

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WO-A1-2012/143245
WO-A1-2013/071937
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DESCRIPTION

Field of technology

[0001] The present invention relates to a shaft generator arrangement of a ship. More particularly the invention relates to a ship's main shaft generator arrangement having a protection arrangement.

Prior art

[0002] A ship has a main engine that is arranged to rotate a propeller of a ship. The engine is for example a diesel or gas engine, and it is often called as main engine as well. A shaft connects the engine to the propeller and it is called as main shaft. In order to produce electric power for loads on the ship, the ship may have a separate engine (or engines) that is connected with a generator (or generators). Another solution is that a generator is in connection with the main shaft which means that the main engine rotates the propeller and also produces electric power through the generator. The generator around the main shaft is called as shaft generator. The generator of the shaft generator is connected to the grid of the ship through a generator breaker.

[0003] The shaft generator is normally a separately exited generator which means that direct current (DC) voltage is supplied to the windings of the rotor. Shaft generators have been used for decades, and they have proved to be efficient and reliable in marine environment.

[0004] If malfunction occurs in the generator, the generator breaker is opened for disconnecting the generator from the grid. It is also possible to disconnect the DC supply to the windings of the rotor in case of the separated exited generator in order to stop inducing voltage in the windings of the stator. In case of the permanent magnet generator, the engine is shut down to stop inducing voltage in the stator windings. If the generator is a shaft generator, shutting down main engine is not always possible due to e.g. navigational hazards.

[0005] WO 2013071937 which forms the preamble of claim 1, discloses a protection arrangement of a permanent magnet generator used in a power plant like in a wind power plant. This document shows a star point measurement in an generator. The measurement is utilized by a protection relay that commands a circuit breaker. WO2012143245 discloses a solution wherein an ACDC power converter is protected by an additional short-circuiting circuit.

Short description of invention

[0006] The aim of the invention is to provide a solution wherein the main shaft permanent

magnet generator has a protection arrangement that allows the main engine to run even if the generator has a fault situation. The aim is achieved in a way described in the independent claim.

[0007] A shaft generator arrangement of a ship according to the invention comprises a permanent magnet generator to be in connection with a main shaft of the ship, and a frequency transformer arranged to transform voltage of the generator. The arrangement has also a generator breaker between the generator and the frequency transformer through which the generator is connectable to the frequency transformer. The windings of the permanent magnet generator are connected to a star point, and which arrangement comprises a star point breaker located close to the generator between the windings and the star point. The connection between the generator and the main shaft is to be arranged by mounting the generator around the main shaft or via gearing.

[0008] The arrangement further comprises a first current measurement arranged to measure currents between the generator and the frequency transformer, and a second current measurement arranged to measure currents between the windings and the star point, and a protection relay that is connectable to the first and the second current measurements and to the star point breaker and the generator breaker. The protection relay is arranged to open the star point breaker if 2- or 3 - phase short circuit between the phases of the generator is detected as response to the second measurement, and to open the generator breaker if double ground fault is detected as response to said first and second measurements.

[0009] The protection relay is arranged to open the star point breaker due the malfunction of the generator breaker, and the protection relay has an overcurrent protection function to detect overcurrent in case of the 2- or 3 -phase short circuit, and a differential current protection function to detect differential current in case of the double ground fault.

List of figures

[0010] In the following, the invention is described in more detail by reference to the enclosed drawings, where

Figure 1
illustrates an embodiment of the inventive arrangement,

Figure 2
illustrates a frequency transformer of the inventive arrangement in more detail, and

Figure 3
illustrates an embodiment of the inventive arrangement with a transmission gear.

