Nov. 18, 1958 H. A. WINTERMUTE 2,860,723

ELECTRICAL PRECIPITATORS AND ENERGIZING CIRCUIT THEREFOR

Filed Aug. 23, 1954 4 Sheets-Sheet 1

Fig 1.

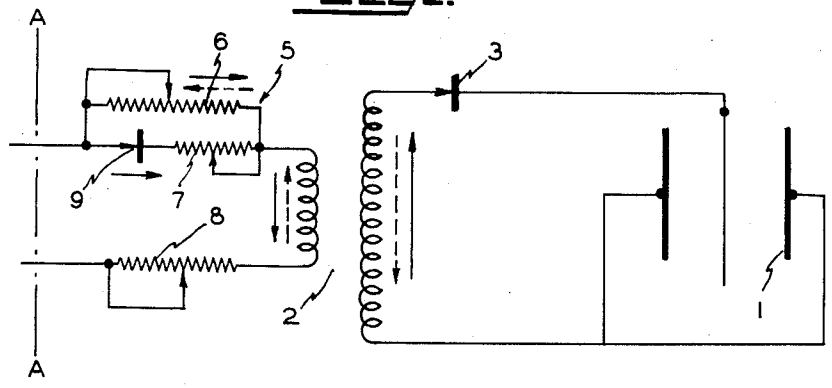
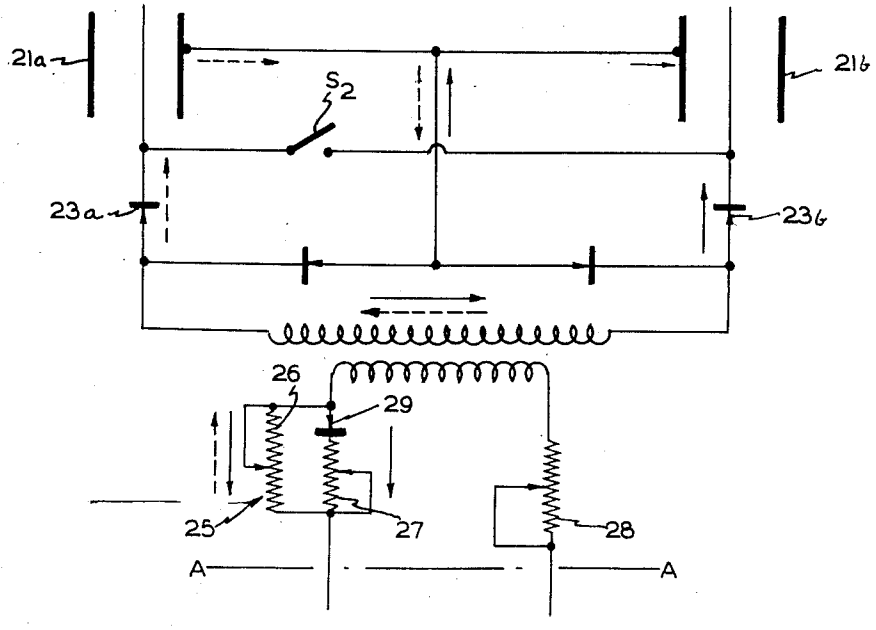


Fig 2.



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Filed Aug. 23, 1954 4 Sheets-Sheet 2

Fig 3.

