

Dec. 5, 1939.

E. JANETSCHKE

2,182,628

CONVERSION SYSTEM

Filed Sept. 7, 1937

2 Sheets-Sheet 1

Fig. 1.

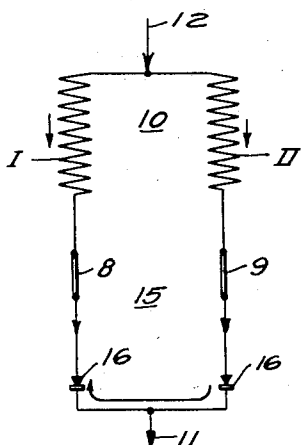


Fig. 2.

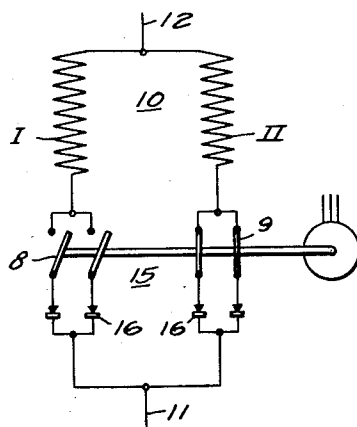


Fig. 3.

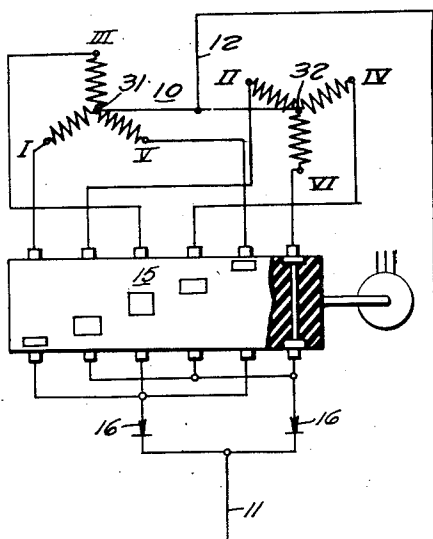
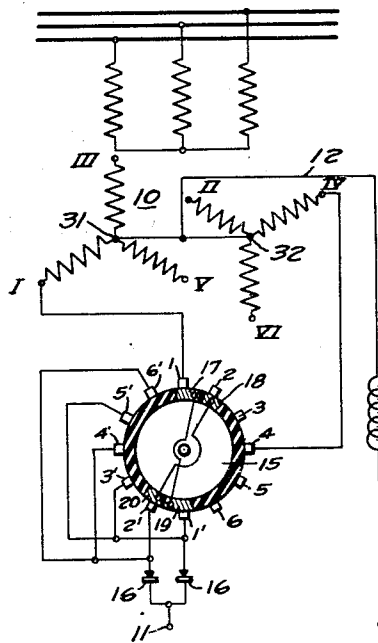


Fig. 4.