Description of the invention

[0011] Figure 1 illustrates an example of an arrangement according to the invention. The shaft generator arrangement of a ship comprises a permanent magnet generator 1 that can be arranged around a main shaft 2 of the ship thus being in connection with the main shaft. The ship's main engine 3 provides power to the main shaft in order to rotate a propeller 4 of the ship. The generator around the main shaft transforms a part of the power into an electric form, which can be used in loads connected to electrical grid 6 of the ship. The permanent magnet generator 1 provides at least 0.5 MVA. The arrangement has a frequency transformer 5 arranged to transform voltage of the generator 1, and a generator breaker 7 between the generator 1 and the frequency transformer 5 through which breaker 7 the generator is connectable to the frequency transformer. The transformation of voltage means in this context that amplitude, frequency and/or phase of the voltage is changed.

[0012] The windings 1A of the permanent magnet generator (more precisely the windings of the stator) are connected to a star point 9. Further, the generator 1 comprises a star point breaker 10 between the windings and the star point.

[0013] The arrangement further comprises a first current measurement 15 arranged to measure currents between the generator 1 and the frequency transformer 5, and a second current measurement 14 arranged to measure currents on the windings 1A near the star point 9, and a protection relay 11 that is connectable to the first 15 and the second 14 current measurement and to the star point breaker 10 and the generator breaker 7 through corresponding connections 17, 16, 13, 12. The connections with the first and second measurements 17, 16 provide measurement data to the protection relay, which drives the breakers 7, 10 to open if needed as response/s to said measurements.

[0014] The protection relay 11 is arranged to open the star point breaker 10 if 2- or 3 - phase short circuit between the phases of the generator is detected as response to the first 15 or second 14 measurement and to open the generator breaker 7 if double ground fault is detected as response to said first 15 and second 14 measurements. Since each winding of the generator is phase specific, 2- or 3 -phase short circuit can be a short circuit between the windings or between the lines of the phases. The protection relay 11 is also arranged to open the star point breaker 10 due the malfunction of the generator breaker 7.

[0015] The protection relay has an overcurrent protection function to detect overcurrent in case of the 2- or 3 -phase short circuit, and a differential current protection function to detect differential current in case of the double ground fault. The double ground fault occurs when there exist two simultaneous ground faults. One ground fault can be in the generator and the other ground fault in the grid of the ship. In this case the fault current flows through the ground (the ship's hull) and the frequency converter. Table 1 below shows some characteristics of the protection relay.

Table 1. Protection relays characteristics

Function	Characteristics
Overcurrent protection	Pick-up current setting: 0,1 ... 40 x In (RMS or peak-to-peak)
	Pick-up inaccuracy: ±0,5% *I* or ±15mA;
	Instant operation time: <50ms
Current differential protection	Pick-up current setting: 0.01 ... 100% ID *iff*
	Pick-up inaccuracy: ±1,5% or ±30mA
	Instant operation time: <40ms

[0016] The arrangement may further comprise a ground fault detection device 18 to detect a single ground fault and providing a ground fault message for monitoring the arrangement. In this embodiment the protection relay 11 can also be arranged to open the star point breaker in case of the frequency transformer is stopped and the ground fault message is provided. Since the electric systems are insulated in seagoing vessels as IT (Insulated Terra) systems, the ground fault detection device 18 detects faults in the insulation decreasing the resistance of the insulation material.

[0017] The arrangement further comprises a star point breaker cabinet having the star point, the star point breaker and the second current measurement at a vicinity of the permanent magnet generator. It can be noted that in previous solutions breakers are situated relatively far away from the generator.

[0018] The frequency transformer 5 may comprise a direct current bridge 5A and two inverters 5A, 5B, one being connected for the generator 1 and the other for the grid 6. This kind of structure illustrated in figure 2 provides good driving possibilities. It is also possible to supply power from the grid to the generator, which in this case runs as electric machine. In this way the propeller 4 of ship can be rotated even if the main engine 3 is not running, for example due to a fault situation.

[0019] The arrangement can comprise a grid breaker 8 between the frequency transformer and the grid of the ship. It is convenient to place in a main switch board 20.

[0020] So, the invention makes it possible to utilize the permanent magnet generator with the main shaft of the ship in such a way that the main engine runs to rotate the propeller even if the generator has a fault. In any fault situations the star point breaker can be opened. The inventive arrangement is at least as reliable as prior art solutions like the separately exited generators. Therefore the inventive permanent magnet shaft generator arrangement provides a new and reliable solution, also for more powerful arrangements, like at least 1.5 MVA, and as marine standards require.

