J. H. LENDI.

RECTIFYING SYSTEM FOR HIGH TENSION ALTERNATING CURRENTS.

APPLICATION FILED JAN. 24, 1916.

1,234,099.

Patented July 17, 1917.

3 SHEETS—SHEET 1.

Fig. 1.

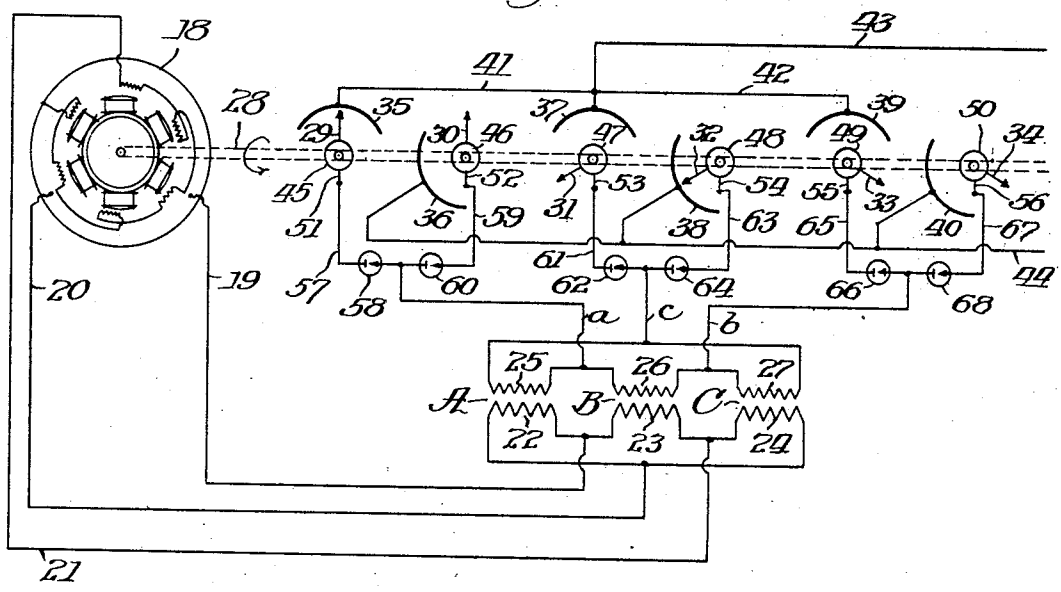


Fig. 2.

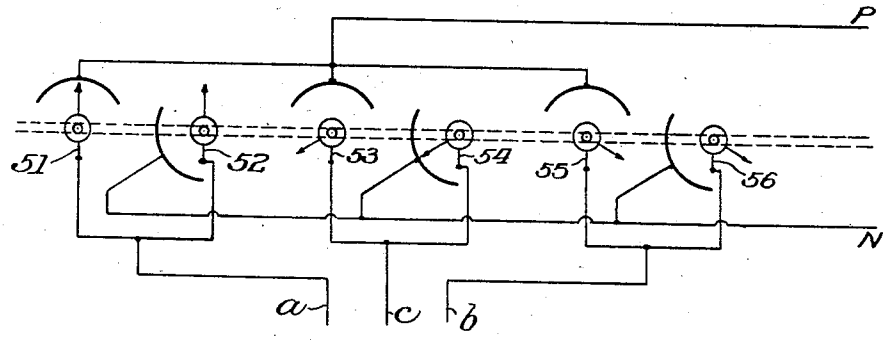
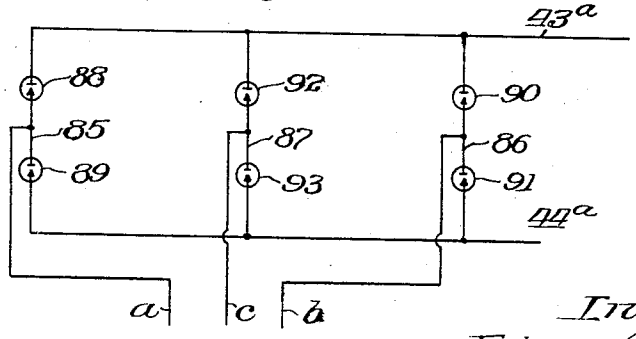


Fig. 3.



Witness:

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3 SHEETS—SHEET 2.

Fig. 4.

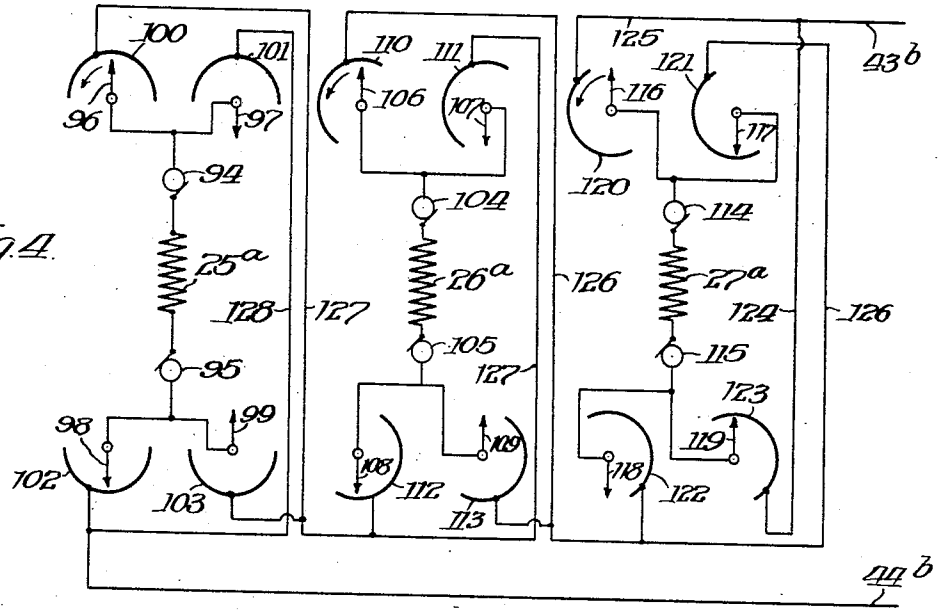


Fig. 5.

