INDUSTRIAL DUST COLLECTION

Thesis for the Degree of M. E.

Carleton W. Brown

1931

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INDUSTRIAL DUST COLLECTION

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by

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Candidate for the Degree of

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American Air Filter Company

Mid-West Air Filter Company

Whiting Corporation

Tirage et Ventilation Mecaniques de Paris

Prat-Daniel Corporation

Westinghouse Electric and Manufacturing Company

Dust Recovery and Conveying Company

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INDUSTRIAL DUST COLLECTION

Rapid strides in the development of industry within recent years have created dust problems which constitute a serious nuisance. Atmospheric pollution in large cities has increased to such an extent that the elimination of dust has become a primary consideration in the design of modern plants.

In the past, industry has considered the dust evil merely as an unavoidable nuisance. Dust producing plants, such as cement mills, located themselves away from centers of population to avoid complaints arising from the objectionable conditions. Such methods of operation made economic efficiency an impossibility, due to the resulting high rate of labor turnover, the inevitable destruction of equipment, the loss of material, and the added cost of transportation. As industry came to the realization that this method was basically unsound from an engineering, as well as from a business standpoint, equipment was developed to eliminate the production of dust, or collect that which was unavoidable. The purpose of such collection was only the abatement of a nuisance, with no thought of any material of economic value being collected.

Recently it has been found that in some industries the material taken out of circulation is a valuable by-product or even a fraction of the main plant output. So, with the economic lure of by-product recovery, as well as the existing health and property hazard demanding improvement, the installation of dust collecting equipment is rapidly becoming a common practise in modern industry.

CLASSIFICATION OF "DUSTS"

According to Prof. W. E. Gibbs, in his much quoted book "Smokes and Clouds", the solid matter in suspension in the atmosphere may be divided into three classes. In order to fully appreciate Industrial Dust Problems it is necessary to understand the basis of this division. Dust is classified as those particles greater than 1/1000th of a centimeter in diameter, or 10 microns, a micron being 1/1000th of a millimeter. The particles ranging from 10 microns to 1/10th of a micron in diameter are known as clouds. Smoke is composed of particles ranging from 1/10th to 1/1000th of a micron. In this discussion we shall deal only with dust, those particles over 10 microns in diameter, since these constitute the major problem in industrial collection.

THE NEED FOR DUST COLLECTION

The industries utilizing dust collectors may be grouped under three headings according to the principle need for collection in each particular field. The first need for collection is the abatement of a dust nuisance, and the best example of this use is the modern power plant. The tendency today in power plants is toward the use of pulverized fuel. Due to the fact that in pulverized fuel burning the fuel burns in suspension in the gases in the combustion chamber, a greater percentage of solid matter reaches the chimney than when solid fuel is fired on a grate. Approximately twenty percent of the ash reaches the stack in the solid fuel burning, eighty percent in pulverized fuel firing. Increased boiler ratings, a modern efficiency method, increase the dust discharge from stoker or hand fired boilers, and plants which formerly considered their dust problems as negligible are forced to install collectors. It is becoming a common practice for power plants to install dust collectors, whether fired with solid fuel on a grate or with pulverized fuel.

A second need for dust collection is the recovery of valuable materials. Dust collecting apparatus may form a very efficient unit process in the preparation of such materials as dried milk and fruit juices or powdered soaps. In spray drying the material, in liquid form, is sprayed into a warm current of air and dried instantaneously, forming small solid particles. The next problem is the separation of the solid particles from the air stream. This is usually accomplished by passing the air stream into a settling chamber which removes the larger particles, the smaller particles passing along with the exhaust. In order to recover this valuable material, which constitutes a large percentage of the whole, the exhaust is passed through an efficient collector, which

separates the finer particles from the air stream.

The third problem in the field of industrial dust collection is the combined need for the abatement of a dust nuisance and the recovery of valuable materials. Various types of grinding and smelting plants are faced with this problem. In silica sand, glass, metal refining, limestone grinding, cement, chemical, zinc oxide, coal pulverizing, polishing, and grinding plants, the dust which floats in the air, if collected, is in almost all cases valuable, if allowed to contaminate the air, a nuisance.