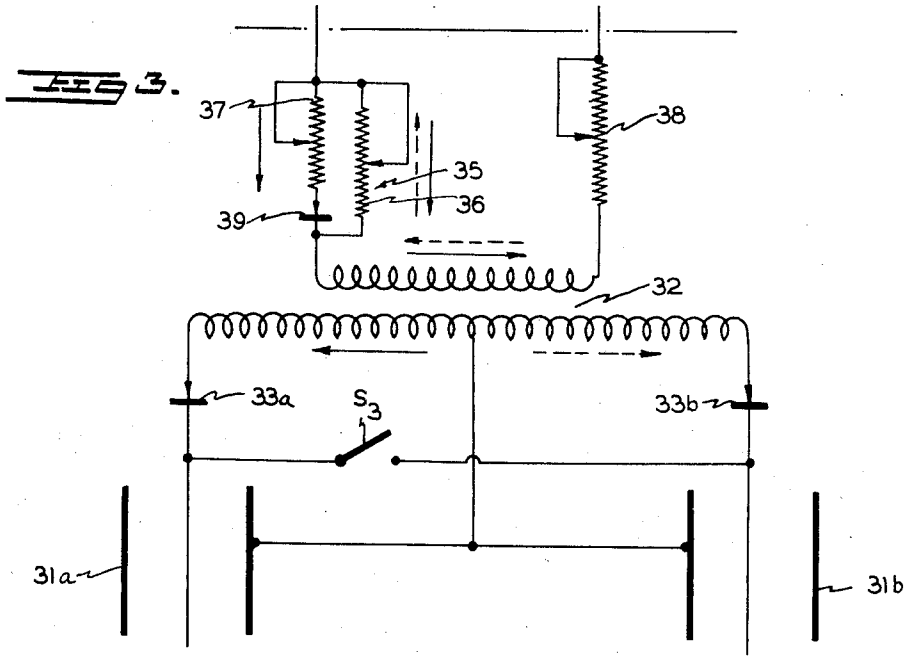
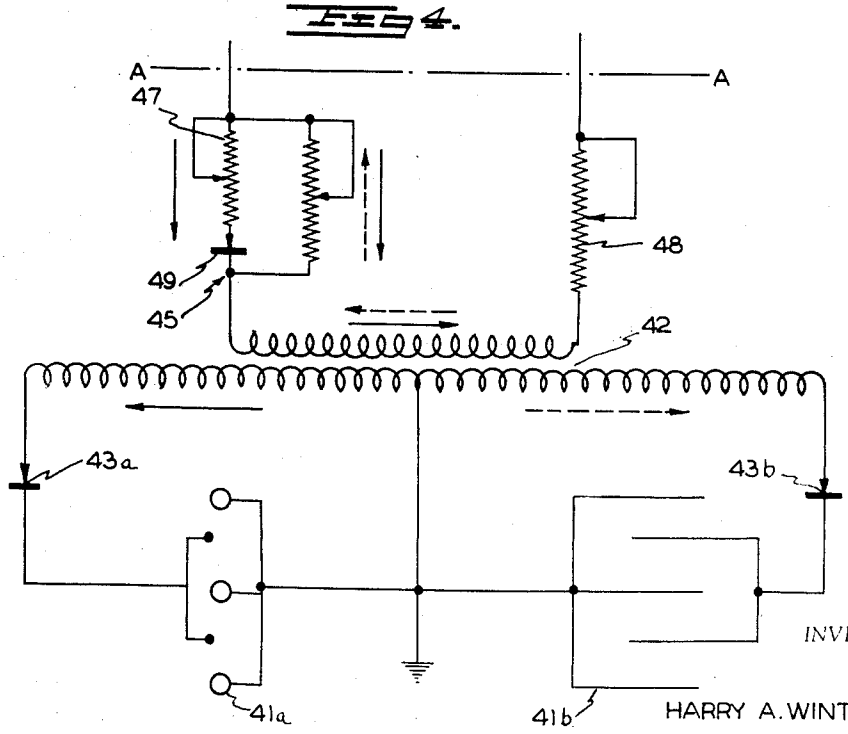


Fig 4.