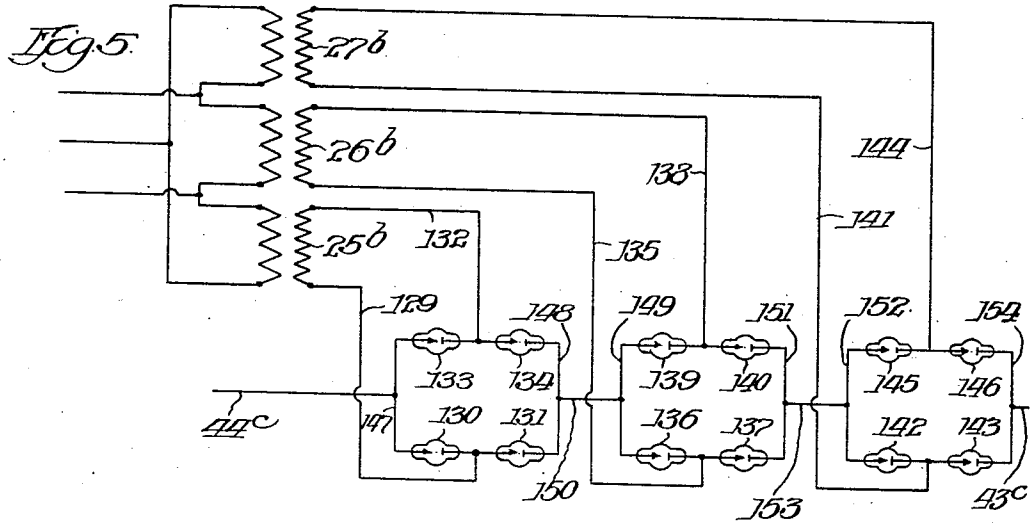
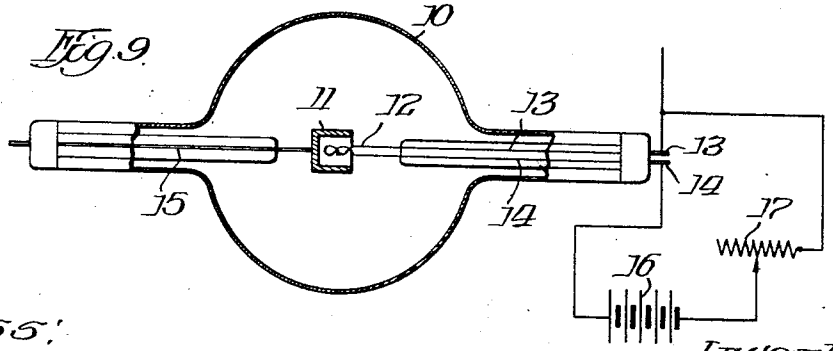


Fig. 9.



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3 SHEETS—SHEET 3.

Fig. 8.

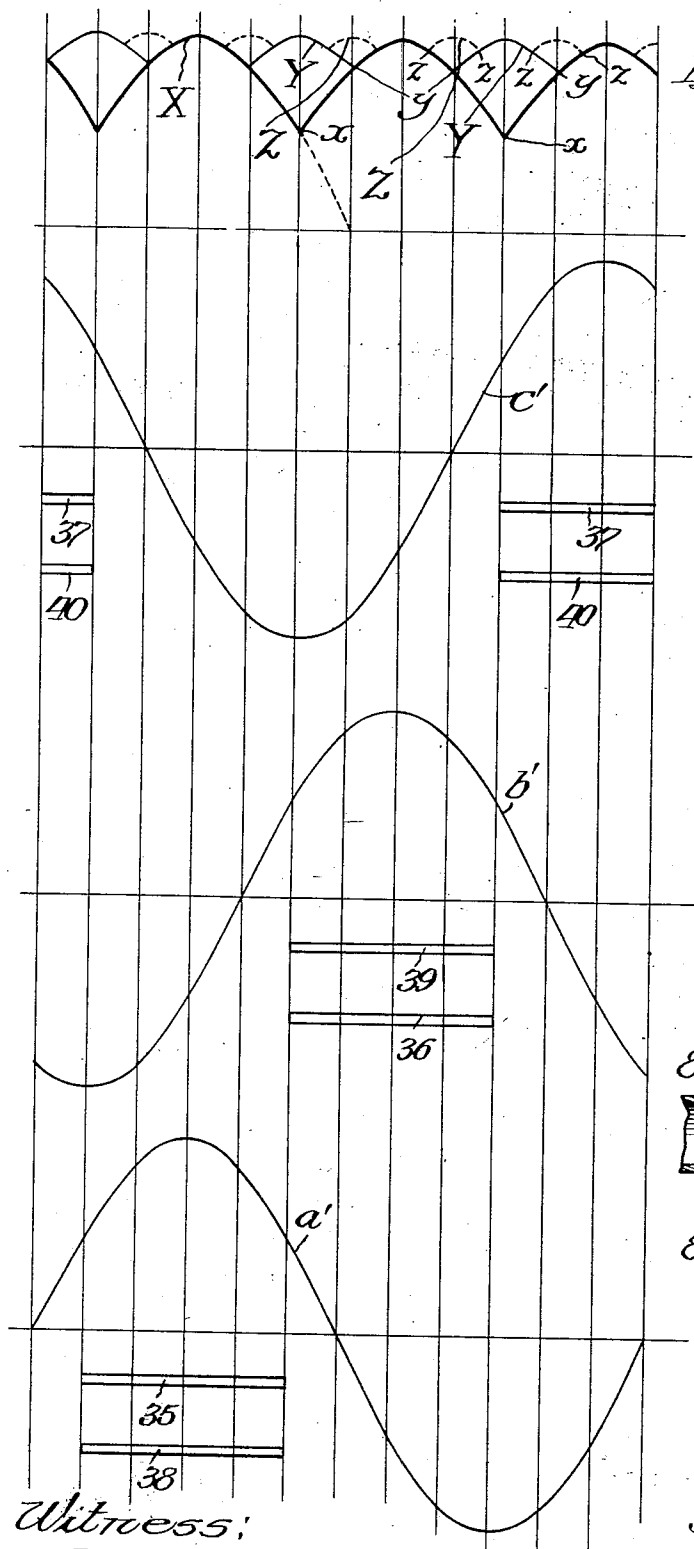


Fig. 7.