During the process of heating metallic lead, in order to manufacture the oxides of lead, such as red lead, a large amount of lead oxide dust is liberated. Should this dust be allowed to escape into the atmosphere, it would be a menace to the men employed, and to the surrounding territory, as well as a great economic loss due to the valuable material allowed to escape.

The energy expended in grinding and pulverizing material is not directly proportional to the degree of fineness of the finished product. The energy used to grind a material from its original state to twenty mesh fineness is small compared with the energy required to grind a material from a twenty mesh to a three hundred fifty mesh. The dust loss from any grinding or pulverizing process occurs from the finest, and generally most valuable, material after it has taken its due of wear and power from

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every operation in the course of production. It is imperative that this dust loss be collected in order to counteract to some degree the additional energy used in reducing it to so fine a mesh. By the use of separators and air filters it has been made possible to produce bone black consistently finer than three hundred fifty mesh without loss of material.

While the finer dust produced in grinding processes is most valuable, it is also the greatest health hazard. It is the smallest particles which pass the natural dust filter system of man and cause injury to the respiratory system. The proper dust collection system alleviates this hazard in the process of saving the valuable commercial product.

TYPES OF COLLECTORS

In order to fully understand and appreciate the real value of dust collectors, it is necessary to become familiar with the various types and the particular type of work to which each is adapted. Dust collectors may be divided into five main types. One of the earliest and simplest is the settling chamber which is merely a large chamber into which the gas or dust-laden air is discharged. The velocity of the gases entering the chamber is decreased to a point where the large particles of dust will settle to the bottom, and the gas, with the remaining finer particles, will pass on out of the chamber. This type is of definite value only where the volume of gas is comparatively small and the concentration of dust is relatively heavy. It can be readily seen that where large volumes of gas are involved the space required for a settling chamber of sufficient size would be out of the question.

Let us next consider the case of large volumes of gas with comparatively light concentration. Here we may use the electric precipitator since it best adapts itself to this condition. This type of collector consists of a chamber with alternate vertical rows of positive and negative electrodes. High potential rectified alternating current is applied to the electrodes, ionizing the dust laden gas and inducing a high potential charge on the dust particles. These electrically charged particles move towards the positive electrodes, and cling to them until they build up to such a thickness that they drop to the floor of the chamber from their own weight.

