Oct. 23, 1962 C. A. GALLAER 3,059,395

ELECTRIC PRECIPITATORS

Filed Jan. 27, 1960

FIG. 1

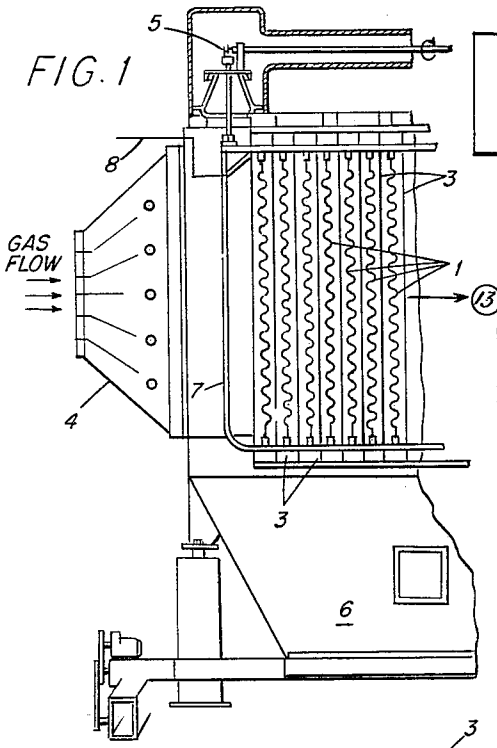


FIG. 5

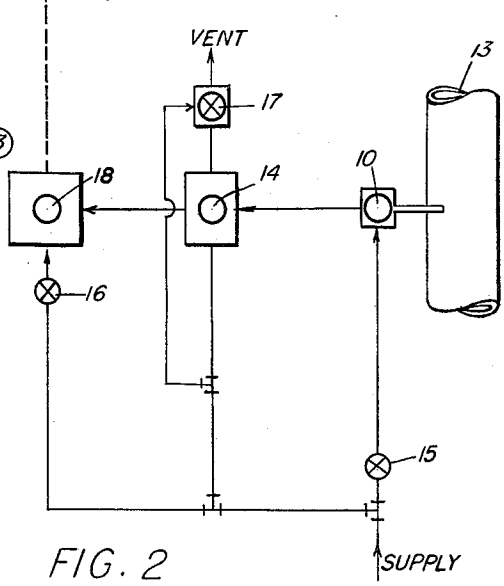


FIG. 2

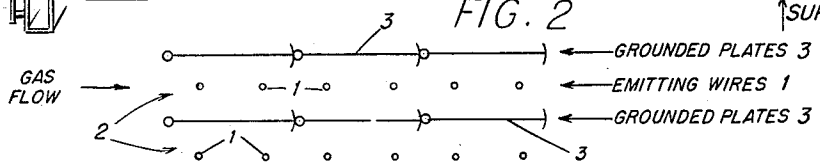
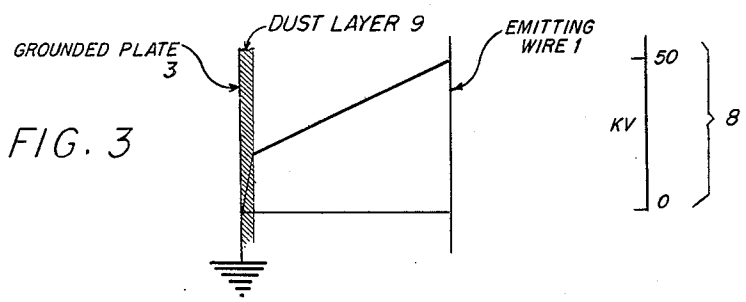