[0021] In order that the inventive system runs properly several items have be considered. The corresponding prior art solutions rely on the switching voltage off (the separate excitation) but the invention has a new approach of switching current off (star point breaker). The protection relay arrangement have to control both generator breaker and star point breaker in such a way that switch actions of the breakers do not hinder each other or cause malfunctions. In addition, the arrangement having said breakers and measurements and the protection relay has to work at variable frequency level (possibly also in low frequency level). For example in case of a usual embodiment the permanent magnet generator runs in a range of 5 - 30 Hz AC in its stator windings. This is due to the rotation speed of the main shaft that is in many solutions about 50 - 100 rpm at nominal speed. So, the components of the arrangement should be suitable for the said low frequency range. If gearing is used, the frequency range in the stator windings can be, for example 30 - 75 Hz. Variable shaft generator frequency levels (ranges 5 - 30 Hz and 30 - 75 Hz) has be to taken into account in order to provide power to the vessels electrical grid having e.g. 50 or 60 Hz frequency or DC-distribution. Further the permanent magnet generator can be arranged to provide at least 1.5 MVA, which means that the arrangement should fulfil reliability and safety requirements being determined by the marine standards already mentioned above.

[0022] It may be possible that a ship has two main shafts 2. In this case according to the invention the arrangement comprises another permanent magnet generator being connectable with another main shaft of the ship, and another generator breaker between the other generator and the frequency transformer through which the other generator is connectable to the frequency transformer. Windings of the other permanent magnet generator are connected to another star point, and the arrangement comprises another star point breaker between the windings of the other permanent magnet generator and the other star point. The arrangement further comprises another first current measurement arranged to measure currents between the other generator and the frequency transformer, and another second current measurement arranged to measure currents between the windings of the other permanent magnet generator and the other star point. The other elements correspond with the generator, the breaker, the star point and the first and second measurement described above and illustrated in figure 1. So the same reference numbers can also be used to refer to the other elements.

[0023] The protection relay is connectable to the other first and the other second current measurement and to the other star point breaker and the other generator breaker. The protection relay is correspondingly arranged to open the other star point breaker if 2- or 3 - phase short circuit between the phases of the other generator is detected as response to the other first or other second measurement, and open the other generator breaker if double ground fault is detected as response to said other first and other second measurements. Instead of the protection relay there can be another protection relay that is arranged to do these tasks and has said connections.

[0024] The figures of this presentation are schematic figures, so in real solutions there can be other devises as well, for example voltage limiting units and filters within the frequency transformer. Since the power system are usually with three phases said breakers and current

measurements has connections with each phase. Although the protection relay 11 is described as one device in figure 1, it may also be distributed into several locations, like near the breakers, but still working together as one protection relay described above. The protection relay 11 can be situated with the same cabinet 19 with the frequency transformer as well as the ground fault detection device 18, the generator breaker 7 and also the first current measurement. The star point breaker is situated within the generator assembly, or on the generator or in a cabinet at vicinity of the generator.

[0025] The generator also works with in high torque at low rotation speed. However, if desired, the inventive arrangement can be constructed with a transmission gear 30 as well as described in figure 3. In this case the generator can also be connected via the transmission gear. In addition, it can be noted that in case of 2- or 3- phase short circuit, the short circuit current can be stopped even if the frequency transformer does not run and the generator breaker is open. This is not possible in prior art permanent magnet solutions.

[0026] It is evident from the above that the invention is not limited to the embodiments described in this text but can be implemented in many other different embodiments within the scope of the accompanying claims.

