

Aug. 10, 1943.

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2,326,237

RECTIFYING APPARATUS FOR ELECTRICAL PRECIPITATORS

Filed Jan. 12, 1942

2 Sheets-Sheet 1

Fig. 1.

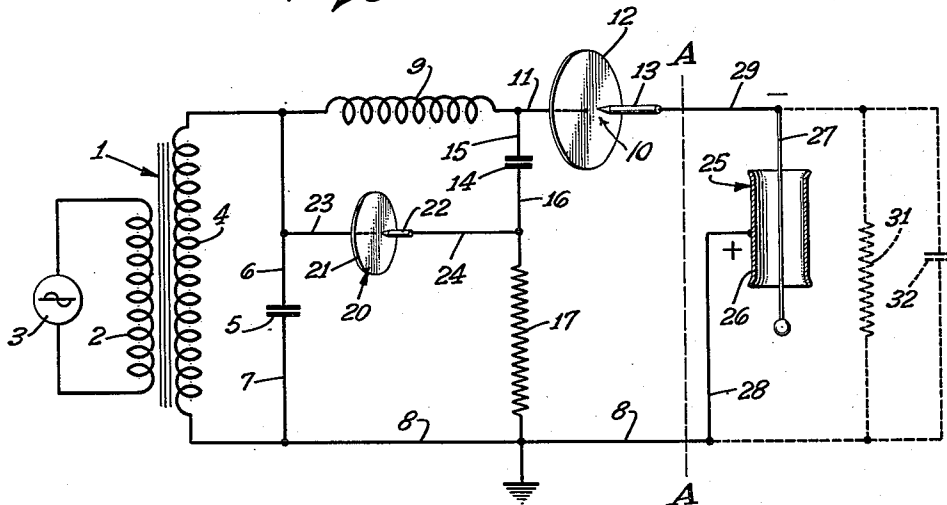
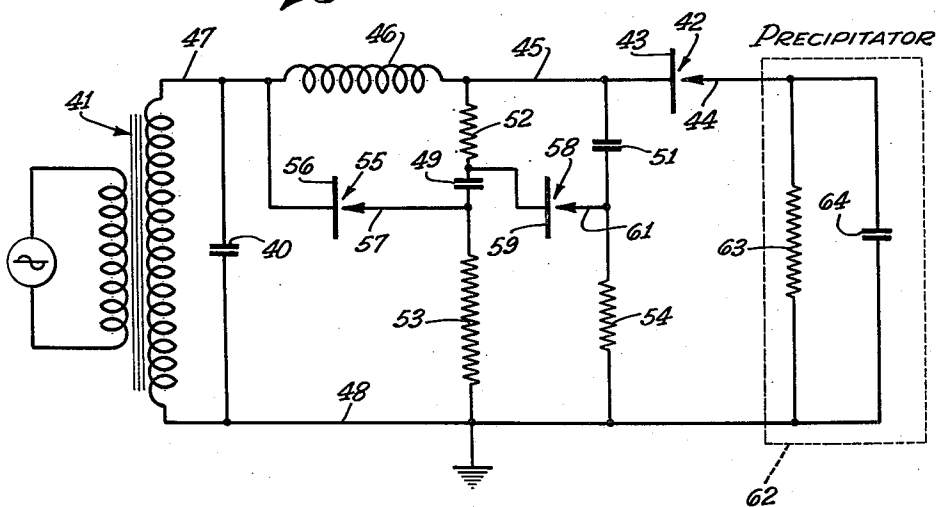


Fig. 2.