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ELECTRICAL PRECIPITATORS AND ENERGIZING CIRCUIT THEREFOR

Filed Aug. 23, 1954 4 Sheets-Sheet 3

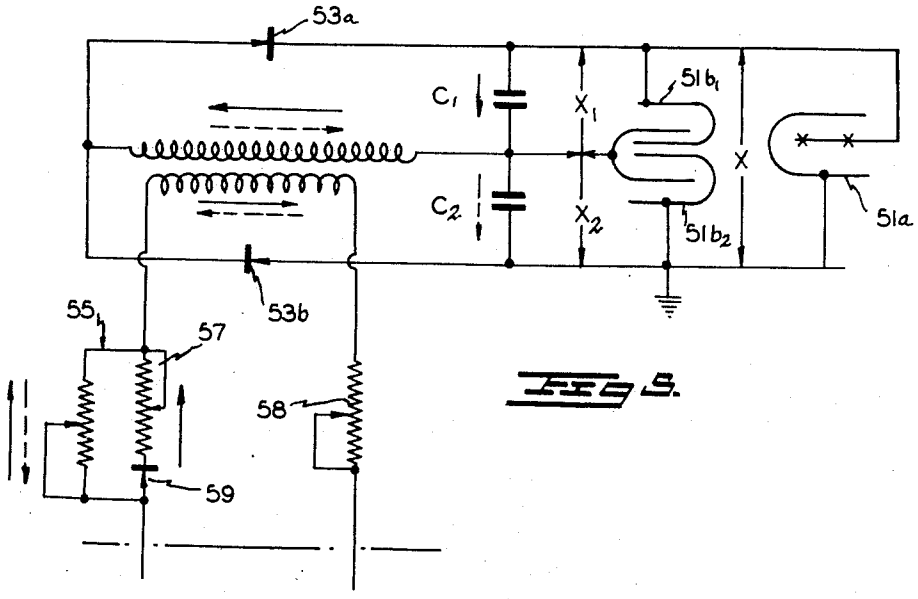


Fig 5.

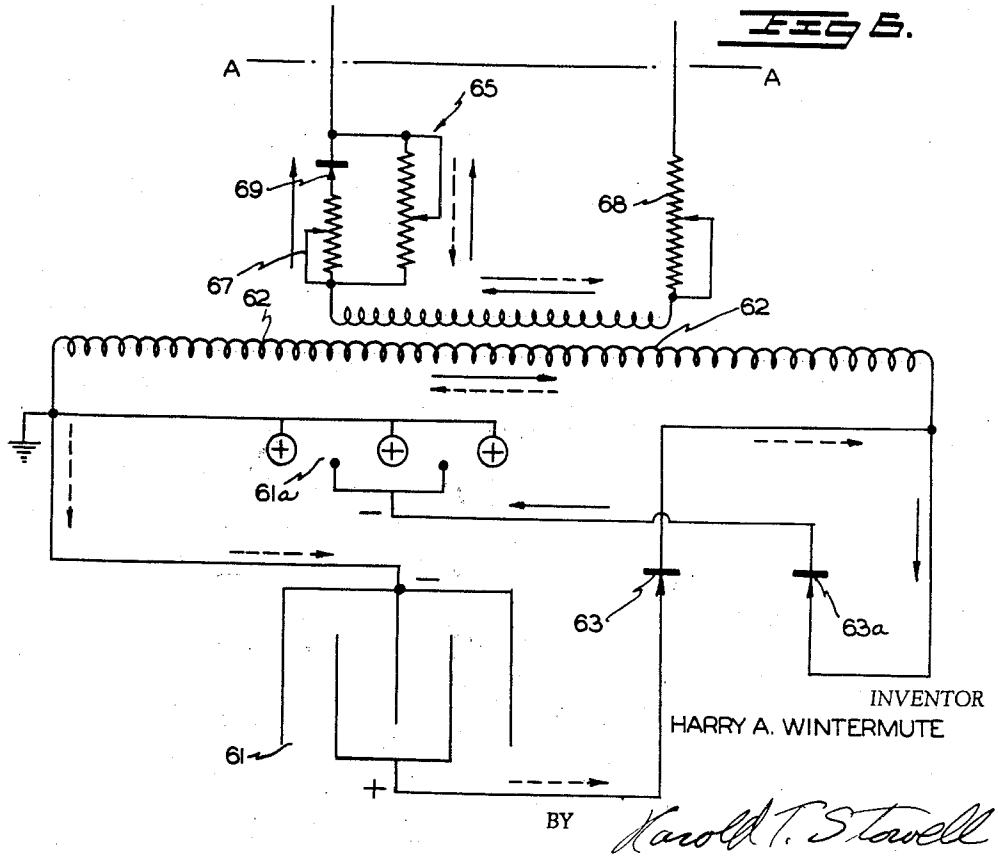


Fig 6.