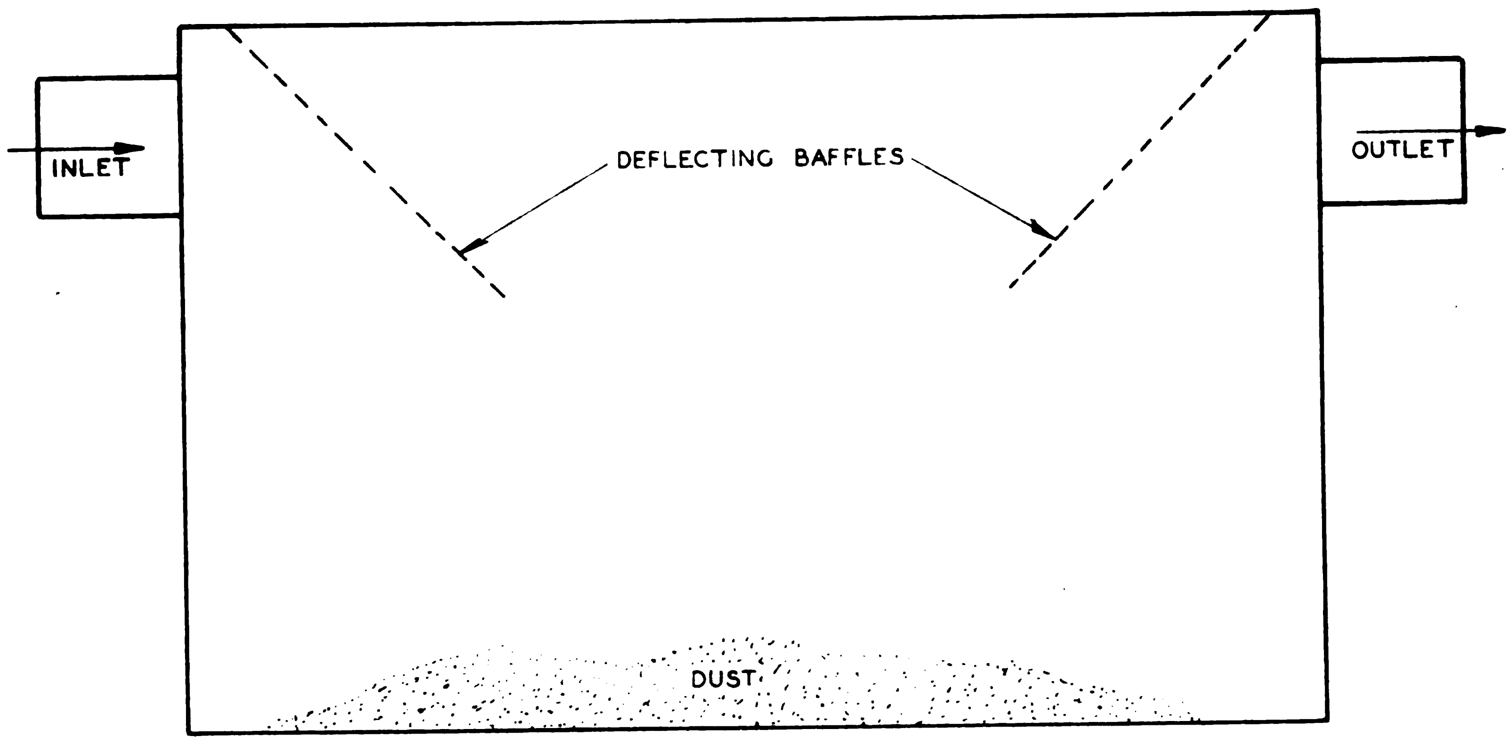
Air washers or gas scrubbers as they are sometimes called may be used in connection with non-acid forming gases or dust. The more common gas scrubbers are made up of a series of spray nozzles and a set of eliminator plates. The dust-laden gas passes through the mist from the spray nozzles, then the dampened particles of dust adhere to the eliminator plates as the gas scrubs over them.

Air filters may be employed when the dust-laden gas is at a temperature less than 250° F. and the dust concentration is light. They may be divided into two main types. The first, and original type, is the dry filter which consists of a fine screen through which the air is strained. The second, is the viscous type which utilizes the principle of adhesion. In this type the dust-laden gases are impinged against a surface coated with a viscous material which holds the dust particles and allows the dust free gas to pass on.

Perhaps the best known and most widely used collector is the centrifugal type. The centrifugal collector consists of a circular or volute casing into which the gases are admitted tangentially. The dust-laden gas is subjected to centrifugal action by being forced to flow in a curved path. The dust, due to its density, tends to move radially outward and also down, thus describing a helical path, and finally comes to rest at the bottom of the collector. The dust free gas passes upward and out through the center of the collector, following the action of a cyclone. This type of collector may be adapted to any volume of dust-laden gas with a high dust concentration.

SETTLING CHAMBERS

One of the earliest types of dust collectors was the settling chamber, which consisted of a large gas tight chamber (Fig. 1) into which the dust-laden gases were discharged, and the dust allowed to settle out due to gravity. The cross sectional area of the chamber must be greater than the area of the gas supply duct in order to decrease the velocity of the gas. The length of the settling chamber may be determined by calculating the time required



TYPICAL SETTLING CHAMBER

FIG. 1

11-8-30 C.W.B.

for the dust particles to fall to the bottom of the chamber, and with this factor and velocity of gas being known, the problem is simple. In practice the length should be about fifty percent greater than the actual calculated length. While this type of collector is simple and requires little attention it is not practical due to the space required and will only separate out the heavier particles of dust.

ELECTRIC PRECIPITATORS

The precipitation of suspended matter in gases may be accelerated by electricity, either in the form of direct or alternating current. When an alternating electromotive force is applied to a gas containing suspended particles, the action consists in an agglomeration of the particles into larger aggregates of the suspended particles which produces more rapid settling of these aggregates due to the influence of gravity.

