July 31, 1934. H. A. WINTERMUTE 1,968,330

SYSTEM FOR ELECTRICAL PRECIPITATION

Original Filed May 18, 1927 2 Sheets-Sheet 1

Fig. 1.

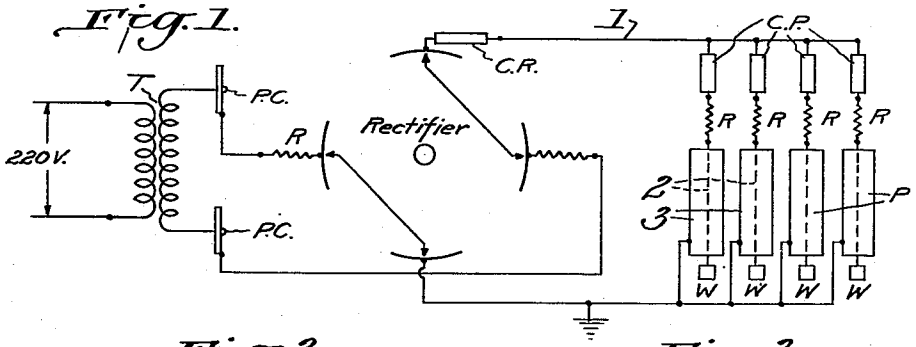


Fig. 2.

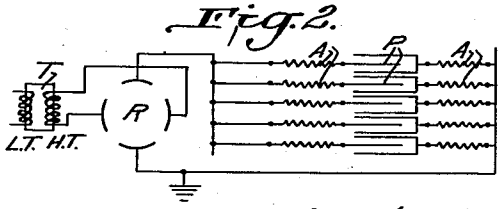


Fig. 3.

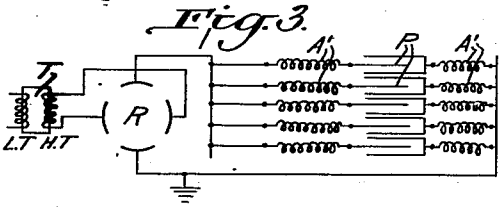


Fig. 4.

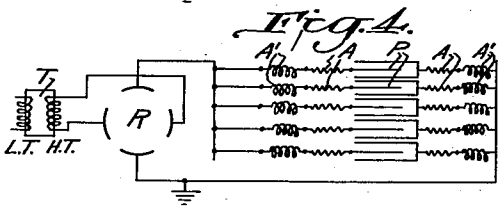


Fig. 5.

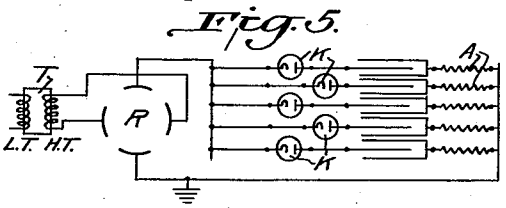


Fig. 6.

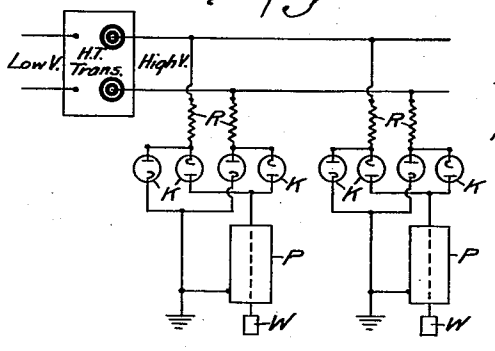


Fig. 7.

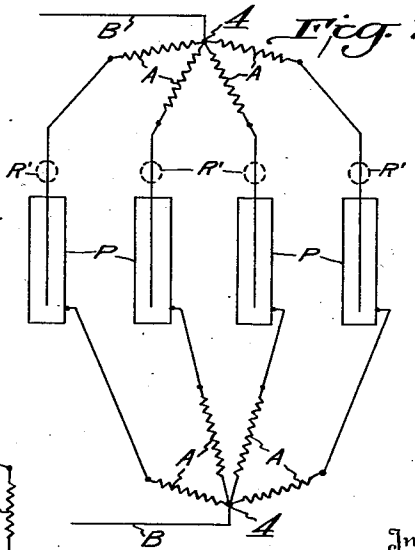
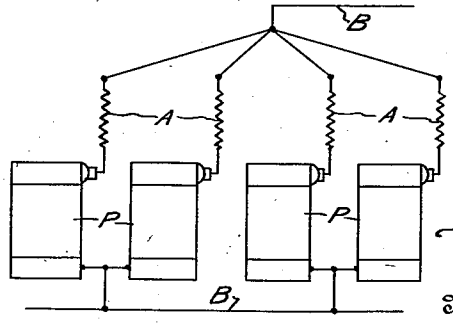


Fig. 8.