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ELECTRICAL PRECIPITATORS AND ENERGIZING CIRCUIT THEREFOR

Filed Aug. 23, 1954 4 Sheets-Sheet 4

Fig 7.

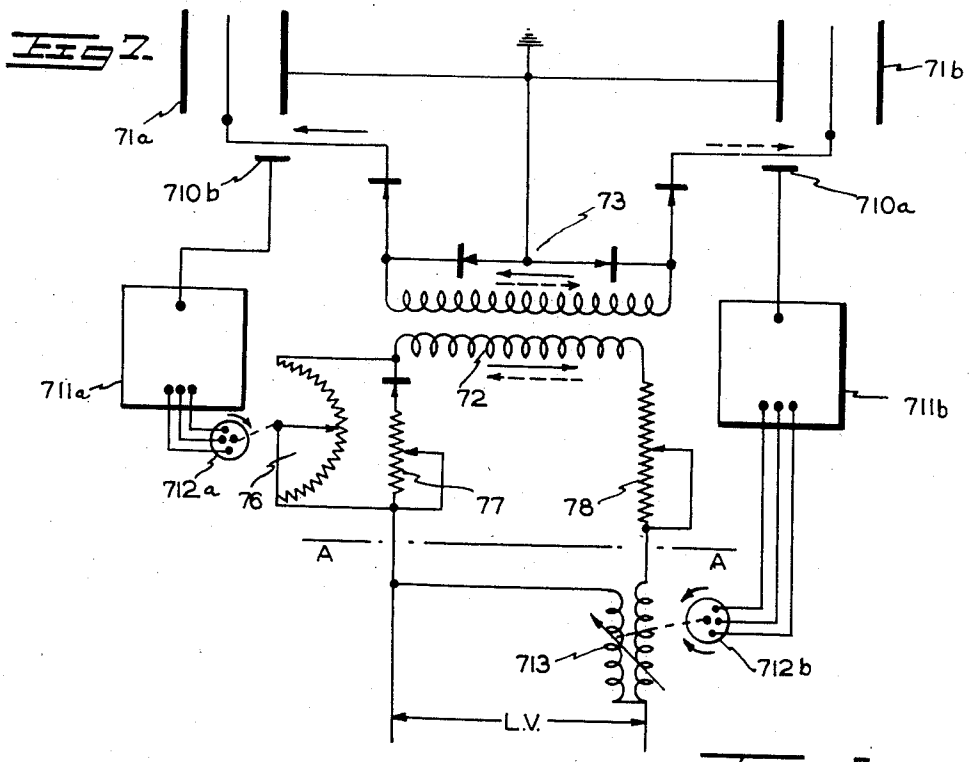


Fig 9

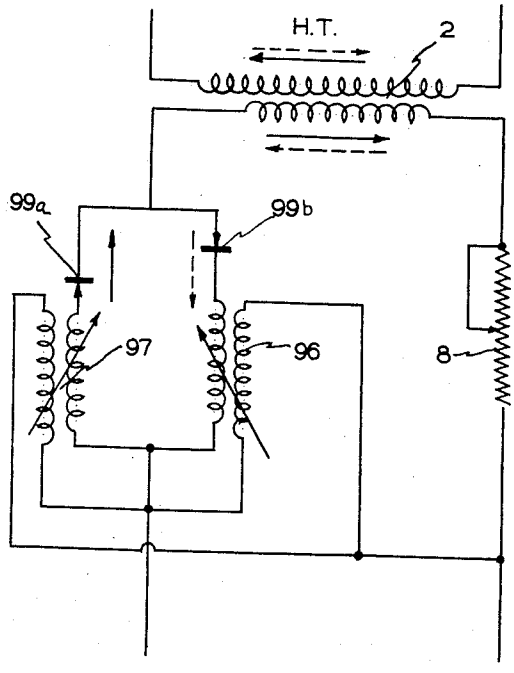
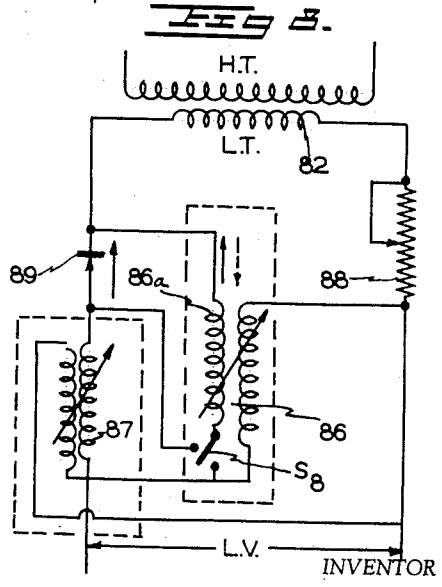


Fig 8.



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ELECTRICAL PRECIPITATORS AND ENERGIZING CIRCUIT THEREFOR

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Application August 23, 1954, Serial No. 451,397

14 Claims. (Cl. 183—7)

This invention relates to an arrangement for producing and controlling respective high and low voltages simultaneously from a single source for use in electrical precipitators and other electrical treating apparatus, such as emulsion breaking apparatus.

In modern electrical precipitators, there is often need for more than a single treating voltage. This is particularly true of precipitators having more than one treatment stage, or having different sections in which different electrode spacings or voltage requirements exist, or in which different gas velocities may exist. Similarly, different sections or locations in a precipitator may utilize different types of electrodes, requiring different voltages. Other considerations which may require different voltages are different concentrations and types of dust particles suspended in the gas stream at different locations or sections, variations in gas conditions such as temperature, water vapor content or other conditioning agents, and differences in the ionizing characteristics of the particular gas or gases being treated.

Different voltages for any of the above conditions can, of course, be obtained by using separate sources of energization for the different treating requirements, but this solution is obviously expensive, both in initial cost and in the additional maintenance required. Voltage control for different voltage requirements can also be secured by using resistance elements in the high tension circuits. However, resistance