In the case of large volumes of rapidly moving gases the settling process as outlined above is too slow to be of commercial value, so we must turn to another type.

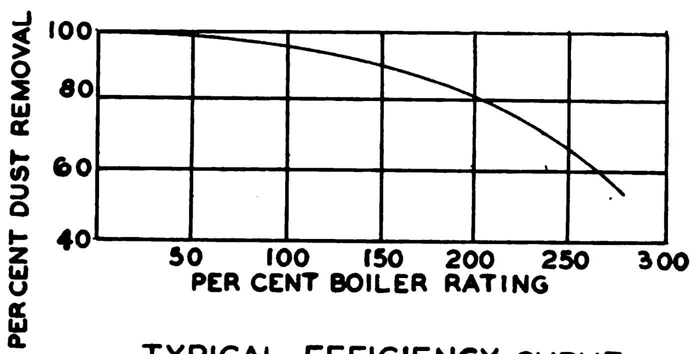
If we bring a needle point connected to one side of a high potential direct current line near to a flat plate connected to the opposite side of the line we find that the air space between becomes highly charged with electricity of the same sign as the needle point, regardless of whether the needle point is positive or negative, and any insulated body or particle brought into this space will receive a charge of the same sign. If the body or particle is free to move it will be attracted to the plate of opposite charge. The speed with which the particle will move towards the plate is directly dependent upon the potential gradient between the needle point and the plate.

Electrical precipitation takes place regardless of whether the discharge electrode is positive or negative and the direction of the discharge is independent of the polarity and determined only by the size and shape of the opposing electrodes. However, in practice, it is found that the negative discharge is much more stable and can be operated at a higher potential without danger of disruptive discharge. Consequently, it has become standard practice to make the discharge electrodes negative and the grounded electrodes the positive.

Conditions of temperature, acidity, and like qualities of the product to be handled limit the application of the several mechanical methods on the market for collecting or suppressing dust. The electrical precipitator, on the other hand, is applicable to any form of dust, whether acid or alkaline, at an almost limitless range of temperature. The electrical method has been successfully operated in a number of plants of various kinds, and has proved itself simple, economical, and effective when operating on valuable dusts.

Electrical precipitation processes are being applied to power plants located in centers of population to remove the fly ash from the flue gas; to gas plants for removing the dust, tar and lamp black from the gases; to industrial processes producing fine powders, as in the manufacture of lamp black, zinc oxide, and dried foods; to cement plants to collect potash and cement dust; to lead and copper smelters to eliminate the dust nuisance and to reduce metal losses from the stacks, as well as to iron blast furnaces for recovering potash values and eliminating ore dust. Designed simply for the suppression of a nuisance, the value of otherwise wasted material which they have collected has made them almost invariably a profitable investment. One amazing development has been the ability of the process to obtain potash in commercial quantities from cement kiln vapors. The dust collected is not finished cement, but chiefly raw mix carried out by the gases. This raw mix contains a small amount of potash, the most of which is condensed and caught in soluble form in the dust. The material thus collected, even in its crude form, is a fertilizing agent which finds a ready market at nearly as good a price as the finished cement.

The electrical precipitation process, however, possesses the inherent defect that as the dust concentration is increased, the efficiency of the collector falls off as shown by the accompanying typical efficiency curve.