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- WO2013071937A **[0005]**
- WO2012143245A **[0005]**

Patentkrav

1. Akselgeneratoranordning til et skib, hvilken anordning omfatter en permanent-magnetgenerator (1), som kan forbindes med en hovedaksel (2) på skibet, en frekvenstransformer (5) indrettet til at omforme spændingen af generatoren (1), og en generatorafbryder (7) mellem generatoren (1) og frekvenstransformeren (5), gennem hvilken generatoren (1) er forbundet med frekvenstransformeren (5), hvor viklinger (1A) af permanentmagnetgeneratoren (1) er forbundet med et stjernepunkt (9), og hvilken anordning omfatter en stjernepunktsafbryder (10) mellem viklingerne og stjernepunktet,
idet anordningen yderligere omfatter en første strømmåling (15) indrettet til at måle strøm mellem generatoren (1) og frekvenstransformeren (5),
akselgeneratoranordningen er **kendetegnet ved, at** den omfatter en anden strømmåling (14) indrettet til at måle strøm mellem viklingerne (1A) og stjernepunktet (9), og et beskyttelsesrelæ (11) som er forbundet med den første (15) og den anden (14) strømmåling og med stjernepunktsafbryderen (10) og generatorafbryderen (7), hvilket beskyttelsesrelæ (11) er indrettet til at åbne stjernepunktsafbryderen (10), hvis der detekteres 2- eller 3-fase-kortslutninger mellem generatorens faser som respons på den første (15) eller anden (14) måling, og åbner generatorafbryderen (7) hvis der detekteres dobbelt jordfejl som respons på nævnte første (15) og anden (14) målinger, og
idet beskyttelsesrelæet (11) er indrettet til at åbne stjernepunktsafbryderen (10) som følge af generatorafbryderens (7) funktionsfejl, og
beskyttelsesrelæet (11) har en overstrømsbeskyttelsesfunktion til at detektere overstrøm i tilfælde af 2- eller 3-fase-kortslutningen, og en differensstrøm-beskyttelsesfunktion til at detektere differensstrøm i tilfælde af den dobbelte jordfejl.

2. Akselgeneratoranordning til et skib ifølge krav 1, hvor anordningen yderligere omfatter en jordfejlsdetekteringsindretning (18) til detektering af en enkelt jordfejl og tilvejebringelse af en jordfejlbesked til overvågning af anordningen.

3. Akselgeneratoranordning til et skib ifølge et hvilket som helst af kravene fra 1 til 2, hvor anordningen yderligere omfatter et stjernepunktsafbryderskab, som har stjernepunktet (9), stjernepunktsafbryderen (10) og den anden strømmåling (14)

i nærheden af permanentmagnetgeneratoren (1).

4. Akselgeneratoranordning til et skib ifølge krav 3, hvor frekvenstransformeren (5) omfatter en jævnstrømsbro (5A) og to vekselrettere (5B, 5C).

5. Akselgeneratoranordning til et skib ifølge et hvilket som helst af kravene fra 1 til 4, hvor permanentmagnetgeneratoren (1) kører ved variabel hastighed eller fast hastighed.

6. Akselgeneratoranordning til et skib ifølge et hvilket som helst af kravene fra 1 til 5, hvor permanentmagnetgeneratoren (1) tilvejebringer mindst 0,5 MVA.

7. Akselgeneratoranordning til et skib ifølge et hvilket som helst af kravene fra 1 til 6, hvor permanentmagnetgeneratoren (1) er omkring hovedakslen (2).

8. Akselgeneratoranordning til et skib ifølge et hvilket som helst af kravene fra 1 til 6, hvor anordningen omfatter en gearkasse (30) af hovedakslen (2), og permanentmagnetgeneratoren (1) er i forbindelse med hovedakslen (2) gennem gearkassen (30).