elements for this purpose are costly and less desirable than the placing of control means in the low tension circuits, since such resistances are of very fine wire and require glazed surfaces to prevent the wires from quickly corroding through. Also, on slight overloads these fine wires tend to burn out, necessitating shutdowns for replacement of burned out elements. The necessity of meeting the resistance and/or ballasting requirements in such an arrangement, together with the elimination of heat, makes this method of control also relatively expensive.

It is a primary object of the invention to obviate the above difficulties and disadvantages by securing voltage control for each of the half waves of the cycles of alternating current separately. In general, this is accomplished by the use of an electric valve or rectifier in the low tension circuit which passes current in only one direction, and which is shunted by a resistance or other impedance device to pass a controlled amount of alternating current. The current passed by the rectifier and its shunt together supplies energy for one half wave, and that passed by the shunt alone controls the value of the other half wave. Since the voltage for one of these half waves is greater than for the other, the voltage to one electrostatic section may be made greater than that for the other section by proper connection on the high voltage side as will be shown below. The current flow to each of the precipitator sections is dependent upon the operating voltage of that section. Alternatively, both half waves may be paralleled and connected to a precipitator unit, in which

case the precipitator is alternately energized with high and low voltages. This has the added advantage of reducing the peak voltage across the rectifier unit without reducing the effective peak voltage across the precipitator electrodes.

It is a particular advantage of the invention that the voltage control elements are in all cases in the low tension or primary side of the precipitator transformer.