Inventor:
Harry A. Wintermute
By Byrnes, Townsend & Potter
Attorneys.

July 31, 1934. H. A. WINTERMUTE 1,968,330

SYSTEM FOR ELECTRICAL PRECIPITATION

Original Filed May 18, 1927 2 Sheets-Sheet 2

Fig. 9.

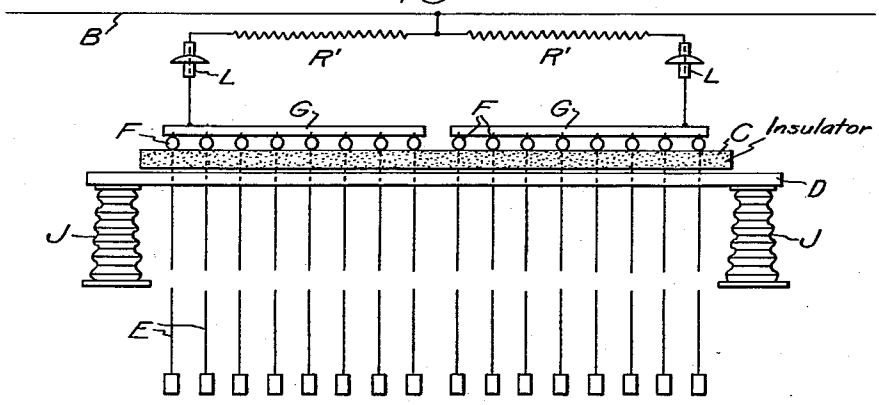
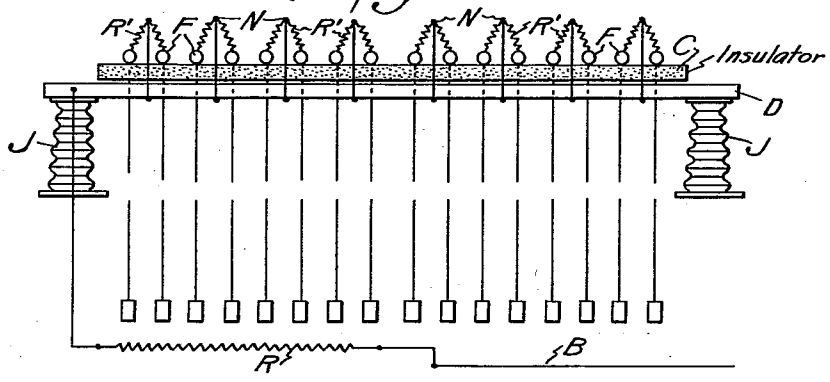


Fig. 10.



Inventor:

Harry A. Wintermute

By Byrnes, Townsend & Potter

Attorneys.

Patented July 31, 1934 1,968,330

UNITED STATES PATENT OFFICE

1,968,330

SYSTEM FOR ELECTRICAL PRECIPITATION

Harry A. Wintermute, Plainfield, N. J., assignor to Research Corporation, New York, N. Y., a corporation of New York

Original application May 18, 1927, Serial No. 192,376. Divided and this application October 18, 1932, Serial No. 638,371

7 Claims. (Cl. 183—7)

This invention relates to the art of electrical precipitation of materials (such as dust, fumes, etc.) suspended in gases.

The precipitation of such materials is effected by passing the gases containing them through a high-tension electrical field, in which high electrical potential difference is maintained between electrodes, the material being deposited on such electrodes.

In practice, it has been found desirable to use a number of electrical precipitation units connected in multiple.

This practice, while it enables large volumes of gas to be handled, has been found to present certain difficulties in that as more units (each unit consisting of a number of discharge and collecting electrodes) are connected in multiple, the voltage or potential difference between the electrodes of each unit has to be lowered, in order to prevent the increased tendency to "arc over".