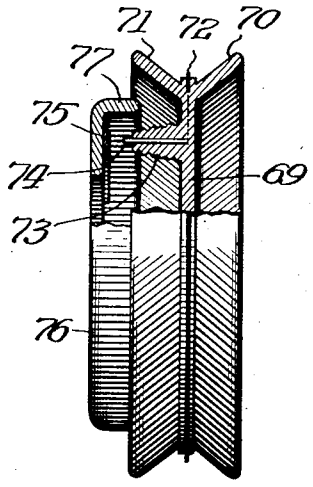
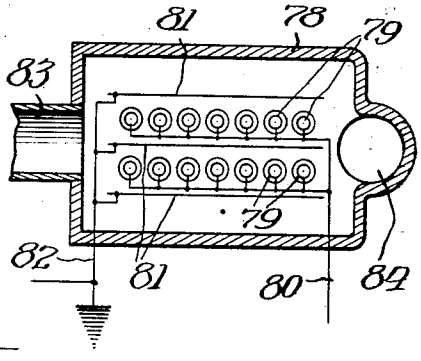


Fig. 6.



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JOHN H. LENDI, OF CHICAGO, ILLINOIS.

RECTIFYING SYSTEM FOR HIGH-TENSION ALTERNATING CURRENTS.

1,234,099. Specification of Letters Patent. Patented July 17, 1917.

Application filed January 24, 1916. Serial No. 73,903.

To all whom it may concern:

Be it known that I, JOHN H. LENDI, a citizen of the United States, residing at Chicago, in the county of Cook and State of Illinois, have invented a new and Improved Rectifying System for High-Tension Alternating Currents, of which the following is a specification.

My invention relates to a rectifying system for high tension alternating currents characterized by the use of commutating devices or other rectifying means connected with the high tension side of a polyphase source of high tension alternating current, by which a substantially constant unidirectional current is delivered to the main conductors used to supply high tension unidirectional current for any desired purpose. My system while particularly adapted to use in connection with dust precipitation devices is not, however, limited to this use, but may be employed for any purpose in connection with which it is necessary to have high tension uni-directional current of substantially constant value. By my invention I combine the high tension waves delivered from the high tension windings of the polyphase transformer so as to most effectively utilize the waves in the combined uni-directional current.

My invention will best be understood by reference to the drawings in which—

Figure 1 is a diagrammatic drawing showing one form of my rectifying system in its entirety,

Fig. 2 shows in a diagrammatic drawing a modified arrangement of the commutating devices,

Fig. 3 shows in a diagrammatic drawing an arrangement of current rectifying devices for carrying out my invention,

Fig. 4 shows in a diagrammatic drawing a rectifying system in which the rectified high tension waves are delivered to the uni-directional supply conductors in series relation,

Fig. 5 shows in a diagrammatic drawing a modified arrangement of current rectifying devices for combining the high tension waves in series relation,

Fig. 6 shows in a diagrammatic view an arrangement of dust collecting mechanism for use in connection with the rectifying system,

Fig. 7 is a detail view of one of the commutating devices,

Fig. 8 is a drawing of the curves of the various electric motive forces of the several phases and the resultant curves of electromotive force produced by my rectifying system, and

Fig. 9 is a detail view of one of the rectifying devices that I prefer to employ in carrying out my invention.

Similar numerals refer to similar parts throughout the several views.

In order to better understand the operation of my system in which current rectifying devices are employed, refer first to the rectifying mechanism shown in Fig. 9, which is a device known as a "kenetron" and which consists of a glass globe 10 containing in it a first electrode 11 in the form of a cup partly within which is located a hot wire electrode 12, the terminals of which are connected by wires 13 and 14 which extend through one of the arms of the tube, being hermetically sealed therein. The cup 11 is connected by a conductor 15 with an external terminal of the tube being hermetically sealed in the other arm thereof so that the wire 15 and the wire 13 outside of the tube constitute the terminals to be connected to the high tension source of alternating current. Between the wires 13 and 14 outside of the tube a battery 16 and variable resistance 17 are connected in series for the purpose of maintaining the hot wire electrode 12 in heated condition. The tube is exhausted to a very high degree, the vacuum obtained being as nearly perfect as possible, and for this condition it has been found that current flow will only take place from the anode 11 to the cathode 12 when the latter is highly heated, this effect being due to a thermionic discharge given off by the highly heated cathode. I find such a device to be particularly effective in rectifying high tension alternating currents, for the reason that it completely prevents the passage of current from the electrode 12 to the electrode 11 and there is therefore no danger of breaking down the gap between the electrodes by high tension waves which

are negative relatively to the anode and cathode referred to. The kenetron construction described is not of itself my invention and I therefore make no claim for it apart from the combination in which it is employed in carrying out my system, for my invention consists in the combination with the terminals of a high tension polyphase source of alternating current of commutating and rectifying devices of which the kenetron may be a part to secure the results to be described.