The specific nature of the invention as well as other objects and advantages thereof will clearly appear from a description of a preferred embodiment as shown in the accompanying drawing, in which:

Fig. 1 is a schematic circuit diagram of the invention as applied to a single stage precipitator;

Fig. 2 is a schematic circuit diagram of the invention shown applied to a precipitator having two separate sections;

Fig. 3 shows another arrangement for supplying a two section precipitator with different voltages;

Fig. 4 shows the invention applied to a precipitator having a high voltage charging section and a low voltage precipitating section;

Fig. 5 shows the invention applied to a precipitator having a plurality of sections, each having a different voltage;

Fig. 6 shows an alternative arrangement for supplying charging and precipitator sections with different voltages;

Fig. 7 shows an arrangement similar to that of Fig. 2 with automatic control added;

Fig. 8 shows the basic system of the invention, but using voltage regulating transformers in place of resistors; and

Fig. 9 shows an alternative arrangement for full wave control according to the invention.

Referring to Fig. 1, the precipitator conventionally represented at **1** is supplied with the usual high voltage transformer **2**, suitably rectified by any conventional type of rectifier **3**. The primary of transformer **2** is supplied with relatively low voltage from any suitable or conventional source through the customary ballasting resistance **8** and is controlled or set to the desired operating value by means of voltage control **5**. Voltage control **5** comprises a half wave rectifier **9**, which may be of any known type, such as a kenetron tube or other electronic tube rectifier, copper oxide or selenium rectifier, etc., or may also be a half wave mechanical rectifier. In series with rectifier **9** is a variable resistor **7**, and in parallel with this series arrangement is a second variable resistor **6**. Since the rectifier **9** passes current in only one direction, it will be apparent that the alternate half waves of current flow in the opposite direction will be controlled entirely by the setting of resistor **6**. In the direction of current flow through the rectifier, the current will be controlled by the value of resistor **6** in parallel with the combined resistance of the rectifier **9** and variable resistor **7**. In this manner, the magnitude of current flow in both directions can be separately adjusted within reasonable limits, as sufficient for practical purposes. Thus each half cycle of current in the primary circuit corresponding to current flow in one direction as indicated by the solid arrows can be controlled as to magnitude, while the half cycles of current in the opposite direction as indicated by the dotted arrows in the primary circuit can also be controlled as to magnitude. In the secondary circuit, due to the orientation of rectifier **3**, current will flow only in the direction of the solid arrow. It will therefore be seen that current flow through the resistor **6** (indicated by the dotted arrow) will not directly contribute to the electrical discharge with the arrangement of Fig. 1. However, a distinct advantage is derived from use of this arrangement in that it has been found that by its use the peak voltages across the rectifier **9** and transformer **2** can

be materially reduced without affecting the peak operating voltage across the precipitator. Without the resistor **6**, and using a conventional hookup, the peak voltages across the rectifier and transformer were found to be approximately thirty percent higher than when the resistor is used, for the same precipitator voltage.

Fig. 2 shows the invention applied to a standard bridge valve type rectification hookup. In this case, two precipitator sections (or two separate precipitator units) **21***a* and **21***b* are so connected in the transformer secondary circuit that each is subject to current flow in one direction only. The direction of current flow in the circuit is respectively indicated by solid and dotted arrows as before.

In Fig. 2 and in the succeeding figures, the same reference characters will be employed as in Fig. 1, except that they will be preceded in the case of Fig. 2 by a "2," in the case of Fig. 3 by a "3," etc. For example, rectifier **9** in Fig. 1 will be identified in Fig. 2 by numeral 29, in Fig. 3 by 39, etc.

Continuing with Fig. 2, it will be apparent that the respective voltages in precipitator sections **21***a* and **21***b* can be controlled by properly adjusting resistors **26** and **27**, as explained in connection with Fig. 1. In this way, by the use of a single control arrangement in the low voltage or primary side of the precipitator adjoining circuit, it is possible to select two different operating voltages in the secondary side for two different sections or parts of a precipitator, or for two different precipitators with all of the advantages previously mentioned.

It should be noted that precipitator sections **21***a* and **21***b* can also be operated in parallel by simply electrically connecting together center or discharge electrodes in the arrangement of Fig. 2, for example, by means of switch S_2. With such an arrangement, successive half waves of energization of different amplitudes will be supplied to both precipitators together, and such a voltage supply may be desirable in some cases.