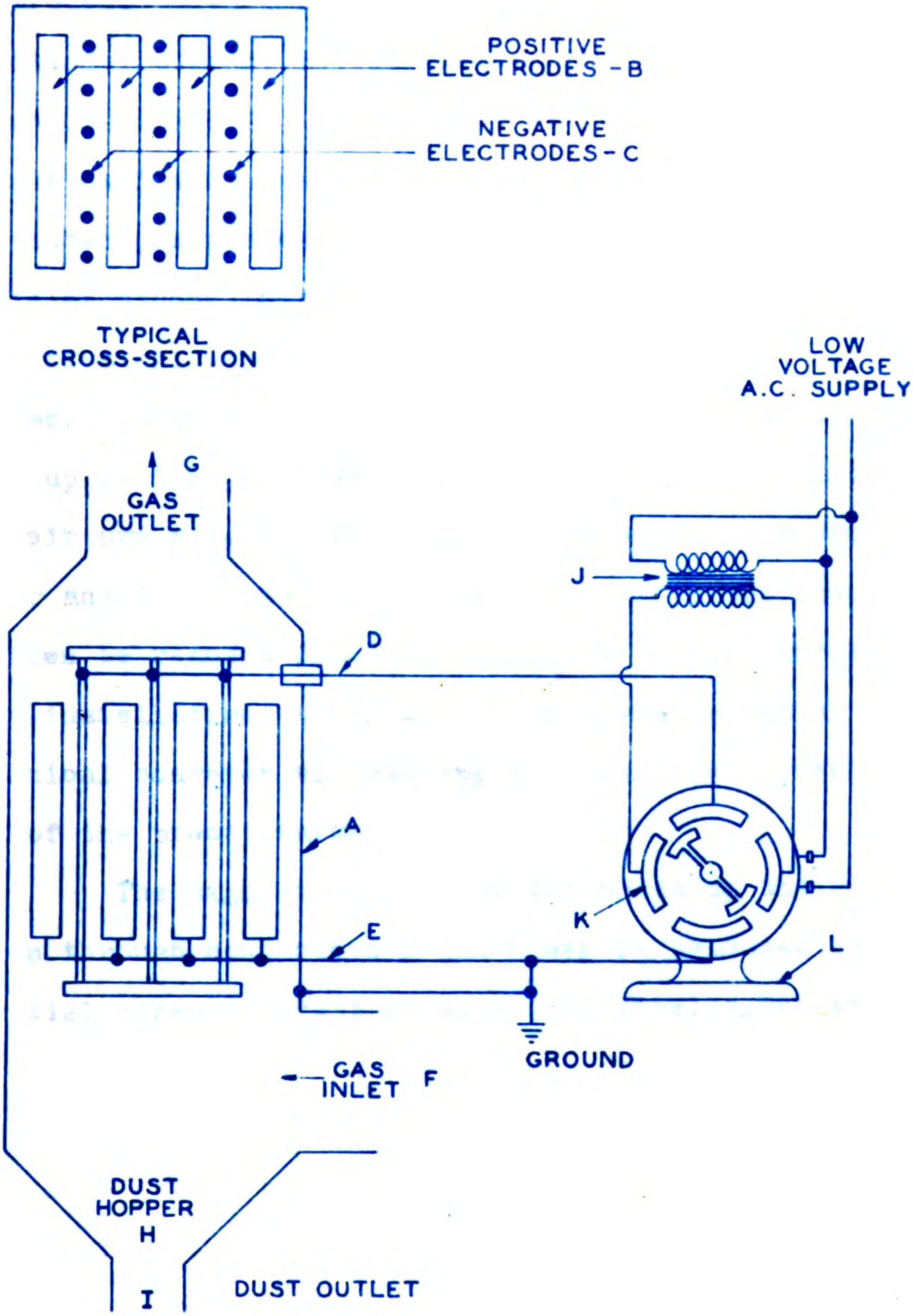


TYPICAL EFFICIENCY CURVE

At a really heavy dust concentration, this method is practically useless. The efficiency of the electric precipitator also varies with the size of the dust and the time that the dust-laden gas remains in the precipitation chamber. Since a collector in which the efficiency rises as the volume and dust concentration increase is the ideal dust separator, the character of an electrical precipitator is the least desirable in this respect. Other objections to the electrical precipitation method are the high initial cost, and operating expense. Only where the dust collected is a valuable material is this means of collection practical from an economic standpoint.

The general design of the electrical precipitators is shown by Fig. 2. There are many variations of this design but the main differences lie in the material used in construction and not in the general layout.

In general, an electrical precipitator consists of a housing (A), through which the dust-laden gas passes.



TYPICAL ELECTRICAL PRECIPITATOR
FIG. 2

1-24-31 C.W.B.