9. Akselgeneratoranordning til et skib ifølge et hvilket som helst af kravene fra 1 til 8, hvor anordningen yderligere omfatter en yderligere permanentmagnet-generator (1), som er forbundet med en yderligere hovedaksel (2) på skibet, og en yderligere generatorafbryder (7) mellem den yderligere generator og frekvenstransformeren (5), gennem hvilken den yderligere generator (1) er forbundet med frekvenstransformeren, og viklinger (1A) af den yderligere permanentmagnetgenerator er forbundet med et yderligere stjernepunkt (9), og hvilken anordning omfatter en yderligere stjernepunktsafbryder (10) mellem viklingerne af den yderligere permanentmagnetgenerator og det yderligere stjernepunkt, idet anordningen yderligere omfatter en yderligere første strømmåling (15) indrettet til at måle strøm mellem den yderligere generator (1) og frekvenstransformeren (5), og en yderligere anden strømmåling (14) indrettet til at måle strøm mellem viklingerne (1A) af den yderligere permanentmagnet-generator (1) og det yderligere stjernepunkt 9).

10. Akselgeneratoranordning til et skib ifølge krav 9, hvor beskyttelsesrelæet (11) er forbundet med den yderligere første (15) og den yderligere anden (14) strømmåling og med den yderligere stjernepunktsafbryder (10) og den yderligere generatorafbryder (7), hvilket beskyttelsesrelæ er indrettet til at åbne den yderligere stjernepunktsafbryder, hvis 2- eller 3-fasekortslutningen mellem faserne af den yderligere generator detekteres som respons på den yderligere første eller yderligere anden måling, og åbner den yderligere generatorafbryder, hvis der detekteres dobbelt jordfejl som respons på nævnte yderligere første og yderligere anden målinger.

11. Akselgeneratoranordning til et skib ifølge et hvilket som helst af kravene fra 1 til 8, hvor anordningen yderligere omfattende et andet beskyttelsesrelæ (11) er forbundet med den yderligere første (15) og den yderligere anden (14) strømmåling og med den yderligere stjernepunktsafbryder (10) og den yderligere generatorafbryder (7), hvilket beskyttelsesrelæ er indrettet til at åbne den yderligere stjernepunktsafbryder, hvis 2- eller 3-fase-kortslutningen mellem faserne af den yderligere generator detekteres som respons på den yderligere første eller yderligere anden måling, og åbner den yderligere generatorafbryder, hvis der detekteres dobbelt jordfejl som respons på nævnte yderligere første og yderligere anden målinger.

12. Akselgeneratoranordning til et skib ifølge et hvilket som helst af kravene fra 1 til 11, hvor anordningen omfatter en ledningsnetafbryder (8) mellem frekvens-transformeren (5) og skibets ledningsnet (6).