FIG. 3



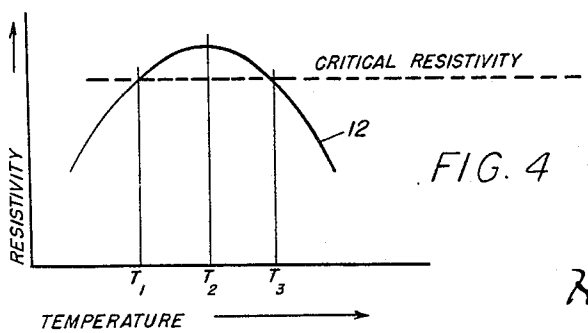


FIG. 4

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ELECTRIC PRECIPITATORS

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This invention relates to electric precipitators and more particularly to ones adapted to remove dust from a dust laden gas stream. Such precipitators have emitting electrodes, which are customarily wires, in the gas stream and electrically grounded collecting electrodes which generally form the walls of the passage through which the stream is passed. The emitting wires and collecting plates are thus associated in spaced relation from each other in the passage. These are a multiplicity of wires and plates, and a precipitator has a multiplicity of passages so that the volume of incoming gas can be split up among the passages for simultaneous treatment. Direct current is applied to the emitting wires and the voltage is sufficient to ionize the gas forming a corona and charge the dust particles negatively. The electric field causes the particles to travel to the collecting plates where they form a dust layer. The higher the voltage, the more ions are formed, the greater the force, the higher the current and the more efficient the cleaning operation. It follows that the higher the voltage in a precipitator, the more efficient is its operation.

However, there is a limit to the voltage usable. The breakdown voltage of the path of the current from the emitting wire to the collecting plate must not be exceeded or an arc-over will occur and dust collection will stop.

It has been noted that the path of the direct current from wire to plate shows the current must pass not only through the gas but also through the layer of dust on the surface of the plate. It is found that the voltage drop through the dust layer is more rapid than through the gas and that the dust has certain other qualities hereinafter referred to which have enabled the inventor to make an improved precipitator which avoids arc-overs. According to the invention, the temperature of the gas is used to regulate conditions according to the dust to automatically keep the voltage as close to the normal or most efficient voltage as possible from moment to moment.

In the drawings,

FIG. 1 is a diagrammatic sketch in vertical section of one end of the precipitator viewed from the side, in which the invention can be embodied.

FIG. 2 is a detailed view in plan of one of the passages in the precipitator of FIG. 1.

FIG. 3 is a diagram of the voltage drop situation at the wire and plate with a kilo volt scale beside it.

FIG. 4 is a graph in which the curve illustrates the relationship of the resistivity of a sample of fly ash and the temperature of the gas.

FIG. 5 is a schematic drawing of the temperature sensing unit, voltage control equipment and the gas stream.

As shown in the embodiment of FIGS. 1 and 2, there are a great number of emitting wires 1 serving as emitting electrodes. There may be as many as thousands of wires in a precipitator divided among a number of parallel passages 2, the walls of the passages being formed by the ground plates 3 that are the collecting electrodes. There is an inlet 4 for the gas. It is shown at the left in FIG. 1. The gas outlet is shown diagrammatically in the form of a pipe 13 at the right of FIG. 2. The machine has the usual rapping mechanism 5 and collecting bin 6. Current is supplied to the emitting wires 1 through the frame 7 which carries the wires 1 as usual.

The dust particles in the gas stream entering at the

inlet 4 are charged negatively by the ionization of the gas close to the emitting wires 1. The particles tend to gravitate to the grounded collecting plate 3 under the influence of the electric field and give up their charges to the plates. The sum of all these ionic charges reaching the grounded plates is the total direct current flow in the precipitator. The higher the voltage on the emitting wire, the greater the number of negative ions released in the corona and the higher the current in the precipitator. Since the charge impressed on a charged dust particle is proportionate to the voltage, a high voltage is desirable for best efficiency. As suggested in FIG. 3, the voltage 8 of the wires may be of the order of 50 kv. below the voltage of the grounded plates.

As already mentioned, the dust particles form a layer of dust 9 on the walls of the passage, i.e. on the collecting plates 3 (see FIG. 3).

