ELECTRICITY

Dust, Soot, Smoke and Fumes

Cleared From Factory Air by Electrical Precipitation

"A Classic Invention"

PROBLEMS IN SMOKE, FUME, AND DUST ABATEMENT. By F. G. Cottrell. In Annual Report of the Smithsonian Institution, 1913. Washington: Government Printing Office, 1914.

THE precipitation of suspended matter, whether in gases or liquids, may be accelerated by electricity in the form of either direct or alternating current, but the mode of action and the type of problem to which each is best applicable differ in certain important respects.

Where an alternating electromotive force is applied to a suspension the action consists for the most part in an agglomeration of the suspended particles into larger aggregates out in the body of the suspending medium and a consequently more rapid settling of these aggregates under the influence of gravity.

Thus, it has been stated that if powerful Hertzian waves are sent out under proper conditions into foggy air the alternating fields set up in space cause an agglomeration of the particles of liquid into larger drops, which then settle much more rapidly. Considerable work aimed at the application of these phenomena to the dispelling of fog on land and sea was said to have been done some years ago in France and England, but very little as to definite results appears to have been published. Another application of alternating current along these lines is found in a process now in use in the California oil fields for separating emulsified water from crude oil.

Queen Elizabeth

would not let her subjects burn coal in the city of London while Parliament was holding session.

Dr. Cottrell

solved the queen's problem in more permanent fashion and gave his invention to the public.

Alternating current may thus be used to advantage where the masses of fluid to be treated are fairly quiescent, and a simple agglomeration of the suspended particles into larger aggregates is sufficient to effect separation by gravity or otherwise.

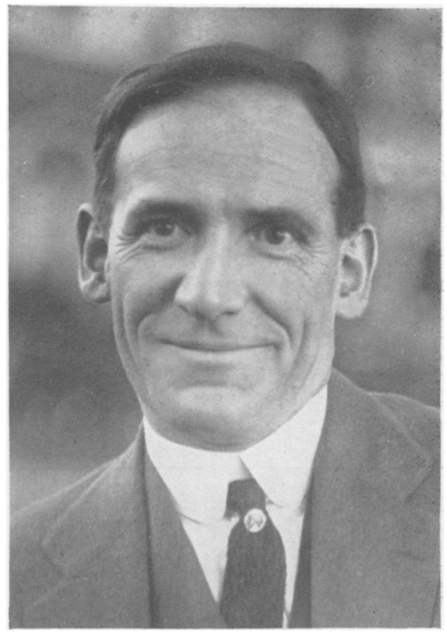
In the case of the large volumes of rapidly moving gases in smelter flues the agglomerating and settling process is, however, too slow even when the flues are expanded into as large dust chambers as are commercially feasible. It is in such cases that unidirectional current methods have been particularly important.

Theory of Electrical Precipitation

If we bring a needle point connected to one side of a high potential direct-current line opposite to a flat plate connected to the other side of the line we find that the air space between becomes highly charged with electricity of the same sign as the needle point, irrespective of whether this is positive or negative, and any insulated body brought into this space instantly receives a charge of the same sign. If this body is free to move, as in the case of a floating particle, it will be attracted to the plate of opposite charge and will move the faster the higher its charge and the greater the potential gradient between the point and plate.

Even if there are no visible suspended particles the gas molecules themselves undergo this same process, as is evidenced by a strong wind from the point to the plate, even in perfectly transparent gases. The old familiar experiment of blowing out a candle flame by presenting it to such a charged point is simply another illustration of the same phenomena.

As above indicated, the first step toward practicability was of necessity a commercially feasible source of high-tension direct current. The obstacles to building ordinary direct-current generators for high voltages lie chiefly in difficulties of insulation, and if this is avoided as to individual machines by working a large number in series the multiplication of adjustments and moving parts intrudes itself. On the other hand, high potential alternating current technique has in late years been worked out most thoroughly, and commercial apparatus up to 100,000 volts and over has been available for some years in the market.



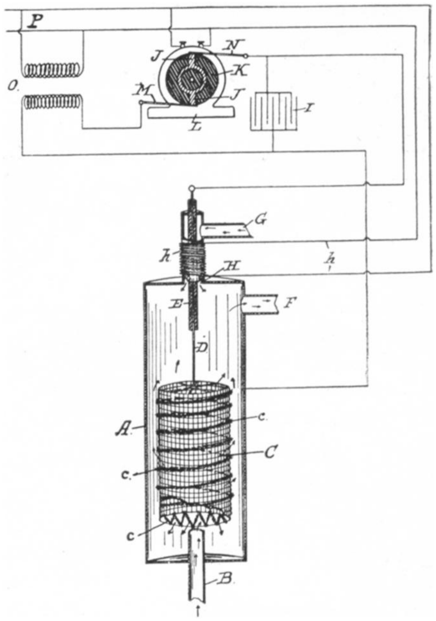
DR. FREDERICK G. COTTRELL

The procedure actually used in the installations described below is diagrammatically illustrated in the early Patent Office drawing (fig. 2), and consists in transforming the alternating current from an ordinary lighting or power circuit *P* up to some 20,000 to 75,000 volts through the transformer *O*, and then commutating this high potential current into an intermittent-direct current by means of a special rotating contact maker *J* driven by a synchronous motor *L*. This unidirectional current is applied to a system of electrodes in the flues carrying the gases to be treated. In the particular form shown in the drawing the wall of the chamber *A* itself acts as one electrode, the other electrode *C* being suspended within it. The heating circuit *h* and inlet for clean gas *G* are merely for protection of the insulation from condensation of acid and moisture.