In the system shown in Fig. 1 a three-phase alternating current generator 18 is shown having conductors 19, 20 and 21 extending therefrom to deliver the three-phase current to the primary windings 22, 23 and 24 of the transformers A, B and C, these primary windings being delta connected and the winding 22 being connected between the conductors 19 and 20, the winding 23 between the conductors 19 and 21 and the winding 24 being connected between the conductors 21 and 20. But one of the three-phase generating windings is shown in connection with the generator 18, but as is well known in the art it will be understood that the other two generating windings are similar to the one shown and displaced therefrom and from each other by 120 electrical degrees.

The secondary windings of the transformers A, B and C are shown at 25, 26 and 27 respectively, and these secondary windings which are the high tension windings are delta connected and are also connected to the high tension conductors *a*, *b* and *c*, the secondary winding 25 being connected between the conductors *c* and *a*, the secondary winding 26 being connected between the conductors *a* and *b* and the secondary winding 27 being connected between the conductors *b* and *c*. It will be understood that the conductors *a*, *b* and *c* are typical of any high tension three-phase supply system and for purposes of comparison the supply conductors in Figs. 2 and 3 are similarly designated.

The shaft 28 of the generator has mounted upon and insulated from it six commutating arms 29, 30, 31, 32, 33 and 34 which are arranged in pairs, the arms 29 and 30 of one pair having one angular position and the arms 31, 32 and 33, 34 of the other pairs being displaced from the first pair and from each other by 120 degrees. These commutating arms coöperate with commutating segments 35, 36, 37, 38, 39 and 40 respectively, each being of substantially 120 degrees in extent, the segments 35, 37 and 39 being similarly disposed angularly and connected together by conductors 41 and 42 with the high tension positive conductor 43 while the other segments 36, 38 and 40 are in the same angular position relatively to each other, but displaced substantially 120 degrees from the segments 35, 37 and 39, the segments 36, 38 and 40 being connected to the negative 44 of the high tension unidirectional source of supply.

The commutating arms 29, 30, 31, 32, 33 and 34 are supplied with alternating current by the slip rings 45, 46, 47, 48, 49 and 50 upon which rest the brushes 51, 52, 53, 54, 55 and 56 respectively.

The brush 51 is connected by wire 57 through kenetron 58 with the conductor *a;* the brush 52 is connected by wire 59 through kenetron 60 with conductor *a;* the brush 53 is connected by wire 61 through kenetron 62 with conductor *c;* the brush 54 is connected by wire 63 through kenetron 64 with conductor *c;* the brush 55 is connected by wire 65 through kenetron 66 with conductor *b*, and the brush 56 is connected by wire 67 through kenetron 68 with conductor *b*. The kenetrons referred to are connected in the several wires so that current flow may occur through them only in the direction indicated by the arrow heads forming a part of the diagrammatic representations of the kenetrons.

Referring to Fig. 8 the waves of alternating electromotive forces delivered from the transformer windings 25, 26 and 27 are shown at *a'*, *b'* and *c'* respectively. The arms carried by the shaft 28 are disposed relatively to the waves of electromotive force delivered from the generator 18 and the commutator segments are so disposed relatively to the arms that the commutating devices are effective in completing the circuit from the secondary windings of the transformers A, B and C as indicated by the disposition of the diagrammatic representations of the commutator bars in Fig. 8, that is to say, the segments 35 and 38 are effective in completing the circuit from the secondary winding 25 for the middle 120 degrees of the positive waves of the electromotive force *a'*, the segment 39 and 36 are effective in closing the circuit from the secondary winding 26 during the middle 120 degrees of the positive waves of the electromotive force *b'*, and the segments 37 and 40 are effective in closing the circuit from the secondary winding 27 during the middle 120 degrees of the positive waves of the electromotive force *c'*. In other words, the middle 120 degrees of each positive current wave of the three phases is delivered to the positive conductor 43 and supplied thereby to the devices employed for utilizing the unidirectional current and is returned by the other main or negative conductor 44 to the secondary winding from which it is delivered, and the curve of rectified current thus supplied to the circuit, including the conductors 43 and 44, is shown at X in Fig. 8. It is to be borne in mind that as a result

of the delta connection of the secondary windings 25, 26 and 27 the following operation is taking place at all times: Considering simply the closed circuit formed by the series arrangement referred to, the algebraic sum of the instantaneous values of the electromotive forces is at all times zero and therefore during any interval when current delivered from one of the secondary windings is being communicated to the conductors 43 and 44 the algebraic sum of the electromotive forces developed in the other two secondary windings is equal in amount at any instant to the electromotive force in the winding delivering the current to the conductors 43 and 44 and opposite in direction and as a result of the connection of the conductors *a*, *b* and *c* above described, at any time that one of the secondary windings is effective in sending positive current waves to the circuit including the conductors 43 and 44 the other two secondary windings are effective also in delivering current through the same path, and therefore all of the secondary windings are effective at all times in supplying current to the commutating devices and to the conductors 43 and 44. For example, when the secondary winding 25 is sending positive current through conductor *a*, arm 29 and segment 35 to the conductor 43 this conductor *a* is the negative terminal of the combined secondary windings 26 and 27, the other terminal being the conductor *c*, which conductor is the negative terminal at this time for the secondary winding 25. At this time the algebraic sum of the electromotive forces in the secondary windings 26 and 27 must be negative and equal in amount to the electromotive forces in the winding 25 in order that the algebraic sum of all of the electromotive forces developed in all three windings may be zero, and therefore for this condition the secondary windings 26 and 27 are together effective in delivering to the positive conductor *a* an amount of current substantially equal to that delivered to said conductor by the secondary winding 25. The operation of the several secondary windings referred to so that they are at all times effective in delivering current to be commutated as a result of the parallel relation of the secondary windings relatively to the conductors extending to the commutating devices is, as far as I am aware, novel and eliminates the necessity of special commutating devices for inverting the negative waves of electromotive force developed in the secondary windings, for, as will be observed in connection with Figs. 1 and 8, the commutating arms and segments are provided in my system only in connection with the positive waves of electromotive force developed by the several secondary windings.