Electrical precipitation systems comprise in general a step-up transformer, a rectifier to change the alternating current to a pulsating direct current which is delivered to the discharge electrodes of the precipitator, through which the gases carrying suspended material are passing. In this high tension circuit, surges, oscillations or transient currents may be set up and kept in existence by the pulsations from the rectifier feed, the changing of the gas conditions, the static charge in the precipitate, variations in current flow from the corona discharge points, etc. The precipitator itself has considerable inductance and capacity, which are distributed and tend to foster and aggravate this surging condition.

The larger the units, or the more units in parallel, the more pronounced this tendency to surging or oscillation is found to be. Such oscillations may take place between units or different parts of the same units, and while they may be of small power value, are often just large enough when superimposed on the main voltage to cause disruptive discharges at points where they happen to reach a maximum value.

Furthermore, when such disruptive discharge or arcing occurs, or when for any other reason a relatively large flow of current occurs at a certain point or portion of the precipitator, the voltage is immediately reduced in the remainder of the precipitator, due to the flow of energy from such other portions through the relatively low resistance path at this point. This phenomenon, which may be called localization of the electrical field, not only results in a waste of electrical power, but decreases the efficiency of the precipitating action which is dependent upon the maintenance of a high potential difference between all portions of the opposing electrodes.

When such conditions exist or arise, it is necessary to reduce the precipitating voltage in order to prevent such breakdowns, which reduces the corona discharge, and lowers the percentage of recovery.

It is characteristic of electrical precipitators comprising separated electrodes between which a stream of gas is flowing that a small increase of voltage above a given discharge point very greatly increases the current flow (corona discharge) thereby increasing the efficiency of the precipitator. In other words, the gas resistance does not remain constant, but decreases with increased current flow.

In the usual treater the current flow may be largely localized in a relatively few points in the treater, leaving the remainder of the unit practically ineffective. By the use of resistances or impedances so distributed as to break up the treater or unit into relatively small parts isolated from each other by such resistances or impedances and with resistances or impedances also located in the direct path of the current flow, any tendency to localization due to whatever cause produces a potential drop in its path partly neutralizing the tendency toward localization and at the same time the adjoining elements are prevented from pouring their energy into the disturbed area by the separating resistance or impedance.

Surges, high frequency oscillations, etc., are primarily generated at the rectifier and transmitted to the active treater parts. The connecting lines, insulators, bushings, etc., and active parts of the treater, including the gas, deposits on the collecting electrodes, etc., all compose a complex electrical circuit which is capable of reflecting the surge waves received from the rectifier and so producing standing voltage waves within the treater. Such stationary waves occurring in the active treater produce localized current flow. The resistances or impedances introduced in the circuit between the active treater parts and the rectifier tend to prevent the establishment of such standing waves and thus produce uniform distribution of current flow throughout all parts of the treater and so maintain every part at maximum efficiency at all times.

The "snapping" which ordinarily occurs without producing power arcs is probably due to the

breakdown of these standing waves, the energy discharged at the time of rupture or in a single "snap" being only the energy of the particular wave discharged. However, the discharge of one such wave produces disturbances in adjoining or neighboring waves, causing them to break while the original wave is developing its original potential. In this manner continual snapping in the treater is developed and the voltage in the treater can only be further increased at the expense of a further increase in the rate of snapping, with enormous increase of current flow, most of which current is undoubtedly used in the snapping or in the maintenance of the standing waves.

It is well known that a small treater, say a single pipe or plate, is far more efficient than the results per pipe or plate obtained from a group of similar units in multiple. The use of suitable values of resistances or impedances in series with both sides of the circuit to each unit (including its discharge electrode) produces a condition of isolation equivalent in some degree to the operation of the units singly.

Therefore, this invention has for its main object to provide means whereby an increased voltage and the accompanying increased efficiency may be uniformly and continually maintained at each of a number of interconnected electrical precipitation units or elements. A further object of the invention is to prevent or minimize arcing or disruptive discharge, and to also minimize localization of the electrical field at certain portions of the precipitator.