This housing contains the positive (B) and negative (C) electrodes. Either high potential direct current or uni-directional current is supplied to the electrodes through conductors D and E. The dust-laden gas enters the precipitator at F and passes up between the electrodes. As the dust-laden gas passes between the electrodes the dust particles become ionized and are attracted to the positive electrodes allowing the dust free gas to pass on and out of precipitator at G. The dust particles continue to build up on the positive electrodes until they fall, due to their own weight, or are shaken loose by a mechanical rapper and fall into dust hopper (H). The dust collected may then be removed from hopper at the dust outlet I. In large installations this removal is accomplished by a mechanical conveyor without any interruption to the operation of the precipitator.

The high static charge impressed on the electrodes through conductors D and E may be produced by high potential direct current or uni-directional alternating current. Although it is possible to produce high potential direct current of 50,000 volts and more it has been found to be more practical to use rectified high voltage alternating current. This is accomplished, as shown in Fig. 2, by stepping up the voltage of the low voltage supply, by means of a transformer J, to the desired potential. This high potential alternating current is then changed to uni-directional current by means of a rotating contact maker or mechanical rectifier (K) driven by a synchronous motor (L).

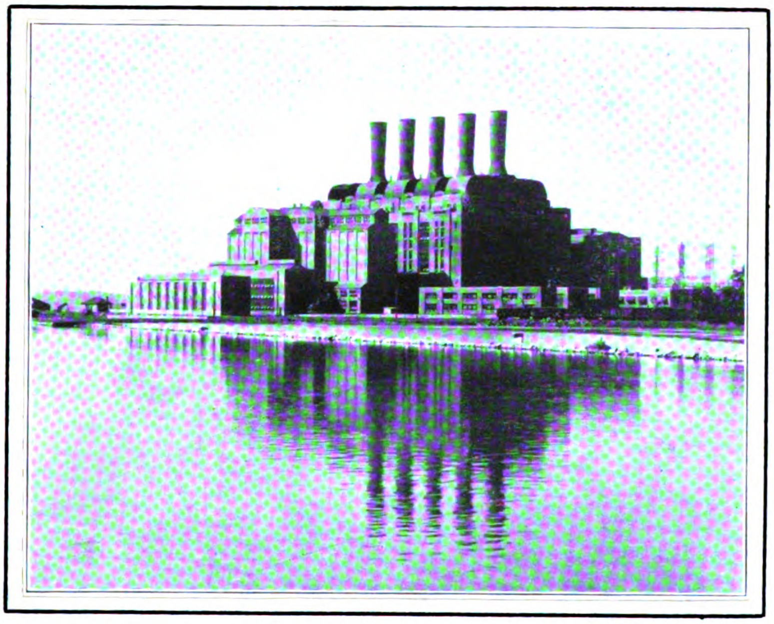
In general practice the positive electrodes (B) are iron plates and the negative electrodes chain or two strands of iron wire between which is twisted cotton or asbestos and mica preparations, depending upon the particular dust-laden gas at hand.

The writer had the privilege of seeing the electrical precipitator installation at the Trenton Channel Plant of the Detroit Edison Company (Fig. 3) in operation. In this installation the precipitator consists of a dust chamber in which are suspended 2 inch concrete slabs spaced 10 inches apart, center to center, which act as the positive electrodes. The negative electrodes consist of 12 gage steel rods spaced mid-way between the concrete slabs. This installation was designed and installed by the Detroit Edison Company under license of the Research Corporation of New York and is an innovation as far as electrical precipitators are concerned.

AIR WASHERS

Air washers or gas scrubbers, in general, are not applicable to industrial dust problems, and their use is almost completely confined to air washing in connection with air conditioning. Two exceptions to this are the installations at the Calumet Power Station in Chicago and at the Kneeland Street Station in Boston.

Considerable time was spent by the writer at the Calumet Station in connection with flue dust problems



TRENTON CHANNEL STATION
DETROIT EDISON CO.

FIG. 3

and it was his privilege to witness a series of tests of the gas scrubber in operation on a powdered fuel boiler there. While the gas scrubber was successful in removing the fly ash, the difficulties encountered in connection with its operation tend to prohibit its general use. The water from the scrubber contains sulphuric and sulphurous acids which attack and destroy the majority of materials. The problem then, with this type of collector, is one of constructing a plant to withstand the action of the acids formed, rather than the collection of the dust. Concrete and rubber linings have been tried, but to the writer's knowledge have not proved satisfactory.