While the commutating arms are described above as being carried by the shaft 28, it will of course be understood that this arrangement is shown for the sake of simplicity and that I do not limit myself to this construction, but that I may employ any other arrangement by which the commutating arms may be operated synchronously with the rotor of the generator.

While any desired form of commutating devices may be used which will communicate the middle 120 degrees of each positive wave of electromotive force to the direct current conductors, I find it convenient to employ for this purpose the construction shown in detail in Fig. 7 in which a disk 69 of insulating material, such for example as gutta percha or other similar material having high dielectric strength is employed, which disk is mounted upon the shaft provided to rotate the same and carries at its outer edge outwardly projecting inclined flanges 70 and 71 between which a conducting ring 72 is mounted. This conducting ring 72 constitutes the slip ring construction referred to in connection with Fig. 1 and in practice is engaged by any suitable conducting brush for communicating the current to said ring. The disk 69 has projecting outwardly from one side of it just inside of one of the flanges referred to a boss 73 in which is mounted a conducting rod 74 electrically connected with the ring 72, this rod 74 constituting one of the commutating arms shown diagrammatically in Fig. 1. The rod 74 coöperates with a conducting segment 75 supported from the base of the machine by a disk 76 of insulating material of high dielectric strength provided at its outer edge with inturned flange 77 extending around the boss 73 and inside of the flange 71. The segment 75 is connected with the circuits of the system as described above and each is of substantially 120 degrees extent for the system shown and described in connection with Fig. 1. It will be understood that my system contemplates the generation of very high electromotive forces, such, for example, as 100,000 volts or over and that for these electromotive forces it is unnecessary to have the rod 74 make contact with the segment 75 to close the circuit by means of the commutating devices, although substantially the same construction may be employed for lower voltages if desired by bringing the segment close enough to the rod so that it makes contact with the end of said rod as it rotates.

One of the purposes for which the high tension unidirectional current delivered by the system shown in Fig. 1 may be employed is indicated in Fig. 6, and consists in devices for precipitating dust as follows: A chamber 78 is provided across which a plurality of rods 79 extend, these rods being

connected together and to a conductor 80 forming one of the electric terminals of the device. Between the rods 79 plates 81 are disposed which are connected together and to the other electric terminal 82 of the device, the latter terminal being preferably grounded as indicated. The dust laden gas is delivered into the chamber through the inlet opening 83 across the rods 79 between the plates 81 and the condition of electro static stress produced by the electrodes in the chamber serves to separate the dust from the air, after which the cleaned air is discharged from the chamber through the stack 84. The terminals 80 and 82 are connected with the high tension direct current wires 43 and 44 shown in Fig. 1.

The degree to which the rectified current produced by the system shown in Fig. 1 may be made to approach a constant value is determined by the number of phases employed in the system. As stated above, with a three-phase system the rectified current has the form indicated at X in Fig. 8 and the lowest value is that shown at the points x. For a six-phase system the middle sixty degrees of each rectified wave remains the same, and these parts of the waves of rectified current are connected by similar waves as indicated at Y in Fig. 8, the lowest values of the rectified current now being the points y. For a 12-phase system the middle 30 degrees of each rectified current wave of the six-phase system remains as in the six-phase system, and these waves are connected by similar waves Z as indicated in Fig. 8, the lowest values of the rectified current being now shown at the points z for which condition it will be observed that the rectified current is of substantially constant value.

For high tension rectifying systems such as shown in Fig. 1, the kenetrons employed serve the important purpose of permitting current flow in but one direction in the several paths in which they are employed, and in addition they protect the commutating devices by preventing the application of high electromotive forces upon the commutating devices until such times as the devices should come into operation. For example, when the commutating arm 29 has nearly completed its 120 degrees of operative rotation opposite the segment 35 the arm 30 approaches the segment 36 and were the kenetron 60 not present in the wire 59 the same electromotive force impressed upon the arm 29 would be impressed upon the arm 30, with the result that there might readily be a jumping of the current from the arm 30 to the segment 36 and thus to the negative conductor 44 which would in large part defeat the operation of the rectifying system as a whole. Permitting as they do current flow in but one direction, the kenetrons serve as a protection to the rectifying system, and it will be understood that these kenetrons may be used in multiple groups to any extent that may be necessary to carry the necessary amount of current to be rectified.

For conditions in which the potential of the rectified current may be lower than above referred to and where there is no danger of the current jumping across relatively wide gaps from the commutating arms to their segments, the arrangement shown in Fig. 2 may be employed, in which the conductors a, b and c are connected directly to the brushes 51, 52, 53, 54, 55 and 56, this system being in all respects identical with that shown in Fig. 1 with the exception that the kenetrons are omitted from the various circuits.

If preferred, for certain conditions, particularly those requiring but a small current flow, the commutating devices above described may be dispensed with and kenetrons alone may be used to rectify the polyphase high tension alternating current. Such a system is shown diagrammatically in Fig. 3 in which the conductors a, b, and c are connected to wires 85, 86 and 87 respectively, the wire 85 being connected with the negative terminal of the kenetron 88 and the positive terminal of the kenetron 89, the wire 86 being connected with the negative terminal of the kenetron 90 and the positive terminal of the kenetron 91 and the wire 87 being connected with the negative terminal of kenetron 92 and the positive terminal of kenetron 93. The positive terminals of the kenetrons 88, 90 and 92 are connected together and to the positive conductor 43^a by which rectified current is supplied to the devices to be operated by the system, and the negative terminals of the kenetrons 89, 91 and 93 are connected together and to the conductor 44^a of the rectifying current system.

It will be understood that whether the arrangement shown in Figs. 1, 2 or 3 be employed the current is rectified as shown diagrammatically in Fig. 8, and that the operation of the secondary windings 25, 26 and 27 is the same in each case.

The system thus far described may be called a multiple rectifying system for the reason that the electromotive force impressed upon the supply conductors by which rectified current is communicated to the desired devices is of the same amount as that delivered from each of the secondary windings of the polyphase transformer or transformers. My system of rectification is also applicable to a series arrangement of the secondary windings of these transformers and embodiments of my invention in series arrangements are shown in Figs. 4 and 5.