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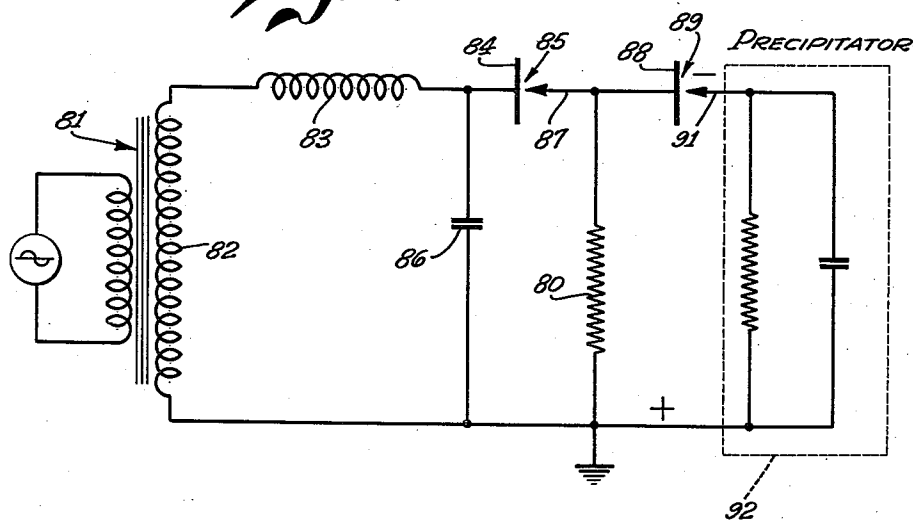
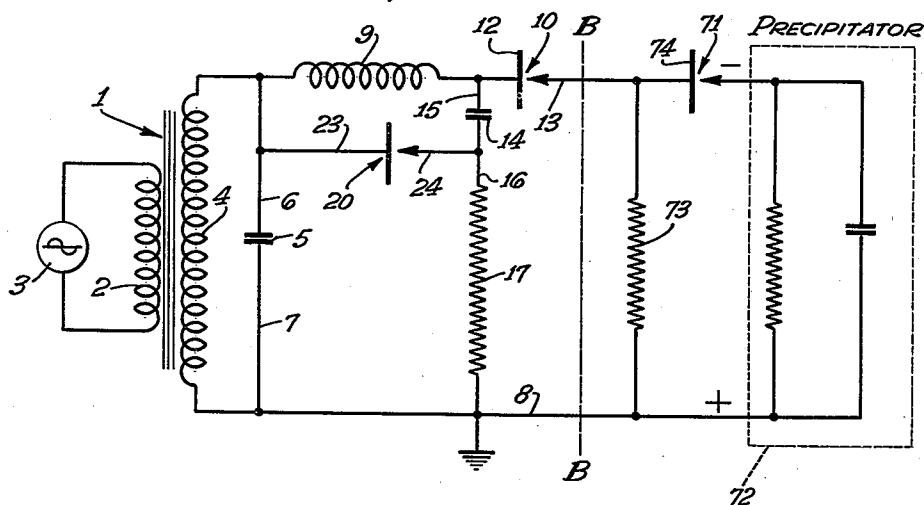
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RECTIFYING APPARATUS FOR ELECTRICAL PRECIPITATORS

Filed Jan. 12, 1942

2 Sheets-Sheet 2



BY

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UNITED STATES PATENT OFFICE

2,326,237

RECTIFYING APPARATUS FOR ELECTRICAL
PRECIPITATORS

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Application January 12, 1942, Serial No. 426,503

20 Claims. (Cl. 183-7)

This invention relates to electrical rectifying devices for supplying unidirectional current at high voltage to an electrical precipitator and more particularly to rectifying apparatus utilizing for rectification a spark gap defined by a pair of asymmetric electrode members such as a point and a plane.

It has long been recognized that there is a distinct polarity effect in the flashover between asymmetric electrodes as between a point and a plane. In general, with a gap between a point and a plane, the gap will flash over at a lower potential when the pointed electrode is positive than when it is negative. As a broad rule, this polarity effect is found to increase with the spacing between the electrodes and also with the difference in potential. As a basis for discussion, it may be stated that in the operating ranges of interest herein, approximately twice the voltage is required to break down the gap when the point is negative as when it is positive.

An electrical precipitator does not, in general, represent a purely resistance load since it comprises spaced insulated complementary electrodes whereby it has appreciable electrical capacity. As a basis for this discussion, an electrical precipitator may be represented by a capacity in parallel with a resistance. In view of this capacity, the average commercial embodiment of an electrical precipitator supplied with rectified current maintains a residual charge establishing between its electrodes an effective inverse or back voltage having a value of around 93% of the maximum applied voltage. In other words, after the precipitator or treater is charged, it has an inverse or back voltage of around 93% of the maximum applied voltage.

As pointed out previously, a point to plane gap will break down or conduct when the point is positive at about one-half the voltage required when the point is negative. But since the back voltage from the precipitator is substantially or nearly equal to the peak supply voltage, the point actually becomes only slightly positive with respect to the plate, and hence it is difficult to get conduction across the gap except for small spacings. This reduces the rectifying characteristics of the gap. At the same time, the inverse voltage across the gap is practically double the impressed voltage when the point is negative, whereby there is a decided tendency for the gap to arc over at such time. In fact, it is a practical impossibility to prevent the gap from breaking down on each half cycle and the gap is therefore substantially useless as a rectifier.

It is the object of this invention to provide a rectifying device employing gap means between asymmetric electrodes for supplying rectified current at high voltage to an electrical precipitator or treater.