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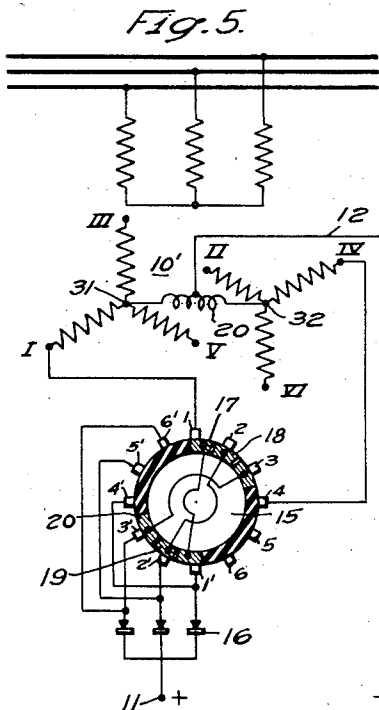
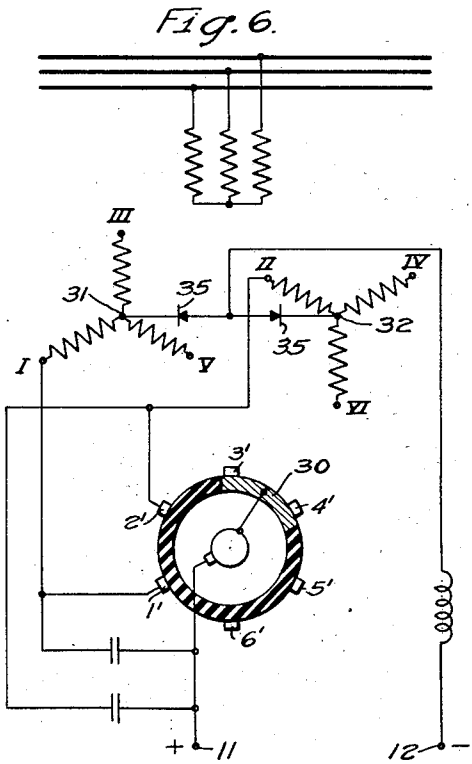
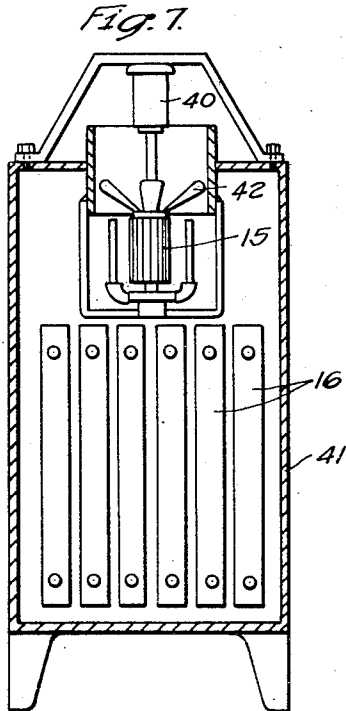
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CONVERSION SYSTEM

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2 Sheets-Sheet 2



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2,182,628

CONVERSION SYSTEM

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Application September 7, 1937, Serial No. 162,795
In Germany September 7, 1936

6 Claims. (Cl. 175—364)

My invention relates to an electric conversion system employing mechanical contacts, and particularly to a valve system for decreasing sparking on the opening of mechanical contacts.

5 It has heretofore been proposed to utilize synchronously operated mechanical contact devices for sequentially connecting the phase terminals of an alternating-current transformer to one or both poles of a direct-current circuit. It has
10 also been known that by advancing or retarding the instant at which the contacts operate voltage control similar to that secured by grid-controlled rectifiers may be accomplished. In the utilization of such devices, considerable difficulty has
15 been experienced because of burning or pitting of the contact elements. According to my invention, this burning and pitting of the contact elements is materially decreased by means of suitable unidirectional conductors or valves, preferably such as the dry plate type rectifiers inserted in series with the mechanical contacts.

The dry-type valves, such as I prefer to use, have a definite reverse current so that it is necessary to utilize sufficient valves connected in
25 series with each of the contacts to reduce the reverse current to a value preferably of the order of one ampere, or at least to a value insufficient to damage the electrical contacts.

Where large currents are to be encountered, it
30 may be necessary to employ a plurality of parallel connected contacts and their associated series connected valves in order to reduce the sparking potential to a value such that the current will be practically harmless to the contact elements.

35 Since in the usual type of converters only a limited number of the active phases of an alternating-current transformer are at any given time delivering current, it is necessary only to provide sufficient valve paths to accommodate
40 the phases delivering current simultaneously, thus materially decreasing the cost of a converter according to my invention.

It is an object of my invention to provide a mechanical rectifier having means for reducing the circulating current to a value substantially harmless to the mechanical contacts.

It is a further object of my invention to provide a conversion system utilizing the minimum number of protective valves.

50 It is a further object of my invention to provide a mechanical contact rectifier having high current capacities, with a minimum number of protective valve elements.

Other objects and advantages of my invention
55 will be apparent from the following detailed

description taken in conjunction with the accompanying drawings, in which:

Figure 1 is a schematic illustration of a simplified embodiment of my invention;

Fig. 2 is a similar view showing the manner
5 of utilizing parallel contact elements;

Fig. 3 is a schematic illustration of a commercial embodiment of my invention;

Fig. 4 is a similar view showing the manner of
10 connecting the contact elements in order to utilize a minimum number of protective valves;

Fig. 5 is a similar view showing a modified type of converter;

Fig. 6 is a further modification particularly
15 adapted to high-voltage conversion; and

Fig. 7 is an elevation partially in section showing the manner of connecting and constructing a conversion equipment according to my invention.