To get from the emitting wires 1 to the grounded collecting plates 3, the current must flow not only through the gas in the passage 2 but also through the dust layer 9. In passing through the dust layer 9 the voltage of course will drop. This voltage drop through the dust layer at any given moment is a function of the resistance of the layer and the quantity of current passing through it. The resistance of the dust layer is a function of its resistivity, and the latter is expressed as the electrical resistance of a unit cross-section of dust of a unit thickness. The breakdown voltage of a dust layer is customarily given as volts per centimeter, i.e. that voltage which will arc through a 1 cm. thickness of dust. The relation to the current is expressed in

$$I=\frac{E}{R}$$

using breakdown voltage as E and resistivity as R. This will give the current in amperes per square centimeter. Thus expressed, the current density is independent of the thickness of the dust layer.

If the voltage drop through the dust layer becomes sufficiently high, the dust layer will break down and allow arcs to pass from the surface of the dust to the plate. Once this happens, the precipitator can be continued in action only by decreasing the voltage. This will decrease the current density in the precipitator and avoid breakdown. This condition can be described as due to "high resistivity" or to the level of the breakdown voltage of the dust layer.

Let us call the resistivity which causes a breakdown of the voltage through the dust layer 9 and formation of an arc in a given precipitator set up, the "critical resistivity" of that condition.

It has been discovered that the ideal current and voltage is definitely related to the temperature of the gas. This is due to the effect of the gas temperature on the resistivity of the dust layer. In FIG. 4 is shown the resistivity of fly ash plotted as a curve 12 against the gas temperature. In this typical curve, it will be noted that the curve rises up to a maximum temperature between 300° F., T_1 and 400° F., T_3. The maximum height is at the point designated T_2. If the critical resistivity is higher than this temperature point T_2 then the precipitator voltage will never have to be lowered because of a breakdown arc in the dust layer. In the graph, the temperature passes the critical resistivity on the way up to the maximum point T_2 from lower temperatures at the point designated T_1 and curves back down below the critical resistivity at a higher temperature point T_3. At any temperature between points T_1 and T_3 the voltage must be reduced to avoid arc-over.

It has been found the voltage drop in the dust layer is such a major factor that by keeping this voltage drop below the breakdown voltage of the dust layer, what-

ever the gas temperature, no arcs occur between the emitting wires and the collecting plates including the dust layer.

To implement this and to monitor the precipitator and be sure it is always operating at the maximum possible voltage setting for the particular conditions, the following continuous temperature actuated voltage control equipment is provided. Specifically, this may be a temperature sensing unit **10** such as a Moore Nullmatic Temperature Transmitter. The Moore Nullmatic Temperature Transmitter consists of a gas-filled thermal system acting in conjunction with a balancing bellows and an air supply to transmit an air pressure having a direct linear relation to the bulb temperature. The transmitting system uses the "null-balance" principle which avoids the effects of bellows non-linearity by maintaining the bellows in a very nearly fixed position for any value of the measured temperature. It may be located at the outlet pipe **13** of a precipitator section or at same other point in the gas stream. The signal from the unit **10** can be sent to a modifier station **14** by compressed air signal. Here it can be adjusted to less than full value if desired. This can bring the sensing unit signal in step with the electrical current situation. From thence the modified signal is transmitted by air to a Conoflow current controller which has been designated as voltage control equipment **18** in FIG. 5. This is connected mechanically to the voltage powerstat associated with the transformer **11**. As the gas temperature rises, the voltage is lowered and vice versa. The amount of decrease per unit temperature rise is a function of the setting of the modifier station **14**.

In initially adjusting the equipment, the modifier station **14** can be set, for example, at 70%. If there is a tendency to arc, the modifier station should be increased so as to decrease the voltage. If there is any question whether the setting of the voltage has been reduced too much, the modifier station **14** setting can be tried a little lower. Once these settings are determined, there should be no necessity for manual change except under extraordinary conditions, provided the gas temperature range is unchanged. If it is desired to return to manual operation, shut the supply and signal air valves **15** and **16**. If it is desired to bleed the air system, the bleeder valve **17** can be used.