A more specific object relating to one form of the invention is to provide for a precipitator, a rectifier circuit employing a pair of asymmetric gap means, one of the gap means supplying the current to the precipitator and the other supplying an unidirectional impulse voltage to said one gap means to initiate the sparking thereof.

At the present time, the high voltage supplied to a precipitator is commonly rectified with a rotating synchronous commutator, or with a vacuum tube. Synchronous rectifiers are generally expensive and use moving parts which are expensive to replace when worn. Also, due to their bulk they are not economical for small power supplies. The vacuum tube rectifier requires an expensive, short lived tube which is not particularly suitable for hard usage as in locations subject to hard mechanical shock or vibration.

It is, therefore, an important object of this invention to provide a rugged, inexpensive rectifying device with no moving parts, for supplying current to an electrical precipitator.

A further object of the invention is to provide a rectifying device which is suited for supplying power to both large and small precipitators and utilizes asymmetric gap means and no moving parts.

Further objects and advantages of the invention will either be specifically brought out in the ensuing description or will be apparent therefrom.

My invention will be better understood from the following description taken in combination with the accompanying drawings, and referring thereto:

Fig. 1 is a wiring diagram showing a rectifying apparatus according to my invention connected to an electrical precipitator, the precipitator being indicated more or less diagrammatically and the asymmetric gaps being shown in perspective as pointed and plane electrodes;

Fig. 2 is a wiring diagram of a modification of Fig. 1 showing an arrangement for obtaining an increased impulse voltage; and

Figs. 3 and 4 are wiring diagrams of modified forms of the apparatus.

Referring to Fig. 1, my apparatus is shown as comprising a high-voltage transformer 1 having its primary 2 connected to a suitable alternating current source 3. The transformer secondary 4 is adapted to produce a high alternating voltage of from 25 thousand to 100 thousand volts, for example, suitable when rectified to be impressed by means of the presently-described power circuit across or between the complementary electrodes of a precipitator.

A condenser 5 is connected by means of conductors 6 and 7 across the secondary 4, the conductor 7 being connected to ground through a conductor 8. A circuit element such as an inductance 9 is shown connected between the con-

ductor 6 and a conductor 11 which is connected to plate 12 of a point to plate gap 10, the point being indicated at 13. The inductance 9 preferably has a surge impedance which is high as compared to its low frequency, say 60 cycle, impedance.

It is to be understood that although I have shown only a point to plate gap, I may employ equivalent asymmetric gap means. The simplest and probably most effective is the gap means shown, i. e. the point-to-plate or plane gap means. The terms "point," "plane," and "plate" are of course relative. A point, as used herein, is a surface having a relatively small radius of curvature, while a plane, as used herein, is a relatively extended surface, as compared to the effective surface of the point, having a relatively large and preferably infinite radius of curvature. Since all bodies must have thickness, the most economical plane surface is afforded by a thin plate.

The asymmetric gap means 10 thus comprises a circular sheet metal plate 12 and a pointed metal rod 13, the rod extending substantially perpendicular to the central portion of the plate with the pointed end of the rod nearest the plate and spaced therefrom by an air gap of suitable dimension.

A condenser 14 is shown connected by a conductor 15 to the conductor 11 and by a conductor 16 to one end of high impedance circuit element such as a resistor 17 which has its other end connected to the conductor 8.

The value of the resistance varies with the operating voltage and it is difficult to give any fixed values. In general operation can be obtained between a range starting at several thousands of ohms and extending to a megohm or more.

A second and separate gap means is indicated at 20 and may be constructed in substantially the same manner as the gap means 10. The gap means 20 comprises a plate 21 and point 22 spaced therefrom by an air gap. The plate 21 is connected by means of a conductor 23 to the conductor 6 and the point 22 is connected by means of a conductor 24 to the conductor 16.

The load is shown as comprising an electrical precipitator 25 indicated diagrammatically as comprising spaced complementary electrodes 26 and 27 which are insulated from one another. For purposes of illustration, the electrode 26 is shown as a cylindrical collecting electrode and the electrode 27 is shown as a fine wire charging and precipitating electrode extending centrally of the electrode 26. The electrode 26 is connected to the conductor 8 through a conductor 28, while the electrode 27 is connected to the point 13 by a conductor 29. The equivalent electrical circuit of the precipitator 25 is indicated in dotted lines and is shown as comprising a relatively high resistance 31 and a relatively low capacity 32 connected in parallel between the conductors 8 and 29.