In Fig. 4 the secondary windings 25^a, 26^a and 27^a for the polyphase current to be

rectified are shown, the primary windings and source of current supply being omitted for the sake of clearness, which primary windings and source are of any desired construction and may be the same as shown in Fig. 1. The winding 25^a is connected by brushes with slip rings 94 and 95, which in turn are connected with the commutating arms 96, 97, and 98, 99 respectively, the arms 96, 97 and 98, 99 coöperating with the semicircular commutator segments 100, 101, 102 and 103 respectively, the arms 96 and 97 being oppositely disposed relatively to their segments 100 and 101 as are also the arms 98 and 99 relatively to their segments 102 and 103. The secondary winding 26^a is similarly connected to slip rings 104, 105, commutating arms 106, 107, 108 and 109 and commutating segments 110, 111, 112 and 113 and the secondary winding 27^a is similarly connected with slip rings 114, 115, commutating arms 116, 117, 118 and 119, and commutator segments 120, 121, 122 and 123, the only difference being that the commutator segments for the winding 27^a are displaced relatively to the commutator segments for the winding 25^a 120 degrees, and that the commutator segments for the winding 26^a are displaced relatively to the commutator segments for the winding 25^a 240 degrees, this displacement corresponding to the displacement between the phases of the three-phase current being rectified. It will be understood that the displacement referred to between the several commutator segments may be secured by any desired arrangement of the commutator arms and segments, whether the arms for the several windings are in the same angular position relatively to each other as shown in Fig. 4 or not, the only requirement being that the commutating action shall be displaced for each secondary winding relatively to the other secondary windings in a manner corresponding with the displacement of the phases of the alternating current being rectified.

The positive conductor 43^b for supplying rectified current is connected by wires 124 and 125 with segments 123 and 120 respectively; the segments 121 and 122 are connected together by wire 126, which wire also connects these segments with the segments 110 and 113, and the segments 111 and 112 are connected together by wire 127, which also connects these segments with the segments 100 and 103. The segments 101 and 102 are connected together by wire 128, which is also connected with the negative conductor 44^b of the circuit for supplying rectified current from the system. As a result of the connections described the arm 96 serves to communicate positive waves of current from the secondary winding 25^a to the wire 127, the return path for these waves being from negative conductor 44^b to segment 102 to arm 98; the arm 106 serves to communicate positive waves of current from the positive winding 26^a to the wire 126, the return path for these waves being through the commutating device connected with the secondary winding 25^a to wire 127, and thus to segment 112 and arm 108; and the arm 116 serves to communicate positive waves from the secondary winding 27^a to the wire 125 and thus to the positive conductor 43^b, the return path for these waves being in series through the commutating devices connected with the secondary windings 25^a and 26^a to wire 126 and thus to segment 122 and arm 118. Similarly the arm 99 serves to deliver negative current waves from the secondary winding 25^a to wire 127, the return path for these waves being from the negative conductor 44^b to wire 128 to segment 101 and thus to arm 97; the arm 109 serves to deliver negative waves from the secondary winding 26^a to the wire 126, the return path for these waves being through the commutating devices connected with the winding 25^a to wire 127 to segment 111 and thus to arm 107; and the arm 119 serves to deliver negative waves from the secondary winding 27^a to the wire 124 and thus to the positive supply wire 43^b of the rectifying current system, the return path for these waves being from conductor 44^b in series through the commutating devices connected with the secondary windings 25^a and 26^a to the wire 126 to segment 121 and thus to arm 117. From the connections it will appear that the electromotive forces developed in the secondary windings 25^a, 26^a and 27^a are always connected in series and in such a manner that the tendency to produce current flow by those electromotive forces is always in the same direction, the sum of the effective electromotive forces being at all times impressed upon the supply conductors 43^b and 44^b of the rectifying current system in such a direction as to send current out through the conductor 43^b and to constitute the conductor 44^b a return path for the rectified current of the system. The series commutating system just described may be employed for potentials which are not sufficiently high to cause improper operation of the commutating devices, and for a rectifying system in which it is desirable to use much higher potentials I find it desirable to employ kenetrons without the use of commutating devices, as, for example, in the arrangement shown in Fig. 5. In this arrangement the secondary windings of the polyphase supply transformers are shown at 25^b 26^b and 27^b. The secondary winding 25^b is connected by wire 129 with positive terminal of the kenetron 130 and the negative terminal of the kenetron 131, and by wire 132 with the positive terminal of the kenetron 133 and the negative terminal of the

kenetron 134; the secondary winding 26^b is connected by wire 135 with the positive terminal of the kenetron 136 and the negative terminal of the kenetron 137 and by wire 138 with the positive terminal of the kenetron 139 and the negative terminal of the kenetron 140, and the secondary winding 27^b is connected by wire 141 with the positive terminal of the kenetron 142 and the negative terminal of the kenetron 143 and by wire 144 with the positive terminal of the kenetron 145 and the negative terminal of the kenetron 146.