DRAWINGS

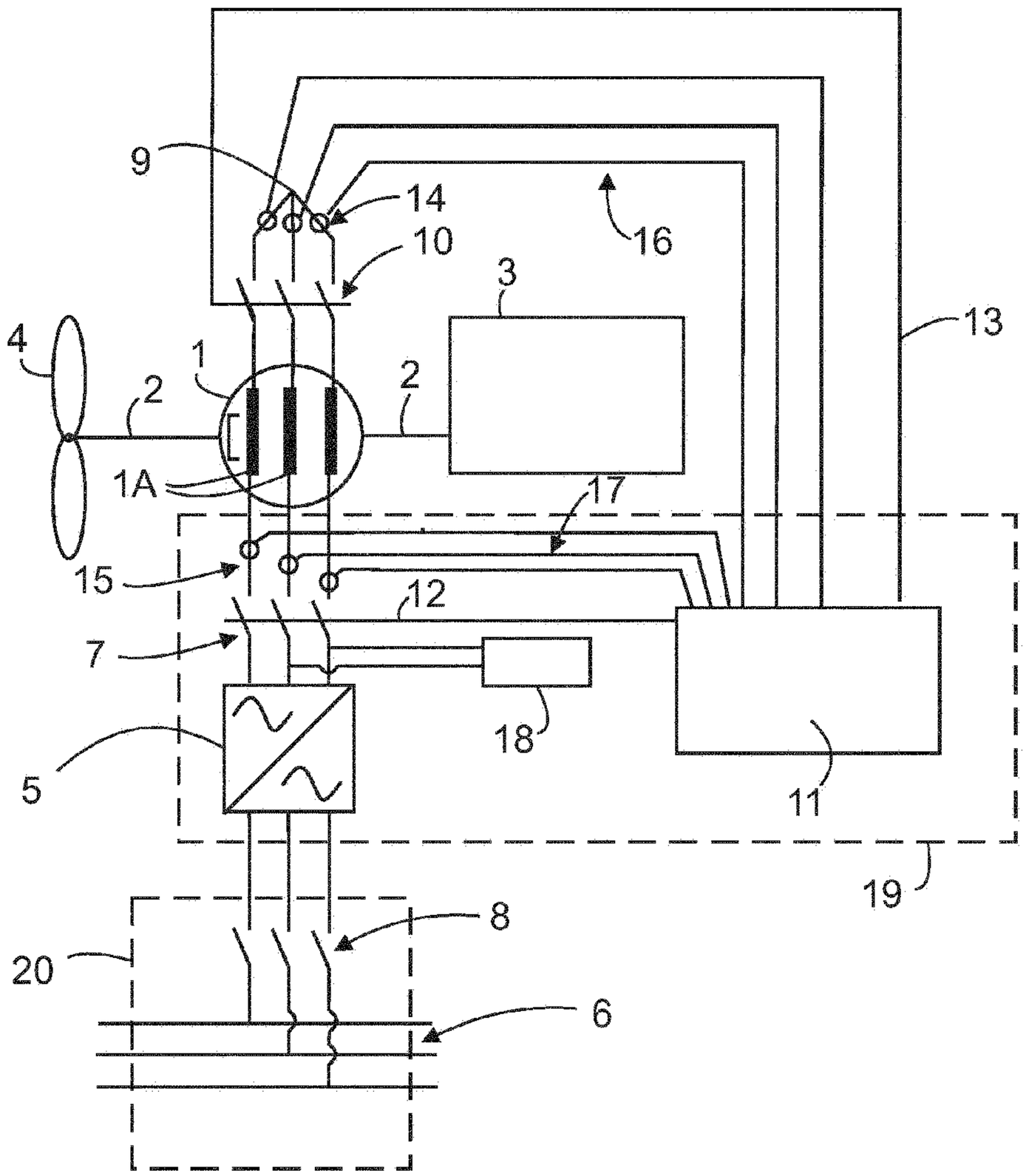

FIG. 1