It will be seen that the dust reaction to temperature change provides an ideal way to anticipate and prevent arcs and to keep the precipitator at maximum efficiency.

What is claimed is:

1. In an electric precipitator for cleaning a dust laden gas stream, an inlet for a dust laden gas stream, an outlet for the cleaned gas, a passage connected to the inlet through which only the dust laden stream passes, emitting electrodes and grounded collecting electrodes located in spaced relation in said passage, means to supply direct current, within the corona range, to the emitting electrodes thereby charging dust particles in the dust laden gas stream and causing said particles to form on the collecting electrodes a dust layer having a voltage drop varying according to the temperature, in combination with control equipment to vary, within the corona range, the voltage produced by the supply means, and a gas temperature sensing unit in the gas stream adapted to activate said control equipment to keep the voltage just below the arc-over point at different temperatures of the dust layer.

2. In an electric precipitator for cleaning dust laden gas stream, an inlet for a dust laden gas stream, an outlet for the cleaned gas, a passage connected to the inlet through which only the dust laden gas stream passes, emitting electrodes and grounded collecting electrodes located in spaced relation in said passage, means to supply to the emitting electrodes direct current, within the corona range, and having a voltage just below the arc-over point in the precipitator thereby charging the dust particles in the dust laden gas stream and causing said particles to form a dust layer on the collecting electrodes, said collecting electrodes having a voltage drop varying according to the temperature of the dust layer, in combination with control equipment adapted to lower, within the corona range, the voltage from, or return said voltage to, the voltage of the supply means, and a gas temperature sensing unit in the gas stream adapted to activate said control equipment to keep the voltage drop in the dust layer just below the break down point of the dust layer at different temperatures thereof; whereby prompt avoidance of arc-over is obtained.

3. In an electric precipitator for cleaning a dust laden gas stream, an inlet for the dust laden gas stream, an outlet for the cleaned gas, a passage connected to the inlet through which only the dust laden stream passes, emitting electrodes and grounded collecting electrodes located in spaced relation in said passage, means to supply direct current, within the corona range, to the emitting electrodes thereby charging the dust particles in the dust laden gas stream and causing said particles to form a dust layer on the collecting electrodes, said dust layer having a critical resistivity below the maximum dust layer arc-over point, said dust layer arc-over point varying above and below the critical resistivity of the dust layer according to the temperature thereof, in combination with control equipment adapted to lower the voltage from, or return said voltage to, the voltage supplied by the supply means, and a gas temperature sensing unit in the gas stream adapted to activate said control equipment to keep the arc-over point of the dust layer below the critical resistivity of said dust layer at different temperatures thereof; whereby prompt avoidance of precipitator arc-over is obtained.

4. In an electric precipitator for cleaning a dust laden gas stream, an inlet for the dust laden gas stream, an outlet for the cleaned gas, a passage connected to the inlet through which only the dust laden stream passes, emitting electrodes and grounded collecting electrodes located in spaced relation to each other in said passage, means to supply direct current, within the corona range, to the emitting electrodes, thereby charging the dust particles in the dust laden gas stream and causing said particles to form a dust layer on the collecting electrodes, said dust layer having a critical break down resistivity below the maximum dust layer arc-over point of the direct current, said arc-over point varying above and below the critical resistivity of the dust layer according to the temperature thereof, in combination with voltage control equipment to lower or raise the voltage supplied by the supply means, and a temperature sensing unit in the gas stream adapted to activate the voltage control equipment when the gas temperature indicates the resistivity of the dust layer is about to go above the critical resistivity level and to activate the voltage control equipment in the other direction when the break down point of the dust layer no longer requires deviation from normal to avoid arcing.

5. An electric precipitator according to claim 4 in which the emitting electrodes are wires and the collecting electrodes are grounded plates.

6. In an electric precipitator according to claim 4 the provision between the temperature sensing unit and the voltage control equipment of a modifier station adapted to reduce the sensing unit signal to less than full value and thereby adjust the magnitude of the voltage change.

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