Fig. 3 shows an arrangement generally similar to Fig. 2, but using a center tap transformer and half wave rectifier arrangement, as will be apparent from inspection of the drawing. Here again, by connecting together the discharge electrode of the high voltage precipitator **31***a* and the low voltage precipitator **31***b*, parallel operation of the precipitators with both receiving alternately high and low voltage pulses may be obtained.

Fig. 4 shows an arrangement generally similar to Fig. 3, except that instead of two similar precipitator sections, the invention is applied to a precipitator having separate charging and precipitating sections, in which the precipitating section **41***b*, as is well known, generally operates at a much lower voltage than the charging section **41***a*. The control circuit of the present invention is well suited to this use, as it provides the necessary voltage in a single, simple and inexpensive arrangement, with all of the control elements in the low tension side.

Fig. 5 shows an arrangement whereby three different voltages can be obtained in a precipitator by the use of the voltage control according to the invention. In this case, sections $51b_1$ and $51b_2$ are respectively supplied with high and low voltages, as in the preceding arrangements. High voltage precipitator section **51***a* is supplied with the sum of the voltages across $51b_1$ and $51b_2$. Condensers C_1 and C_2 serve as a voltage dividing reactance for supplying voltages to the respective sections, and also serve to smooth out the voltage fluctuations. If the voltages across C_1 and C_2 are respectively designated by X_1 and X_2, and the voltage across precipitator section **51***a* is designated as X, then it will be apparent that voltage X equals X_1 plus X_2. While this arrangement does not permit fully independent control of all three voltages, by proper design of the entire system, it will usually be possible to provide a satisfactory voltage relationship among all of the component parts.

It should be noted in connection with Fig. 5 that the rectifiers **53***a* and **53***b* are so oriented that the charges on these condensers are cumulative, thereby producing the desired voltage doubling effect.

Fig. 6 shows another arrangement for energizing charging and precipitator sections from a common source of power with the charging section being energized at one voltage and the precipitating section at a lower voltage. The respective directions of the current flow are indicated as before by solid and dotted arrows, and the figure is self-explanatory.

Fig. 7 shows an arrangement generally similar to that of Fig. 2, but with automatic voltage control added in combination with the respective sections of the half wave control system, for controlling the energization to give maximum or any desired operating conditions. A separate arcing control regulator **710**, **711** and **712** is provided for each precipitator section and is indicated by the respective subscripts "*a*" and "*b*." Each of these regulators may be of a known type, for example, such as that shown in the following U. S. patents: Backer et al., 2,642,149; Willison, 2,666,496; Hall, 2,623,608 and 2,675,092. The high voltage is controlled by voltage regulator **713**, and the low voltage by shunt resistance **76**, each being controlled by its respective regulator. The operations of both sections are controlled by the arcing in the respective sections. During or after the high voltage setting is made, the low voltage control goes into operation and the voltage in this section is brought to the desired point.

Fig. 8 shows an arrangement according to the invention using variable transformer means **86** and **87** in place of the resistors **6** and **7** of the preceding figures. The operation is essentially the same as in the preceding figures, except that the rectifier **9** is now shunted by a winding connected so as to buck the current flowing through the circuit due to the line voltage. Alternatively, the winding **86***a* of transformer **86** may be shunted across rectifier **89** alone, by means of switch S_8, instead of across the combination of rectifier **89** and regulator **87**. The regulators may be either manually controlled or may be automatically controlled in accordance with any known control system.

Fig. 9 shows an extension of the preceding arrangement in which the shunt regulator across the rectifier **99***a* is replaced by a second, oppositely oriented rectifier **99***b* which has in series with it its own regulator **96**. By the use of this symmetrical arrangement, it will be apparent that each half wave may be independently controlled. This control arrangement may obviously be used with any of the preceding precipitator arrangements, and give independent control of each section by means of a simple control arrangement in the low voltage side of the precipitator charging circuit. Automatic voltage control equipment similar to that shown in connection with Fig. 7 may be connected to both the voltage regulators thereby regulating the voltages of each precipitator section independently of each other. In the place of inductive regulators **96** and **97**, any other suitable type of regulators, such as resistance regulators, may be employed.