In order to understand the operation of the circuit we may assume that it has been operating for a sufficient time to bring the precipitator 25 to its average operating potential. In other words the condenser 32 is charged to a potential of around 93% of the peak potential of the transformer secondary 4. With the circuit shown, the point 13 is maintained by the condenser 32 at negative potential of around 93% of the transformer secondary voltage. Thus when the plate 12 is at negative peak volt-

age the voltage differential across the gap 10 is only a small percentage of the peak voltage, neglecting at the present time the gap 20 and its function. To make the gap 10 conduct under these conditions requires a very close spacing. When the transformer secondary reaches a positive peak and places the positive peak potential on plate 12, the inverse voltage across gap 10 is nearly double the transformer voltage. With the short spacing of gap 10 just mentioned, the gap will conduct or fire. Thus, it is ineffective as a rectifier.

From the discussion above it should be obvious that the minimum spacing of the plate 12 and point 13 is determined by the inverse voltage and should be sufficiently great to prevent conduction when the plate is at its positive peak. It follows from the above discussion that this spacing is too great to allow the gap to fire when the plate is at its negative peak.

The purpose of the gap 20 is to place an impulse voltage of the correct polarity and magnitude on the plate 12 during the negative half cycle thereof and preferably just prior to the peak negative voltage supplied thereto by the transformer secondary.

The condenser 14 is connected in series with the resistance 17 across the transformer secondary 4. The condenser 14 is charged by the transformer secondary 4 through the resistance 17. The condenser 5 is charged in parallel with the condenser 14. Considering the half cycle when the plate 12 is negative, the charging of the condenser 14 places a positive potential on the point 22. The plate 21 is negative at this time because it is connected to the other side of the condenser through the inductance 9 and also to end of the transformer secondary which is negative. The spacing of the gap 20 is such that the gap will fire at a time just prior to the time the transformer places negative peak potential on the plate 12. The spacing of the gap is great enough to prevent firing on the opposite half cycle. It will be noted that there is little or no inverse voltage on said opposite half cycle whereby the gap 20 will perform a rectifying function.

When the gap 20 fires as pointed out above, the condensers 5 and 14 are effectively placed in series with the gap 10. Just prior to the firing of gap 20, conductor 24 was substantially at ground potential, being different therefrom by the voltage drop through resistor 17 produced by the charging current of condenser 14. When the gap 20 fires the conductor 24 is substantially instantaneously brought to the high negative potential of conductor 6, negative charge having flowed from the plate across the gap to said conductor 24. This negative charge flows to condenser 14, holding a positive charge to the other side thereof, and releasing a negative charge to flow to plate 12 of main gap 10. The high surge impedances of resistor 17 and inductance 9 prevent instant dissipation of these charges. Thus the negative potential of plate 12 is momentarily increased, by an amount substantially equal to the transformer voltage, and at a time near or coincidental with the peak of the negative cycle of the transformer voltage. This increased negative potential of plate 12 is sufficient to break down the gap 10, and flashover is thus initiated by negative charge derived from condenser 14. Gap 10 being broken down, the condenser 5, charged by transformer 4, then acts as a source of charge for the sudden demands of the flashovers at gaps 20 and 10, the two condensers 5 and

14 acting in series with one another to sustain the flashovers at the two gaps. Before gap 10 again becomes non-conducting, the condenser 5 discharges across gap 10 via impedance 9, to deliver charge to the precipitator. This whole operation occurs in a small fraction of the negative half-cycle, and upon its conclusion, gap 10 resumes its property of isolating or insulating the precipitator from the power source, leaving the high-tension electrode 27 of the precipitator with a negative charge.

On the succeeding or positive half-cycle of the power current, gaps 10 and 20 both have their points at negative potential, and do not discharge, so that no connection to the precipitator takes place.

With correctly proportioned circuit constants and gap spacing the gap 20 breaks down and delivers a high voltage unidirectional impulse of the correct polarity to the plate 12 every other half cycle. In general the gap 10 will either break down every other half cycle when the impulse is delivered or will break down at multiples of that time depending on precipitator load conditions, gap spacing, and other variables which are difficult to evaluate.

In Fig. 2 I have illustrated a circuit which produces a greater impulse voltage and is patterned after the circuit of Fig. 1. The high voltage transformer is indicated at 41. A gap means is indicated at 42 and comprises spaced asymmetric electrodes such as a plate 43 and a point 44. The plate is connected to one side of the secondary of transformer 41 by conductor 45, inductance 46 and conductor 47. The other side of the transformer secondary is connected to ground by a conductor 48. A condenser 40 is connected between conductors 47 and 48. Two condensers 49 and 51 are shown connected in parallel branch circuits between the conductors 45 and 48. The condenser 49 is connected in series between resistors 52 and 53. The condenser 51 is in series with a resistor 54 connected to the conductor 48.