In the operation of mechanical contact rectifiers such as illustrated in Fig. 1, the phase
20 terminals I and II of a suitable transformer 10 are alternately connected to one pole, preferably the positive pole 11 of a direct-current circuit, while the other pole 12 of the direct-current circuit
25 is directly connected to a suitable mid-tap in the transformer winding 10. Because of the inductance of the transformer 10, as well as its associated circuits, it is impossible to instantly commutate from one phase terminal to the other.
30 Consequently, assume the left-hand switch 8 to be closed so that current is passed from the phase terminal I of the transformer 10 through the closed contact 8 to one side 11 of the direct-current circuit. However, as the current through
35 this phase terminal I approaches the end of its conducting period, the contact device 15 closes the contact 9 to the other phase terminal II, connecting it also to the direct-current circuit. At this instant, the phase terminals I and II of the
40 converter are essentially short-circuited and there will be a potential difference as phase terminal I is approaching zero potential while the phase terminal II has an increasing potential. There will be a tendency to circulate a current *ik*
45 which is not supplied to the direct-current line. This circulating current *ik* must be opened by the opening contact 8 in order to provide conversion from alternating-current to direct-current. This circulating current *ik* has heretofore been
50 instrumental in damaging or burning the opening contact.

In order to eliminate this, I have provided in series with the contact elements 8 and 9 suitable
55 unidirectional conductors or valves 16, preferably

of the dry-type, such as copper-oxide plates. These copper-oxide plates have a definite reverse current so that it is necessary to insert sufficient elements in series to reduce the reverse current ik to an amount usually approximately one ampere which the contact can interrupt without suffering mechanical injury.

For simplicity of illustration, I have shown only a single rectifier or valve element 16 connected in series with the contacts 8 and 9. However, it is to be understood that sufficient valves or plates are to be connected in series to reduce the current to the desired minimum.

Where large currents may be encountered it may be desirable to provide a plurality of parallel connected rectifier stacks 16. In the event that this is desirable, a plurality of contact elements are provided which are electrically insulated from each other but connected in parallel each with its individual protective uni-directional conductor 10. In this manner, the inverse current ik applied to each contact element may be reduced to the desired minimum.

In the embodiment according to Fig. 3, a six-phase transformer having two star-connected groups is shown connecting through a rotating type contactor 15, each contact of which is protected by parallel-connected dry-type rectifiers. However, since only two phase terminals will, at any given time, be delivering current, it is possible to dispense with all but two groups of stacks of the dry-type rectifiers 16.

This modification is illustrated in Fig. 4, where the contact device 15 is illustrated as a rotating disc having two groups of contact elements, the opposing contacts of which are spaced apart 360 electrical degrees and the individual contact elements 17, 18 of one group being connected to similar elements 19, 20 of the other group separated therefrom by 360 electrical degrees. Associated with this contact device 15 are two groups of brushes, the opposing brushes of the brush groups being separated by 360° and the individual brushes 1 to 6 and 1' to 6' of the groups being separated an angular distance representing in electrical degrees the phase displacement of the phases of the transformer, in this instance 60 electrical degrees. One group of brushes 1 to 6 is directly connected in series with the phase terminals I to VI of the transformer 10, while the other group of brushes 1' to 6' is so connected that the rotating commutator 15 connects with the brushes in cyclic sequence. For instance, assuming the contact device 15 to be operating in a clockwise direction, phase terminal I connected to brush 1 in series therewith will be connected to brush 1' by means of the contact mechanism 15. In the next succeeding instance, this same contact element will connect phase II with brushes 2 and 2'.

Since only two phases are at any given time carrying current, the commutation between phase I and phase II may be accomplished by only two stacks 10 of rectifier elements. For instance, as the current commutates from phase I to phase II, a difference in potential will be applied between brushes 1 and 2 and 1' and 2' but the circulating current ik between these terminals will be reduced to the appropriate value by means of the series-connected rectifier elements 16. While for simplicity in illustration I have shown only a single stack of rectifier elements 16, it is obvious, as shown in Fig. 3, that any desired number of parallel-connected rectifier stacks 16 may be utilized.