These results are attained by subdividing the precipitator system into as small elements as possible and placing suitable impedances, such as resistances, choke coils, kenotrons, etc., between these elements, by which oscillations and localization of the electrical field are practically eliminated.

As each element is small, the amplitudes of the oscillations are smaller than they would be if they were all in parallel with no preventive means between them. Such oscillations as may tend to arise are promptly damped or dissipated and prevented from reaching harmful values. Furthermore, a momentary increase in current flow through any element due to any disruptive discharge which might occur, or to any other cause, would in turn produce such a drop in potential across the resistance in series with such element as to immediately lower the potential difference between the active portions of such element sufficiently to immediately suppress such increased current flow without appreciably lowering the voltage in other portions of the precipitator.

By thus distributing impedances, etc., in the high tension circuits, the corona discharge at any element is made substantially independent of that from any other, thus enabling more complete and accurate control of the system.

This fundamental idea of providing sufficient impedances between adjoining corona discharges can be applied not only between the units of an electrical precipitation system, but to other localities in the system, in which like conditions of oscillation and localization are liable to occur, and even to the individual discharge electrodes, and examples of such application of the broad invention are described later.

The apparatus used may take a great variety of forms, some of which are illustrated in the accompanying drawings from which the invention will be readily understood.

Referring to the drawings:

Figs. 1, 2, 3, 4, 5 and 6 are diagrammatic illustrations of various arrangements;

Figs. 7 and 8 are diagrams showing methods of electrically connecting the precipitator units with the power lines; and

Figs. 9 and 10 are diagrams showing constructions in which resistances are used in connection with secondary insulation.

Referring to Fig. 1, T is a transformer by which the voltage is stepped up to the required degree. The ends of the secondary coil are connected through choke coils PC (here indicated as of the pancake type) to two terminals of the rectifier whose other two terminals are connected to the discharge and collecting electrodes, the latter being grounded. At the upper terminal of the rectifier is shown a choke coil CR in the line 1, which is connected to each of the precipitator units or sections P, P, by a separate lead in each of which are choke coils CP and resistances R. The precipitators P, P, are shown as having discharge electrodes, 2, 2, and collecting electrodes 3, 3, the discharge electrodes being tensioned by weights W, as is usual.

In Fig. 2 is shown another arrangement in which T is the transformer, R the rectifier, and P the precipitators, here shown for convenience as horizontal. In this arrangement A, A, are resistances on both the discharge and collecting sides of the precipitator.

Fig. 3 shows an arrangement like that of Fig. 2, except that inductive resistances or choke coils A', A', are used.

Fig. 4 shows another arrangement in which the resistance elements are made up of both inductive resistances A', A', and non-inductive resistances A, A.

Fig. 5 shows still another arrangement in which kenotrons K, K, are located in the discharge electrode circuits and resistances, A, A, in the collecting electrode circuits, which may be either inductive or non-inductive.

Fig. 6 shows still another arrangement in which the four kenotrons K shown are used for the rectification means, and the resistance or chokes R are interposed in series between the transformer and the point of rectification. This arrangement places the resistance or choke coils in the alternating current section of the electric circuit instead of the pulsating unidirectional current section.

It is preferred to make the connections as shown in Fig. 7, in which the precipitators are connected to the high voltage power lines B, B, through leads containing resistances A, A, and connected to single points 4, 4. The power lines B, B, may come from a single rectifier, or separate rectifiers R', R' may be provided in the leads to the several elements of the precipitator. This figure shows another arrangement in which impedances are interposed in series with the different elements in the alternating current section of the electric circuit. In this arrangement half wave rectification is used which can be secured by kenotrons or other rectification systems R', R'. In this scheme it is possible to connect the rectifiers between the resistances or chokes and precipitation elements as shown, or they may be located between point 4 of the power line B, B, and the resistances or chokes.

Fig. 8 shows another modification of precipitators and resistances. In this arrangement four precipitator units P are connected from a common source of power, resistances A being con-

nected in series with the discharge electrode system of each unit.

It will be noted that the common characteristic of each of these arrangements is the interposition in the lead of each precipitator unit or section of a sufficient impedance (resistance, choke coil, electric valve or combinations of these devices) to provide each unit or section with a practically separate source of high difference of potential, and to isolate each unit or section from other interconnected units or sections by means effective to prevent transmission of dangerous surges.