An asymmetric gap means is shown at 55 and comprises a plate electrode 56 connected to the conductor 47 and a pointed electrode 57 connected between the condenser 49 and resistor 53. Another asymmetric gap means is indicated at 58 and comprises a plate 59 connected in the circuit between the condenser 49 and resistor 52, and a point 61 connected in the circuit between the condenser 51 and resistor 54. If desired, the gap means 58 may be symmetrical, comprising spaced spherical electrodes, for example. The precipitator is indicated by the dotted rectangle 62 and electric circuit defined by the complementary electrodes thereof is represented by the resistor 63 and condenser 64 connected in parallel between the conductor 48 and point 44 of the main gap 42.

The operation of this form of my invention is quite comparable to that illustrated in Fig. 1. The gap 42 is spaced so as not to fire or spark on the positive peaks of voltage on the plate 43. When the precipitator is charged, such spacing will result in no sparking on either half cycle. The gaps 55 and 58 are set to fire when their plates are above a predetermined negative potential with respect to their associated points, and not to fire when the plates are positive with respect to the points.

During the half cycle the conductor 47 is negative and prior to the peak negative voltage thereon, the condensers 40, 49 and 51 charge in paral-

lel across the transformer secondary. When the charge in these condensers is sufficient the voltage across the gaps 55 and 58 is sufficient to break them down and cause them to spark. This effectively places the charged condensers 40, 49 and 58 in series between plate 43 and conductor 48. A high voltage impulse is therefore produced across the gap 42 causing it to break down and deliver current to the precipitator 62. The high surge impedance of the inductance 46 and resistors 52, 53 and 54, prevents discharge of the condensers therethrough before the gap 42 has a chance to break down and conduct. Conduction across gap 42 having been initiated, however, condenser 40 then discharges through inductance 46 to deliver energy across gap 42 and to the precipitator.

The portion of the circuit to the left of line A—A in Fig. 1 is identical with the portion of the circuit in Fig. 3 to the left of line B—B and the same reference numerals are used on the parts thereof. In Fig. 3 an additional gap 71 is shown connected in series with the gap 10 and precipitator 72 comprising the load. A resistor 73 is connected in parallel to the precipitator, one end being connected to the point 13 and plate 74 of gap 71, the other end being connected to grounded conductor 8.

It is well known that a series of gaps may be substituted for a single gap. On that premise the gap means of Fig. 3, comprising point to plate gaps 10 and 71 in series, is equivalent to the gap means 10 of Fig. 1. Thus the action in Fig. 3 is substantially the same as that described in connection with Fig. 1. When the voltage on plate 12 approaches the negative peak, gap 20 fires and places an impulse voltage on the gap means comprising the gaps 10 and 71 in series causing them to fire and supply current to the precipitator 72.

Each of the gaps 10 and 71 is of such dimensions as to prevent firing when their respective plates are positive. The resistor 73 acts as a return circuit for the silent discharge across the gap means during the non-conducting part of the cycle. This resistor should be small enough to prevent charge accumulation during the non-conducting part of the cycle and yet large enough to prevent bypassing a substantial portion of the current around the gap means 71 during the conducting part of the cycle.

In the circuits illustrated in Figs. 1-3 a plurality of condensers are charged in parallel and then discharged in series in order to impress a high voltage across the gap means isolating the precipitator from the transformer and cause a discharge across this gap means. This discharge need only be sufficient to produce ionization in said gap means, the gap means 10 and 42 of Figs. 1 and 2, for example. For purposes of description the gap means 10 and 42 may be considered the main gap means.

After the main gap means is ionized it will conduct at much lower voltage, as at peak transformer voltage. However, the transformer is incapable of supplying a high current quickly enough to satisfy the requirements of the precipitator. The condensers 5 and 40 are adapted to supply high current to the precipitator after the main gap means is ionized. The condensers 5 and 40 are connected directly across the transformer terminals and may be called the main condensers. The main condensers are capable of delivering considerable energy across main gap 10 in a short period, being connected in a short time

constant circuit comprising the relatively low inductance elements 9 and 46.

Thus, it should be clear that the discharge from the condensers in series through the main gap means may be entirely insufficient to supply the charging current to the precipitator, being only sufficient to maintain the main gap means ionized until current can be fed through the inductances 9 and 46 from the main condensers. Therefore, the capacities of the condensers other than the main condensers may be relatively low as compared to the main condensers; for example, one-tenth or less of the capacity of the main condensers. Since the series discharge may be insufficient to supply the required charging current to the precipitator, it follows that all the condensers except the main condensers may have capacities insufficient to supply the required charging current to the precipitator.