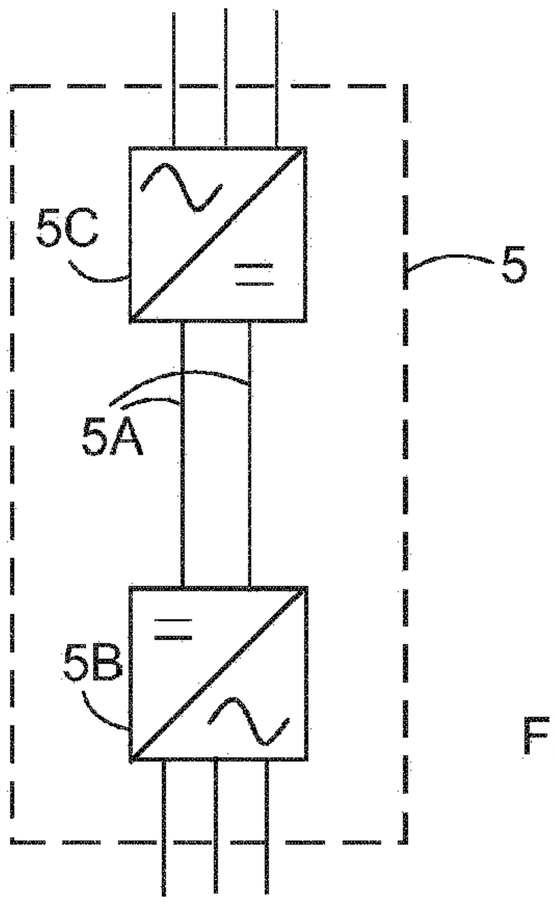

FIG.2

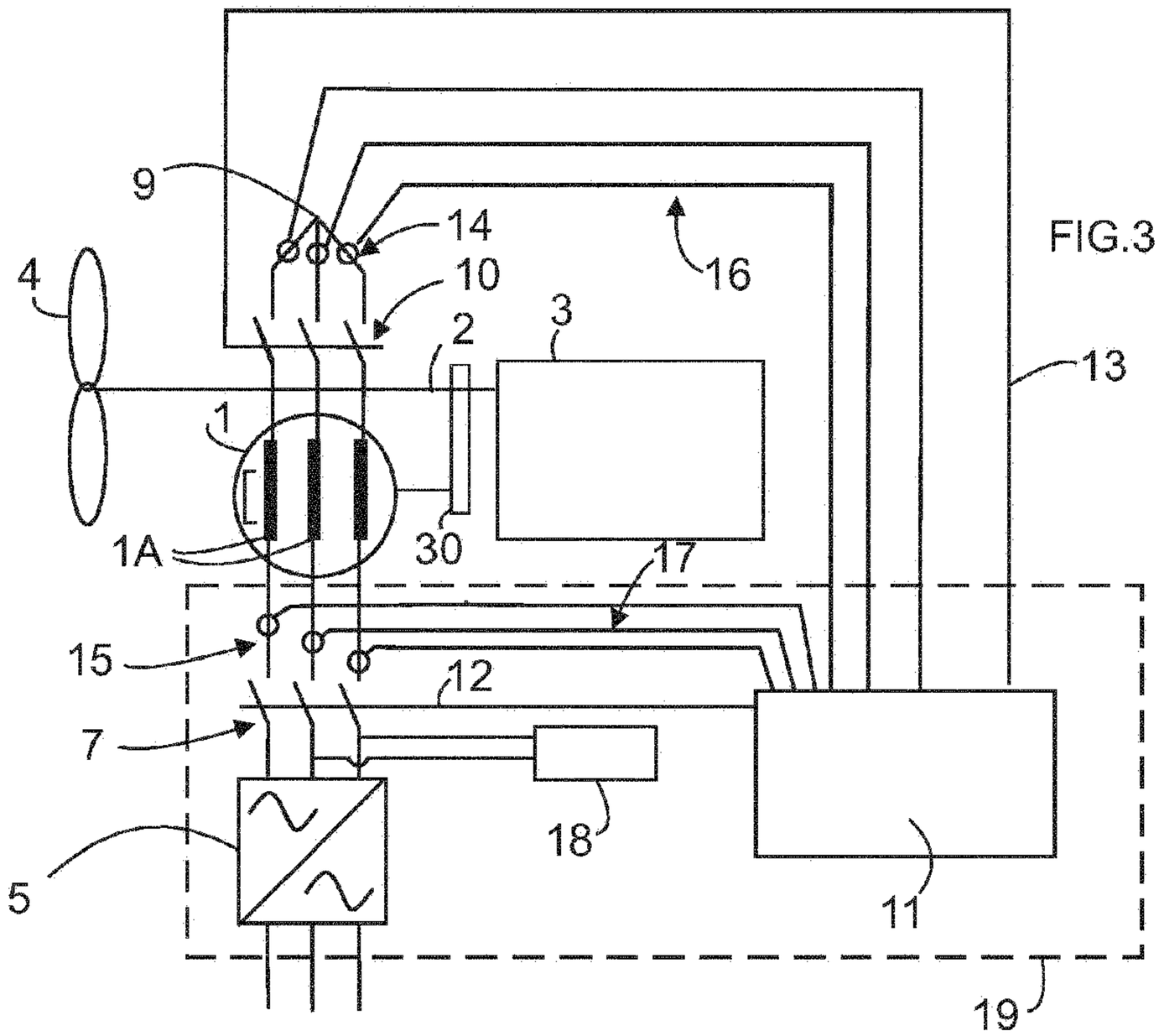

FIG.3