In the modification according to Fig. 5, the transformer 10' is provided with a suitable inter-phase transformer 20 which controls the mode of operation of the converter so that three phases are simultaneously supplying current to the direct-current circuit. In this modification, it is accordingly necessary to provide three contact elements in each of the groups on the rotating contactor 15. It is also necessary to provide three stacks of protective rectifiers 16 in order to control commutation not only from phase to phase of the converter transformer 10', but also between the separate star-connected groups, which as is well known, are maintained at a potential difference by means of the in-phase transformer 20. In general, it will be necessary to provide a number of conducting paths or contact elements equal to the number of phases which at any given time are delivering current, and also to provide a similar number of serially connected protective valves 16.

The dimensioning of the widths of the brush segments 17 to 19 is of particular importance in the connection according to my invention. The connecting point of the following phase and the connecting point of the phase to be disconnected was temporarily overlapped by a given angle. In this connection the overlapping time must be selected sufficiently large that the circulating current in the phase circuits induced by the overlapping and passing through the protective valves 16 decreases until the phase is to be disconnected. The overlapping time must necessarily be sufficiently long to allow the current ik to be reduced to a sufficiently low value to permit arcless separation of the contact elements. This overlapping time, therefore, necessarily depends on the inductance, particularly the leakage inductance, of the transformer phases involved. In order to obtain the necessary overlapping, the width of a contact segment must be selected larger than half the distance between adjacent brushes, but in doing this, care must be taken to avoid mechanical short-circuiting of the neighboring or adjacent brushes by a contact segment. As a result, the width of the contact segment must remain smaller than the difference between the distance between the brushes and the width of a brush.

In the previous modifications, the entire phase potential will appear between adjacent contact elements. Accordingly, great care must be exercised in properly insulating the contact segments from each other. At high voltage this becomes particularly troublesome. Accordingly, in the modification according to Fig. 6, I have eliminated the adjacent contact elements and have provided a single contact element 30 of sufficient width to connect the succeeding phase in time to permit the necessary commutation overlap angle. To accomplish the reduction of the circulating current to a value permitting arcless opening of the contacts, the transformer 10 is provided with two separate star-connected groups 31-32 electrically connected through two oppositely disposed rectifier elements 35 similar to the rectifier elements 16, each of which must be of sufficient capacity to reduce the circulating current ik to the necessary minimum. In the operation of this type of construction, the alternate phases are placed in separate star-connected groups so that commutation occurs between phases in separate star-connected groups, so that the potential producing the circulating current ik must necessarily appear in the electrical con-

nection between the star-connected groups. Therefore, regardless of the direction of the potential, one of the oppositely connected rectifier elements 35 will be properly connected to reduce the current i_k to the desired minimum.

In the operation of both mechanical type contact devices and dry-type rectifiers, greater efficiency is accomplished by cooling both the rectifier and the contact elements. Since it is already necessary to provide a synchronous motor or other suitable driving device 40 for the contactor 15, I propose to also utilize this driving device 40 to secure cooling of the contactor 15 as well as the series connected rectifier elements 16. In the embodiment according to Fig. 7, this is secured by placing the contact elements 15 and their associated protective rectifiers 16 in a suitable casing 41 and propelling air through the casing 41 by means of a fan 42 driven by the motor 40 operating the contact elements.

While for purposes of illustration I have shown and described specific embodiments of my invention, it will be apparent to those skilled in the art that many changes and modifications can be made therein without departing from the true spirit of my invention or the scope of the appended claims.

I claim as my invention:

1. An electrical translating system comprising a transformer, an alternating-current circuit, a three-phase winding in said transformer connected to said alternating-current circuit, a direct-current circuit, a six-phase winding consisting of two three-phase star-connected groups, one side of said direct-current circuit being connected to each of said star points, a uni-directional conductor connected in series between said direct-current circuit and said star points, contact means for successively connecting the phase terminals of said six-phase winding to the other side of said direct-current circuit, a motor operating in synchronism with the alternating-current circuit for operating said contact means, and a fan driven by said motor for cooling both said contact device and said uni-directional conductors.