A modified circuit arrangement is illustrated in Fig. 4 embodying a combination of the principles described in connection with Figs. 1 and 3. Transformer 81 is shown with its secondary 82 having one end connected through a choke 83 to plate 84 of an asymmetric gap means 85. The other end of the transformer secondary is connected to ground and a condenser 86 is shown connected between the plate 84 and ground. Point electrode 87 of the gap means 85 is connected through resistor 80 to ground and directly to plate 88 of an asymmetric main gap means 89 having a point electrode 91 connected to the high potential side of a precipitator indicated by the dotted rectangle 92. The low potential side of the precipitator is connected to ground.

In order to clarify the description it may be assumed that the precipitator is charged, in which case there is a negative potential on the electrode 91 equal to the normal operating potential of the precipitator. The spacing of the gap means 85 is sufficient to prevent discharge thereacross when the transformer secondary places the positive peak potential on the plate 84. The spacing of the gap means 89 is also such as to prevent discharge thereacross when the plate 84 is at its maximum positive potential. The spacing of the gap means 85 is also sufficiently short so that it will fire shortly before the negative peak potential from the transformer secondary 82 is applied to the plate 84, at which time the condenser 86 is substantially completely charged. When the gap means 85 discharges or fires the gap means 89 will also fire and current will be delivered thereacross to the precipitator 92. The spacing of the gap 89 is sufficiently short to cause firing thereof at that time. The surge impedance of the inductance 83 and resistance 80 is sufficient to insure application of the surge across the gap for a sufficient time to insure conduction therefor.

During the non-conducting half cycle when positive voltage from the transformer secondary 82 is applied to the plate 84 there will be substantially no inverse voltage across the gap means 85 in view of the fact that the resistor 80 maintains the point 87 substantially at ground potential. During this time the silent discharge between the point 91 and plate 88 is carried to ground through the resistor 80.

While the circuit illustrated in Fig. 4 is not quite as satisfactory for operation with precipitators having high inverse voltages, it is somewhat more economical in that only a single condenser is used.

Although I have only shown arrangements for

imparting a high negative voltage with respect to ground on the electrode of a precipitator it should be obvious that if a high positive voltage with respect to ground is discharged such voltage may be obtained by changing the ground connection from the positive to the negative side of the circuit. Obviously, under certain circumstances it may be desirable to omit the ground connection altogether. Also, the polarity may be changed by reversing the connections to the asymmetric gap means.

I have illustrated my invention as applied to a single-stage precipitator. Obviously, my invention may be employed for energizing the charging and/or precipitating section of a two-stage precipitator.

I am aware that circuits employing the impulse produced by the discharge of a condenser, or a plurality thereof in series, are old. However, I am not claiming such circuits broadly, and am limiting myself to circuits producing only a unidirectional impulse across asymmetric gap means.

My circuits for supplying high voltage rectified current to electrical precipitators are obviously subject to considerable modification; hence, I do not choose to be limited to the examples described herein, but rather to the scope of the appended claims.

I claim:

1. Rectifying means for impressing a rectified high potential between the complementary electrodes of an electrical precipitator or the like, comprising: an alternating current source; a main asymmetric gap means normally isolating said source from at least one of said complementary electrodes; and impulse means including another gap means for deriving high potential unidirectional voltage impulses from said source and applying said impulses to said main gap means to cause said main gap means to conduct.

2. Rectifying means for impressing a rectified high potential between the complementary electrodes of an electrical precipitator or the like, comprising: a high potential alternating current source; a normally non-conductive main asymmetric gap means in circuit between said source and complementary electrodes; a plurality of condensers connected in parallel across said source and adapted to be charged by said source; and auxiliary asymmetric gap means arranged to be energized from said source and to connect said condensers in series with said main gap means upon conduction and thereby produce a discharge across said main gap means.

3. Rectifying means for impressing a rectified high potential between the complementary electrodes of an electrical precipitator or the like, comprising: an electric circuit for energizing said electrodes comprising a source of alternating current at relatively high potential, said source having two terminals; a first spark gap; an inductance; one of the electrodes being connected to one of the terminals in series with the gap and inductance, the gap being between said one electrode and the inductance; the other electrode being connected to the other of said terminals; a plurality of condensers connected in parallel across the terminals between the gap and the terminals; and asymmetric gap means arranged to discharge said condensers in series through said first-named gap.

4. The invention set forth in claim 3, one of said condensers being connected to the end of the inductance connected to said one terminal

and having a capacity at least ten times as great as the capacity of another of said condensers.

5. The invention set forth in claim 3, one of said condensers having insufficient capacity to effectively energize said electrodes.