The advantages incident to the use of the invention will be evident from an example in practice in which four units were connected in the usual method and operated at as high a voltage as possible. The operating current ranged from 16 to 20 amperes.

With resistances inserted in the manner described, it was found that the current which could be carried ranged from 35 to 40 amperes, this increase in power resulting in over 15% higher precipitating efficiency.

The resistance in series with each unit amounted to about 200,000 ohms, and therefore about 400,000 ohms between any two units. In addition to the increased efficiency, the burning off of discharge electrodes by arc discharges was entirely obviated.

In this test the ballasting resistance on the low tension side of the transformer, which previously had to be used, was omitted, with the result that at the same transformer-ratio, a higher high-tension voltage could be obtained, which notwithstanding the resistances produced a slightly higher voltage at the precipitator itself. As has before been pointed out, it is a characteristic of electrical precipitators that a relatively small increase in voltage may produce a relatively very high increase in corona discharge. As the suspended particles in their passage through the precipitator between the discharge and collecting electrodes are subjected to a greater number of corona discharges, a more efficient separation is effected.

As the resistance of a precipitator does not remain constant, but decreases with increased current flow, it is said to have "negative resistance" characteristics, and as the flow is increased the operation becomes more unsteady, resulting in arc overs or highly localized discharges. In some precipitation problems, unless gas conditioning is used, conditions are met in which

$$\frac{de}{di} < o.$$

It is in these cases that ballasting impedances in series with each corona point are most effective, giving stable current flow and preventing the localization of discharges in a relatively few points. The voltage throughout the precipitator is maintained at the normal value resulting in an even distribution of corona discharge, thus maintaining a maximum efficiency.

As resistances there may be used wire-wound resistances, carborundum rods, or resistances of the semi-conducting type, such as Portland cement concrete, "Transite" board or the like. The resistance, through moisture or precipitate, or both, on the surface of insulators or semi-conducting material, may also be utilized.

As a further development of this invention, the use of these resistances of the semi-conducting type permits the insertion of resistances in close connection with the discharge electrode supports or collecting electrode supports, or even with the discharge elements of each electrode.

Fig. 9 shows an arrangement in which two sections of a precipitator are separately connected through resistances to the high tension line B. From each of the pipes F depend a number of discharge electrodes E. These pipes rest on a transversely extending insulating member or bar C. The bar C rests on the steel beams D, which are in turn supported on insulators J, J. The pipes F are arranged in two sets and extending across each of the two sets are conducting bars or wires G, thereby connecting each set of the bars in parallel. Each of these bars is connected through inlet bushings L and resistances R' to the high tension line B. It will be understood that the discharge electrodes are located between collecting electrodes (not shown) in the usual manner, as shown, for example, in Cottrell Patent No. 1,035,422, Aug. 13, 1912. In this Fig. 9 arrangement, the ballasting resistances R', R' are interposed in the circuit leading to two sets of discharge electrodes.

As shown in Fig. 10, the resistances are still further subdivided. In this system, the supporting bar D is connected to the high tension line B, through resistance R. The means of supporting the sets of electrodes is the same as in Fig. 9, but in this case the conductors M connect the supporting bar D to the points N between which and each of the discharge-electrode-carrying pipes F are interposed resistances R', R'. Therefore, each pipe and its discharge electrodes are separated from the adjoining pipe by adequate resistances to prevent surging.

Some of the advantages of the point construction of discharge electrodes are that alternating current may be used, or the points may be either negatively or positively charged. Moreover, if arcing occurs at any point, this arcing would not affect the corona discharge at the other points, as is the case when there is no high resistance.

It will thus be noted that the parallel circuits as heretofore used in electrical precipitation systems are broken up by resistances, choke coils, etc., whether these parallel connected elements are precipitator units, sections of units, smaller groups of discharge electrodes, single discharge electrodes, smaller groups of collecting electrodes, single collecting electrodes or discharge points on a discharge electrode.

The improved result in general is that it becomes possible to maintain a current discharge from discharge to collecting electrodes, which is substantially free from currents of an oscillatory or high frequency nature.

This uniformity or evenness of current discharge per unit length of electrode permits the use of higher voltages than can now be safely used in any of these interconnected electrical precipitator systems.