The electrodes are of two types corresponding to the plate and point in the experiment above cited. The construction of electrodes corresponding to the plate presents no special problem, as any smooth conducting surface will answer the purpose. With the pointed or discharge electrodes it is quite otherwise, and the working out of practical forms for these proved the key to the first commercially successful installations.

In laboratory experiments when the discharge from a single point or a few such was being studied fine sewing needles or even wire bristles answered very well, but when it was attempted to greatly multiply such discharge points in order to uniformly treat a large mass of rapidly moving gas at moderate temperatures great difficulty was encountered in obtaining a powerful and, at the same time, effective distribution of current.

It may be of interest to note that the clue to the solution of this difficulty came from an almost accidental observation. Working one evening in the twilight, when the efficiency of the different points could be roughly judged by the pale luminous discharge from them, it was noticed that under the particular conditions employed at the time this glow only became appreciable when the points had approached the plates almost to within the distance for disruptive discharge, while at the same time a piece of cotton-covered magnet wire, which carried the current from the transformer and commutator to the discharge electrodes, although widely separated from any conductor of opposite polarity, showed a beautiful uniform purple glow along its whole length. The explanation lay in the fact that every loose fiber of the cotton insulation, although a relatively poor conductor compared to a metallic wire, was still sufficiently conductive from its natural hygroscopic moisture to act as a discharge point for this high potential current, and its fineness and sharpness, of course, far exceeded that of the sharpest needle or thinnest metallic wire. Acting on this suggestion, it was found that a piece of this cotton-covered wire when used as a discharge electrode at ordinary temperature proved far more effective in precipitating the sulphuric-acid mist, which was then the object of study, than any system of metallic points which it had been possible to construct. Perhaps the greatest advantage thus gained lay in the less accurate spacing demanded between the electrodes of opposite polarity in order to secure a reasonably uniform discharge. Much of the importance of this discovery at the time lay in the limited potentials of a few thousand volts then available to the experimenters in their laboratory work.



PATENT OFFICE DRAWINGS

Of the first commercially successful system of electrical precipitation (Cottrell, 1908).

In practice, of course, a more durable material than cotton was demanded for the hot acid gases to be treated, and this was found in asbestos or mica, the the fine filaments of the one and the scales of the other supplying the discharge points or edges of the excessive fineness required. These materials were twisted up with wires or otherwise fastened to suitable metallic supports to form the discharge electrodes in such wise that the current had to pass only a short distance by surface leakage over them, the slight deposit of moisture or acid fume naturally settling on them serving to effect the conduction. With the further development of the electrical technique to provide the far higher voltages now being used in commercial operation, the choice and design of electrodes has become much more flexible, including simple metallic wires, sharp metallic strips, and the like. In fact, the very phenomena of so-called corona loss or direct leakage from the wire into the air on high-tension transmission lines, which are today the chief stumbling block of the power companies in going very far above 100,000 volts on these lines, become exactly what is desired in the processes of precipitation, and with the voltages now used a bare metal wire of moderate size or the relatively thin edge of a metallic sheet may be made to furnish an excellent discharge. . . .

Electrical Precipitation and Gaseous Constituents

The electrical process, it must be remembered, precipitates only suspended particles, be they liquid or solid, but does not in itself extract any of the truly gaseous constituents of the mixture under treatment. What is gas under one set of conditions may, however, be solid or liquid under others. Thus recent experiments upon arsenic-refining furnaces at Anaconda have indicated the practicability of installing two precipitating units in series, the first treating the hot gases as they come directly from the furnaces roasting crude flue dust, their temperature at this point being so high that the arsenic is for the most part in the form of true gas, and only the nonvolatile dust mechanically carried over by the draft is precipitated. Beyond this unit the gases are cooled by admixture of cold air, and the arsenic separates as a cloud of solid fume, which is then precipitated in a state of high purity in the second electrical precipitation.

This principle might, of course, also be applied in a greater number of stages to mixtures of materials of different volatilities and in this way opens up new possibilities for the application of fractional distillation and condensation.

Another indirect method of removing a particular gaseous constituent from a mixture by the electrical processes is illustrated by an installation now in operation at the Hooker Electrochemical Co., Niagara Falls, where the exit gases of the chloride of lime factory are freed from their last traces of chlorine by first blowing into them as they travel along finely divided slaked lime and a little farther down the flue recovering this again by the precipitation unit shown in figures 40 and 41. Although the lime thus remains in the gases only a few seconds, it is in such a fine state of subdivision that absorption is complete and the gases leave the treater without a trace of odor.

Still another application, which in a sense is almost the reverse of this procedure, has been worked out in connection with the drying of solutions and emulsions, such as milk and other unstable material, by atomizing them in a fine spray into warm dry air and collecting by electrical precipitation the fine dry powder left by the evaporation of the microscopic droplets as they float along.

Science News Letter, May 2, 1931

Of the 78 medical schools under the United States flag, the largest enrollment is at the University of St. Thomas, Faculty of Medicine and Surgery, in the Philippines.

The Rare Earth Elements

"Despair of Systematic Chemists"

are the subject of

NEXT WEEK'S CLASSIC OF SCIENCE