It will be apparent that the embodiments shown are only exemplary and that various modifications can be made in construction and arrangement within the scope of my invention as defined in the appended claims.

I claim:

1. A system for energizing electrical precipitators and the like apparatus from a low voltage alternating current source comprising step-up transformer means supplied by said source, rectifying means connecting the electrodes of the apparatus to the secondary circuit of said transformer means to provide unidirectional excitation for said electrodes, voltage control means in the primary circuit of said transformer means comprising primary low impedance diode rectifier means, and first impedance means shunting said primary rectifier means whereby respectively selective regulation of the half-waves of current flowing in each direction is obtained.

2. The invention according to claim 1, including second impedance means in series with said primary rectifier means, said first impedance means shunting the series arrangement of said primary rectifier means and said second impedance means.

3. The invention according to claim 2, said first impedance means being a variable resistor.

4. The invention according to claim 3, said second impedance means being a variable resistor.

5. A system for energizing electrical precipitators and the like apparatus from a low voltage alternating current source comprising voltage step-up transformer means supplied by the source of low voltage, rectifying means connecting the electrodes of the electrical precipitator apparatus to the secondary circuit of said transformer means to provide unidirectional excitation for said electrodes, said electrodes comprise the respective electrodes of a first electrical precipitation section and a second separate electrical precipitation section, said rectifier means being arranged and oriented to supply alternate half-waves of rectified voltage alternately to the electrodes of the respective precipitator sections, voltage control means in the primary circuit of said transformer means comprising primary low impedance diode means, and first impedance means shunting said primary rectifier means whereby respectively selective regulation of the half-waves of current flowing in each direction is obtained.

6. The invention according to claim 5 wherein an electrode of the first precipitator section is connected through a first rectifier to one terminal of said transformer secondary, an electrode of the second precipitator section is connected through a second rectifier to the opposite terminal of said secondary, the other electrodes of the two sections being connected to a common junction point, said point being connected to said one terminal through a third rectifier oppositely oriented from said first rectifier, and being also connected to said opposite terminal through a fourth rectifier oppositely oriented from said second rectifier, said first to fourth rectifiers comprising the rectifying means of the secondary circuit.

7. The invention according to claim 5, wherein an electrode of the first precipitator section is connected through a first rectifier to one terminal of said transformer secondary, an electrode of the second precipitator section is connected through a second rectifier to the opposite terminal of said secondary, the other electrodes of the two sections being connected to a common junction point, said common point being connected to an intermediate point of said transformer secondary.

8. The invention according to claim 5, one of said sections being a high voltage charging section and the other being a relatively low voltage precipitating section.

9. The invention according to claim 2, the secondary rectifier means comprising a first rectifier connected to one secondary terminal and a second rectifier connected in opposite orientation to the same terminal, a first condenser connected between said first rectifier and the opposite secondary terminal and a second condenser connected between said second rectifier and said opposite terminal, a first electrical precipitator section in parallel with said first condenser, a second electrical precipitator section in parallel with said second condenser, and a third electrical precipitator section connected across the non-common terminals of said condenser.

10. The invention according to claim 5, including a variable voltage regulator for controlling said low voltage alternating current source, and automatic voltage control means responsive to voltage conditions in one of said precipitator sections for controlling said variable voltage regulator.

11. The invention according to claim 10, including second automatic voltage control means responsive to voltage conditions in the other of said precipitator sections for adjusting said first impedance means.

12. The invention according to claim 2, said first impedance means comprising induction regulator means.

13. The invention according to claim 12, said second impedance means comprising second induction regulator means.

14. The invention according to claim 2, said first impedance means comprising the series arrangement of a second rectifier means oppositely oriented to said first rectifier means and an induction regulator.

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