The negative terminals of the kenetrons 130 and 133 are connected together by wire 147 to which the negative conductor 44^c of the rectifying system is connected. The positive terminals of the kenetrons 131 and 134 are connected together by wire 148 and the negative terminals of the kenetrons 136 and 139 are connected together by wire 149. The wires 148 and 149 are connected together by wire 150. The positive terminals of kenetrons 137 and 140 are connected together by wire 151 and the negative terminals of kenetrons 142 and 145 are connected together by wire 152. The wires 151 and 152 are connected together by wire 153. The positive terminals of kenetrons 143 and 146 are connected together by wire 154, which is also connected to the positive conductor 43^c of the rectifying system. As a result of the connections described, assuming the direction of positive waves in the secondary windings to be upward, a positive current wave from the secondary winding 25^b flows through wire 132, kenetron 134 to wire 148 and thus to wire 150, from which the current flows in parallel paths through the kenetrons 139, 140 and 136, 137 to wire 153 from which the current flows in parallel paths through the kenetrons 145, 146 and 142, 143 to the supply conductor 43^c of the rectifying system. The return path for these positive waves is from conductor 44^c to wire 147, kenetron 130 to wire 129 and thus back to the secondary winding 25^b. Similarly the path for current flow of positive waves from the secondary winding 26^b is through wire 138, kenetron 140, wire 151 to wire 153 and from thence in parallel paths through kenetrons 145, 146 and 142, 143 to the positive supply conductor 43^c, the return path for these waves being conductor 44^c in parallel paths through kenetrons 133, 134 and 130, 131 to wire 150 to wire 149, kenetron 136 to wire 135 back to secondary winding 26^b Similarly the path for current flow of positive waves from the secondary winding 27^b is by wire 144 to kenetron 146, wire 154 to supply conductor 43^c, the return path for these waves being conductor 44^c in parallel paths through kenetrons 133, 134 and 130, 131 to wire 150, from thence in parallel paths through kenetrons 139, 140 and 136, 137 to wire 153 to wire 152, kenetron 142, wire 141 back to secondary winding 27^b. The path for the flow of negative waves from the secondary winding 25^b is as follows: wire 129, kenetron 131, wire 148, wire 150 and thence in parallel paths through kenetrons 139, 140 and 136, 137 to wire 153, and thence in parallel paths through kenetrons 145, 146 and 142, 143 to positive supply conductor 43^c, the return path for these waves being from conductor 44^c to wire 147, kenetron 133, wire 132, back to secondary winding 25^b. The path for the flow of negative waves from the secondary winding 26^b is by wire 135 to kenetron 137, wire 151, wire 153, thence in parallel paths through kenetrons 145, 146 and 142, 143 to positive supply conductor 43^c, the return path for these waves being from conductor 44^c in parallel paths through kenetrons 133, 134 and 130, 131 to wire 150, thence by wire 149 to kenetron 139 to wire 138, and thence back to secondary winding 26^b. The path for the flow of negative waves from secondary winding 27^b is by wire 141 to kenetron 143, wire 154, thence to positive supply conductor 43^c, the return path for these waves being from conductor 44^c in parallel paths through kenetrons 133, 134 and 130, 131 to wire 150, thence in parallel paths through kenetrons 139, 140 and 136, 137 to wire 153, thence to wire 152, kenetron 145, wire 144 back to secondary winding 27^b. The paths described, it will be seen, afford a series connection between the secondary windings 25^b, 26^b and 27^b, such that the electromotive forces of these windings are at all times combined additively so that the numerical sum of their instantaneous values and not their algebraical sum is impressed upon the main conductors 43^c and 44^c of the rectifying system.

While I have shown my system in the embodiments disclosed in Figs. 4 and 5 as employed for the purpose of rectifying 3-phase high tension alternating current, the waves of the different phases being at any instant connected together in series, it will be understood that this arrangement is equally applicable to a larger number of phases and that as the number of phases increases the reaction due to sending the current through the secondary windings which at any particular instant may be developing but small electromotive forces relatively, is correspondingly reduced.

From the above it will appear that I have provided a rectifying system by which alternating current of very high voltage may be rectified whether of single or polyphase, and further that my system provides a means for rectifying polyphase alternating current in a manner to get the full effect at any instant of all of the current waves without providing separate rectifying or commutating devices for the negative waves from

those employed for the positive waves. For certain purposes, such for example as the precipitation of dust by corona or static discharge a unidirectional current is required of very high potential and for effective operation this unidirectional current must be of practically constant value in order to maintain the operation of the precipitating device since the precipitation occurs only above a certain limiting value of potential, and the effectiveness of the precipitation devices is much greater than it would be with an intermittent high potential rectified current, such for example, as might be obtained from a single-phase alternating current. On account of the very high potential employed in my system it is impracticable to use ordinary rectifying devices, such for example, as electrolytic rectifiers or quench tubes since they do not afford protection for current flow in reversed direction through them for the voltages employed in my system. The kenetrons referred to, however, are admirably adapted to this purpose since their resistance to current flow in a direction opposite to that for which they are designed is practically infinite, and it is therefore practically impossible to force current to flow through them from the heated cathode to the anode.

While I have shown the transformers employed in connection with my system as delta connected, it will be understood that the primary and secondary windings of the transformers may be either star connected or delta connected as desired or that a combination of the two may be employed without interfering with the operation of my system, the principal difference being that with the star connection of the secondary windings as for example in certain embodiments of my system as shown in Fig. 1 the high tension sources are no longer connected together in parallel relation and that therefore during any period of rectification but one current path through the source is effective in supplying current to the rectifying and commutating devices.

While I have shown my invention in the particular embodiments above described, it will be understood, however, that I do not limit myself to these particular constructions as I may employ equivalents thereof without departing from the spirit of my invention.

What I claim is:

1. In a high tension commutator, the combination of a disk of insulating material, a conducting arm projecting from said disk, a slip ring carried by said disk, an insulating base, and a conducting commutating segment secured to said base for cooperation with said arm.

2. In a high tension commutator, the combination of a disk of insulating material, a conducting arm projecting from said disk, a slip ring carried by said disk, an insulating base, and a conducting commutating segment secured to said base for coöperation with said arm, said disk having an insulating flange extending from it between said slip ring and said commutating arm.

3. In a high tension commutator, the combination of a disk of insulating material, a conducting arm projecting from said disk, a slip ring carried by said disk, an insulating base, and a conducting commutating segment secured to said base for coöperation with said arm, said base having an insulating flange extending from it around said arm and said segment.

4. In a high tension commutator, the combination of a disk of insulating material, a conducting arm projecting from said disk, a slip ring carried by said disk, an insulating base, and a conducting commutating segment secured to said base for coöperation with said arm, said disk having an insulating flange extending from it between said slip ring and said commutating arm, and said base having an insulating flange extending from it around said arm and said segment.