6. Rectifying means for impressing a rectified high potential between the complementary electrodes of an electrical precipitator or the like, comprising: an electric circuit for energizing said electrodes comprising a source of alternating current at relatively high potential, said source having two terminals; first gap means connected between one of the electrodes and one of the terminals; a circuit element having a high surge impedance connected between said first gap means and said one terminal; conductor means connecting the other terminal to the other electrode; a condenser connected between said conductor means and a point between said first gap means and said circuit element; and circuit means arranged to provide a series discharge path through said condenser between said conductor means and said point, said circuit means including asymmetric gap means comprising electrodes so spaced and arranged as conduct only when a given voltage difference in only one direction exists therebetween, said circuit means further including a circuit element having a high surge impedance and connected between said asymmetric gap means and said conductor means.

7. Rectifying means for impressing a rectified high potential between the complementary electrodes of an electrical precipitator or the like, comprising: a high potential alternating current source; first gap means; an inductance having a relatively low impedance at 60 cycles; first conductor means connecting said gap means and inductance in series between one side of the source and one electrode; second conductor means connecting the other side of the source with the other electrode; a first condenser having one side connected to the second conductor means and the other side connected to the first conductor means between said one side of the source and said inductance; a high resistance element; a second condenser having one side connected to the first conductor means between the inductance and the first gap means and the other side connected through said high resistance to the second conductor means; and asymmetric gap means connected between said other side of said first condenser and said other side of said second condenser, said first gap means being so constructed and arranged as to spark only when said second gap means sparks, said second gap means being so constructed and arranged as to spark when the voltage thereacross exceeds a given amount in one direction only.

8. The invention set forth in claim 7, said first gap means comprising a plurality of gaps in series; and a high resistance connected between two of said plurality of gaps in series and said second conductor means.

9. Rectifying means for impressing a rectified high potential between the complementary electrodes of an electrical precipitator or the like, comprising: a high potential alternating current source; first gap means; a circuit element having a sixty cycle impedance which is low as compared to its surge impedance; first conductor means connecting one side of said element to one side of the source; second conductor means connecting the other side of the element to one side of the gap means, the other side of said gap

means being connected to one terminal of the precipitator; third conductor means connecting the other side of the source with the other electrode of the precipitators; a first condenser connected between said first and third conductor means; a second circuit element having a high surge impedance; a third circuit element having a high surge impedance; a second condenser, said condenser having one side connected to one side of said second circuit element and the other side connected to one side of said third circuit element, the respective other sides of said second and third elements being connected to the second and third conductor means respectively; first asymmetric gap means connected between the first conductor means and said other side of said second condenser; a fourth circuit element having a high surge impedance and having one side connected to said third conductor means; a third condenser having one side connected to said second conductor means and the other side connected to the other side of said fourth circuit element; and second asymmetric gap means connected between said one side of said second condenser and said other side of said third condenser, said first gap means being so constructed and arranged as to spark only when said asymmetric gap means sparks, each of said asymmetric gap means being so constructed and arranged as to spark when the voltage thereacross exceeds a given amount in one direction only.

10. Rectifying means for impressing a rectified high potential between the complementary electrodes of an electrical precipitator or the like, comprising: a high potential alternating current source connected between said electrodes; first gap means interposed between one side of the source and one electrode whereby to prevent conduction between said electrode and the source at normal operating voltages of the source; and impulse circuit means interposed between the gap means and the source and including condenser means connected to be charged by the source, asymmetric gap means arranged to discharge the condenser means in one direction only to produce a unidirectional impulse sufficient to break down the first gap means, and circuit elements having a high surge impedance to prevent dissipation of the impulse before the first gap means breaks down.

11. Rectifying means for impressing a rectified high potential between the complementary electrodes of an electrical precipitator or the like, comprising a high potential alternating current source; a plurality of condensers connected in parallel across said source, one of said condensers having at least ten times the capacity of another of said condensers; gap means arranged to connect said condensers in series upon conduction of said gap means and thereby produce an impulse voltage, said gap means including asymmetric gap means whereby said condensers are connected in series only when charged in one direction; and additional gap means arranged to discharge said impulse thereacross and thus ionize said gap means whereby said one condenser may discharge through said gap means and charge the precipitator.

12. The invention set forth in claim 11, said other condenser having insufficient capacity to satisfy the charging requirements of the precipitator.

13. Rectifying means for impressing a rectified high potential between the complementary electrodes of an electrical precipitator or the like,

comprising a series circuit including a main condenser, first asymmetric gap means and the precipitator; a high potential alternating current source connected to charge the condenser; another condenser arranged to be charged in parallel with said main condenser and having a capacity insufficient to charge the precipitator; and a second asymmetric gap means arranged to discharge said condensers in series through the first gap means.