The amount of ballasting resistance or other impedance to be used in series with any unit, section, or electrode, cannot be definitely stated in ohms, since the amount used depends upon a number of factors, among which are the spacing distance between discharge and collecting electrodes, the kind of gas and the particular character of suspended precipitate, the length of the electrodes, etc. Further many types of high tension resistance do not have the same amount of resistance in pulsating rectified currents as they have on high-voltage direct currents.

However, according to this invention, the resistance or impedances in series between any two

precipitator units, sections, electrodes or points must, under all ordinary conditions, be sufficient to prevent the localization of discharges or the cross surges or oscillation between the adjacent elements, and for convenience, resistances or impedances of this order are termed "surge-resisting" impedances or resistances.

It has been the custom to insert resistances in the high tension circuits, as for example at the shoes of the rectifier, but these resistances were small, usually varying from 1000 to 10,000 ohms, while according to this invention, resistances of 100,000 ohms or more are inserted in each of the paralleled leads from the high-tension line to the precipitators.

It has also been the practice when precipitator units were to be operated in parallel to introduce resistance on the low voltage side of the transformer. With large size units and a large current flow the use of resistances in the low tension circuit must be minimized to avoid excessive power losses, and where a short circuit occurs in the precipitator an excessive rush of current can happen because of the small amount of resistance in the high-tension circuit.

When the high resistances are distributed in the manner described, these difficulties are largely obviated.

The term "element" as used in the claims is intended to include a section or unit of an electrical precipitator, a set of electrodes in such unit, or a single discharge or collecting electrode.

While alternating current rectifiers have been shown and referred to, it will be understood that any other suitable source of current may be used, such as kenotrons, direct current generators of the Girvin type, or even electrical batteries in series.

This application is a division of my application Serial No. 192,376, filed May 18, 1927.

I claim:

1. A system for the electrical precipitation of suspended particles from gases comprising collecting electrodes defining a plurality of parallel gas passages, discharge electrodes opposed to said collecting electrodes for creating electric fields within said passages, a source of high voltage current, parallel connections between said current source and the discharge electrodes in the separate gas passages, and surge-resisting means in each of said connections.

2. A system for the electrical precipitation of suspended particles from gases comprising collecting electrodes defining a plurality of parallel gas passages, discharge electrodes opposed to said collecting electrodes for creating electric fields within said passages, a source of high voltage current, parallel connections between said current source and the discharge electrodes in the separate gas passages, and surge-resisting means in the connection to each of said discharge electrodes.

3. A system for the electrical precipitation of suspended particles from gases comprising a plurality of collecting electrodes defining a plurality of parallel gas passages, discharge electrodes spaced from the collecting electrodes in each of said parallel gas passages, parallel connections from a source of high tension current to the discharge electrodes in each of said parallel gas passages and surge-resisting impedances in each of said connections.

4. A system for the electrical precipitation of suspended particles comprising a plurality of collecting elements defining a plurality of parallel gas passages, discharge elements in each of said gas passages providing with said collecting elements high voltage paths including said parallel gas passages, a single source of high voltages, and means connecting said paths across said source in parallel to establish voltage drops of the same order of magnitude between the discharge and collecting elements in each of said parallel gas passages, said means including surge-resisting impedances in each of said paths.

5. A system for the electrical precipitation of suspended particles comprising a plurality of collecting elements defining a plurality of parallel gas passages, discharge elements in each of said gas passages providing with said collecting elements high voltage paths including said parallel gas passages, a single source of high voltages, means connecting said paths across said source in parallel to establish voltage drops of the same order of magnitude between the discharge and collecting elements in each of said parallel gas passages, said means including surge-resisting impedances in each of said paths, and additional surge-resisting impedances common to a plurality of said paths.

6. The invention as set forth in claim 4 wherein the impedance in said paths is divided, one portion being serially connected between said source and the discharge element, and another portion being serially connected between said source and the collecting element.

7. A method of precipitating suspended particles from gases which comprises dividing said gases into a plurality of parallel streams, subjecting each of said parallel gas streams to high potential fields from a single source of high potential current, and maintaining substantially constant electrical conditions in each of said gas streams by subjecting the current supply to each of said gas streams to the surge-resisting effect of an impedance.

HARRY A. WINTERMUTE.