2. An electrical conversion system for transferring energy between an alternating and a direct-current circuit comprising a coupling transformer including a winding connected to the alternating-current circuit, a second winding connected to the direct-current circuit, said second winding having two star-connected sections, a connection between said star points, oppositely connected uni-directional conductors in said connection, one side of said direct-current circuit being connected between said uni-directional conductors, a contact device for successively connecting succeeding phase terminals of said second winding to the other side of said direct-current circuit, said succeeding phase terminals being connected to alternate star points, and said contact device being arranged to make contact with the succeeding phase before breaking the contact with the preceding phase.

3. An electrical conversion system for transferring electrical energy between an alternating-current circuit and a direct-current circuit, comprising a transformer means for coupling the circuits, one side of the direct-current circuit being directly connected to said transformer means, a rotating contact device for connecting the phase terminals of the transformer means to the other side of said direct-current circuit, two brush groups cooperating with said contact device, the

opposite brushes of said brush groups being displaced by 360 electrical degrees, each group having a number of brushes corresponding to the number of phases of said transformer means and displaced with reference to each other electrically by the phase angle, the brushes of one group being connected in series with the phases of the transformer means, a plurality of valve groups corresponding to the number of phases simultaneously carrying current, the brushes of said second group of brushes being connected in cyclic sequence with said valve groups, said rotating contact having opposite contact elements separated from each other by 360 electrical degrees, but connected to each other, each group having a number of contact segments corresponding in number to the simultaneous current-carrying phases.

4. An electrical conversion system for transferring electrical energy between an alternating-current circuit and a direct-current circuit, comprising a transformer means for coupling the circuits, one side of the direct-current circuit being directly connected to said transformer means, a rotating contact device for connecting the phase terminals of the transformer means to the other side of said direct-current circuit, two brush groups cooperating with said contact device, the opposite brushes of said brush groups being displaced by 360 electrical degrees, each group having a number of brushes corresponding to the number of phases of said transformer means and displaced with reference to each other electrically by the phase angle, the brushes of one group being connected in series with the phases of the transformer means, a plurality of valve groups corresponding to the number of phases simultaneously carrying current, the brushes of said second group of brushes being connected in cyclic sequence with said valve groups, said rotating contact having contact elements the opposite elements of which are separated from each other by 360 electrical degrees, but connected to each other, each group having a number of contact segments corresponding in number to the simultaneous current-carrying phases, the width of each of said contact segments being larger than half the angle between neighboring brushes but smaller than the difference between the phase angle and the brush width.

5. An electrical current converting system comprising a three-phase alternating-current circuit, a direct-current circuit, a double three-phase transformer for coupling said circuits, one side of said direct-current circuit being directly connected to said transformer, a rotating contact device for connecting the phase terminals to the other side of said direct-current circuit, two groups of six brushes cooperating with said contact device, the brushes of each of said groups being separated 60 electrical degrees, the opposite brushes of said brush groups being separated 360 electrical degrees, three stacks of dry-type rectifiers connected to said direct-current circuit, the brushes of one group being connected in cyclic sequence to said rectifiers, the brushes of the other group being connected in series with the phases of the transformer, two groups of three contact segments on said contact device, each segment of one group being connected to an opposing segment of the other group which is 360 electrical degrees away.

6. An electrical current converting system comprising a three-phase alternating-current circuit, a direct-current circuit, a double three-

phase transformer for coupling said circuits, one side of said direct-current circuit being directly connected to said transformer, a rotating contact device for connecting the phase terminals to the other side of said direct-current circuit, two groups of six brushes cooperating with said contact device, the brushes of each of said groups being separated 60 electrical degrees, the opposing brushes of said brush groups being separated 360 electrical degrees, three stacks of dry-type rectifiers connected to said direct-current circuit, the brushes of one group being connected in cyclic sequence to said rectifiers, the brushes of the other group being connected in series with the phases of the transformer, two groups of three contact segments on said contact device, each segment of one group being connected to an opposing segment of the other group which is 360 electrical degrees away, each of said segments having a width greater than half the distance between adjacent brushes but less than the difference of the distance between brushes and the brush width.

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