5. In a system for rectifying high tension alternating current, the combination of a plurality of polyphase supply conductors for delivering alternating current at high potential, two commutating devices angularly displaced to correspond with the angular displacement of two of the phases and connected with each supply conductor by branch connections one for current flow in each direction through said supply conductor, and conductors connected with said commutating devices for receiving unidirectional current therefrom, said commutating devices being operative for current waves of but one and the same sign for the several phases.

6. In a system for rectifying high tension alternating current, the combination of a plurality of polyphase supply conductors for delivering alternating current at high potential, two commutating devices angularly displaced to correspond with the angular displacement of two of the phases and connected with each supply conductor by branch connections one for current flow in each direction through said supply conductor, conductors connected with said commutating devices for receiving unidirectional current therefrom, said commutating devices being operative for current waves of but one and the same sign for the several phases, and a delta connected source of polyphase current connected with said supply conductors.

7. In a system for rectifying high tension alternating current, the combination of a plurality of polyphase supply conductors

for delivering alternating current at high potential, two commutating devices angularly displaced to correspond with the angular displacement of two of the phases and connected with each supply conductor by branch connections one for current flow in each direction through said supply conductor, conductors connected with said commutating devices for receiving unidirectional current therefrom, said commutating devices being operative for current waves of but one and the same sign for the several phases, and a polyphase step up transformer having delta connected secondary windings connected with said supply conductors.

8. In a system for rectifying high tension alternating current, the combination of a plurality of polyphase supply conductors for delivering alternating current at high potential, two commutating devices angularly displaced to correspond with the angular displacement of two of the phases and connected with each supply conductor by branch connections one for current flow in each direction through said supply conductor, conductors connected with said commutating devices for receiving unidirectional current therefrom, said commutating devices being operative for current waves of but one and the same sign for the several phases, and oppositely connected current valves in the branch connections from each supply conductor, whereby when current flows through a supply conductor and the current valve in one of its branch connections the current valve it its other branch connection by preventing current flow through said other branch connection prevents impressing the potential of said supply conductor upon the commutating device connected with said other branch connection.

9. In a system for rectifying high tension alternating current, the combination of a plurality of polyphase supply conductors for delivering alternating current at high potential, two commutating devices angularly displaced to correspond with the angular displacement of two of the phases and connected with each supply conductor by branch connections one for current flow in each direction through said supply conductor, conductors connected with said commutating devices for receiving unidirectional current therefrom, said commutating devices being operative for current waves of but one and the same sign for the several phases, oppositely connected current valves in the branch connections from each supply conductor, whereby when current flows through a supply conductor and the current valve in one of its branch connections the current valve in its other branch connection prevents impressing the potential of said supply conductor upon the commutating device connected with said other branch connection, and a delta connected source of polyphase current connected with said supply conductors.

10. In a system for rectifying high tension alternating current, the combination of a plurality of polyphase supply conductors for delivering alternating current at high potential, two communicating devices angularly displaced to correspond with the angular displacement of two of the phases and connected with each supply conductor by branch connections one for current flow in each direction through said supply conductor, conductors connected with said commutating devices for receiving unidirectional current therefrom, said commutating devices being operative for current waves of but one and the same sign for the several phases, oppositely connected current valves in the branch connections from each supply conductor, whereby when current flows through a supply conductor and the current valve in one of its branch connections the current valve in its other branch connection prevents impressing the potential of said supply conductor upon the commutating device connected with said other branch connection, and a polyphase step up transformer having delta connected secondary windings connected with said supply conductors.

11. In a system for rectifying high tension alternating current, the combination of a plurality of polyphase supply conductors for delivering alternating current at high potential, two commutating devices angularly displaced to correspond with the angular displacement of two of the phases and connected with each supply conductor by branch connections one for current flow in each direction through said supply conductor, conductors connected with said commutating devices for receiving unidirectional current therefrom, said commutating devices being operative for current waves of but one and the same sign for the several phases, and oppositely connected kenetrons in the branch connections from each supply conductor, whereby when current flows through a supply conductor and the kenetron in one of its branch connections the kenetron in its other branch connection by preventing current flow through said other branch connection prevents impressing the potential of said supply conductor upon the commutating device connected with said other branch connection.

12. In a system for rectifying high tension alternating current the combination of a plurality of polyphase supply conductors for delivering alternating current at high potential, two communicating devices angularly displaced to correspond with the angular displacement of two of the phases and connected with each supply conductor by

branch connections one for current flow in each direction through said supply conductor, conductors connected with said commutating devices for receiving unidirectional current therefrom, said commutating devices being operative for current waves of but one and the same sign for the several phases, oppositely connected kenetrons in the branch connections from each supply conductor, whereby when current flows through a supply conductor and the kenetron in one of its branch connections the kenetron in its other branch connection prevents impressing the potential of said supply conductor upon the commutating device connected with said other branch connection, and a delta connected source of polyphase current connected with said supply conductors.

13. In a system for rectifying high tension alternating current, the combination of a plurality of polyphase supply conductors for delivering alternating current at high potential, two commutating devices angularly displaced to correspond with the angular displacement of two of the phases and connected with each supply conductor by branch connections one for current flow in each direction through said supply conductor, conductors connected with said commutating devices for receiving unidirectional current therefrom, said commutating devices being operative for current waves of but one and the same sign for the several phases, oppositely connected kenetrons in the branch connections from each supply conductor, whereby when current flows through a supply conductor and the kenetron in one of its branch connections the kenetron in its other branch connection prevents impressing the potential of said supply conductor upon the commutating device connected with said other branch connection, and a polyphase step up transformer having delta connected secondary windings connected with said supply conductors.

In witness whereof, I hereunto subscribe my name this 17th day of January, A. D. 1916.

JOHN H. LENDI.