14. The invention set forth in claim 13, the capacity of the main condenser being at least ten times as great as the capacity of the other condenser.

15. Rectifying means for impressing a rectified high potential between the complementary electrodes of an electrical precipitator or the like, comprising: a high-potential alternating current source, a circuit connecting said alternating current source across said complementary electrodes, normally non-conductive asymmetric gap means in series in said circuit, and voltage impulse means adapted to derive unidirectional voltage impulses from said source during alternate half-cycles of the alternating current supplied by said source and to impress said impulses on said asymmetric gap means to increase the voltage drop thereacross sufficiently to render said gap means temporarily conductive.

16. Rectifying means for impressing a rectified high potential between the complementary electrodes of an electrical precipitator or the like, comprising: a high-potential alternating current source, a circuit connecting said alternating current source across said complementary electrodes, normally non-conductive asymmetric gap means in series in said circuit, a plurality of condensers connected in parallel across said source, auxiliary asymmetric gap means having a voltage impressed thereacross derived from said source and arranged upon conduction to connect said condensers in series with said first-mentioned asymmetric gap means and thereby convey a uni-directional voltage impulse to said first mentioned gap means whereby said first-mentioned gap means becomes conductive.

17. Rectifying means for impressing a rectified high potential between the complementary electrodes of an electrical precipitator or the like, comprising: a high-potential alternating current source, a circuit having two sides connecting said alternating current source across said complementary electrodes, normally non-conductive asymmetric gap means in one side of said circuit, a plurality of condensers connected in parallel across said source, and auxiliary asymmetric gap means having a voltage impressed thereacross derived from said source and arranged upon conduction to connect said condensers in series with said first-mentioned asymmetric gap means and thereby impress a unidirectional voltage impulse on said first mentioned gap means whereby said first-mentioned gap means becomes conductive, at least one of said condensers being arranged to discharge thereafter across said first-mentioned gap means via said one side of said circuit.

18. Rectifying means for impressing a rectified high potential between the complementary electrodes of an electrical precipitator or the like having an electrical capacitance, comprising: a high-potential alternating current source, a power circuit connecting said source across said complementary electrodes, gap means in said circuit embodying an electrode of relatively small radius

of curvature connected by a lead of said circuit to one of said complementary electrodes and an electrode of relatively extended surface connected by a lead of said circuit to one side of said alternating current source, said gap means being so spaced as to be non-conductive under the differential of voltage drops thereacross due to the alternating current source voltage and the residual back voltage of the precipitator, and an impulse circuit energized from said source and adapted to deliver negative charge to said extended surface electrode during negative half-cycles of the alternating current in sufficient quantity to raise the voltage drop across the gap means to the point of flashover.

19. Rectifying means for impressing a rectified high potential between the complementary electrodes of an electrical precipitator or the like having an electrical capacitance, comprising: a high-potential alternating current source; a power circuit connecting said source across said complementary electrodes; gap means in said circuit embodying an electrode of relatively small radius of curvature connected by a lead of said circuit to one of said complementary electrodes and an electrode of relatively extended surface connected by a lead of said circuit to one side of said alternating current source, said gap means being so spaced as to be non-conductive under the differential of voltage drops thereacross due to the alternating current source voltage and the residual back voltage of the precipitator; impulse circuiting including a condenser charged by said alternating current source and connected at one side to said extended surface electrode, auxiliary asymmetric gap means, means impressing a voltage derived from said alternating current source across said auxiliary gap means, said gap means being so arranged and spaced as to conduct during the half-cycles of the alternating current when the extended surface electrode of the first-mentioned gap means is negative, and means so connecting said auxiliary asymmetric gap means to the other side of said condenser as to deliver negative charge thereto during conduction, whereby said condenser releases negative charge to said extended surface electrode to initiate flashover of the first-mentioned gap means; and a condenser connected in parallel across said power circuit between said alternating current source and said first-mentioned gap means and adapted to discharge across said first-mentioned gap means upon flashover thereacross initiated by said impulse circuiting.

20. Rectifying means for impressing a rectified high potential between the complementary electrodes of an electrical precipitator or the like, comprising: a high-potential alternating current source having two terminals, conductor means connecting said terminals across said complementary electrodes, normally non-conductive asymmetric gap means in series in one of said conductor means, flashover initiation means connected into said one conductor means at a point between said gap means and the corresponding terminal of said source, and means energizing said flashover initiation means from said source, said flashover initiation means being adapted during alternate half-cycles of the alternating current to conduct a momentary flow of charge in such a direction with reference to said gap means as to increase momentarily the effective voltage drop thereacross.