The quantity of water required for this type of collector, as applied to large power plants, presents another problem, since recirculation of the water will increase the acid concentration, which will further increase the difficulty of constructing equipment to withstand the ravages of the acid.

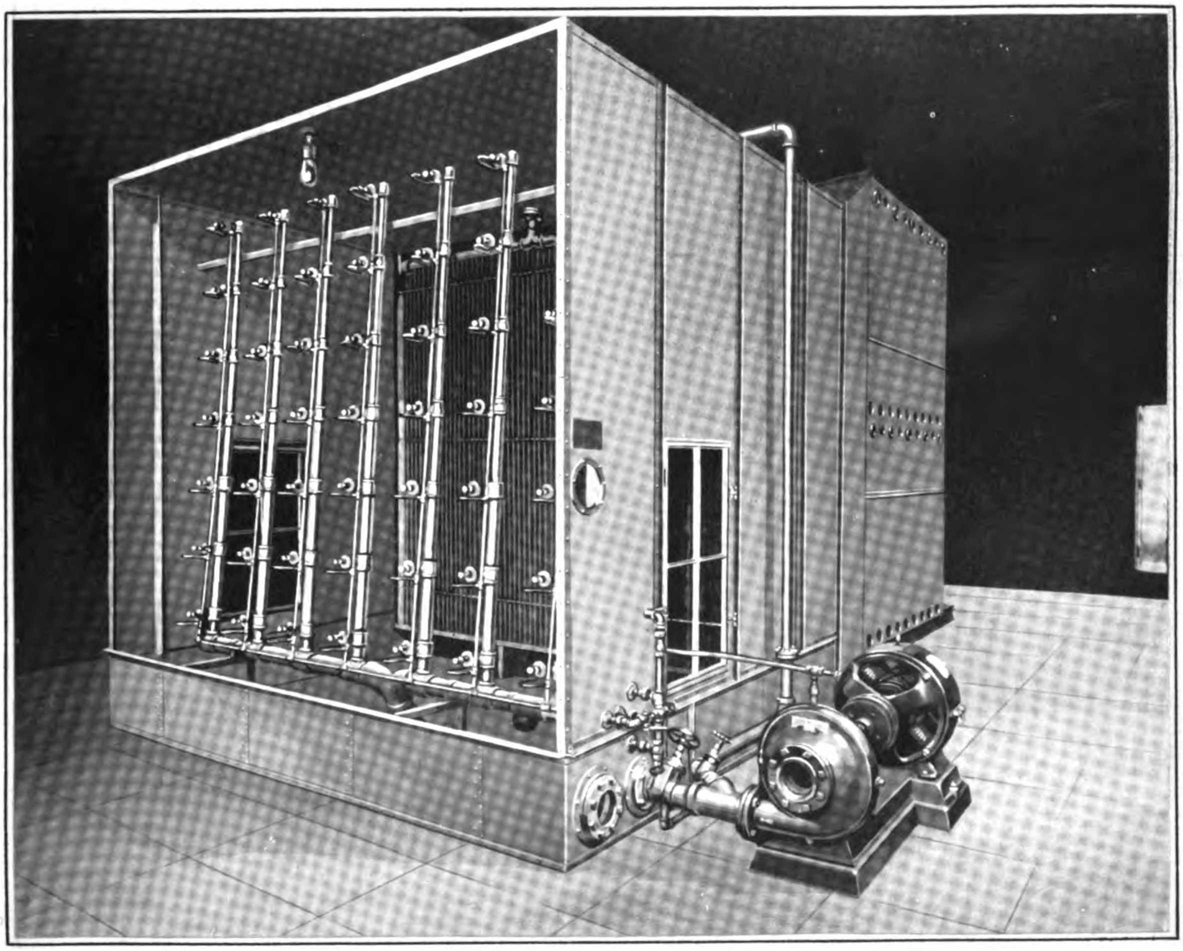
Another problem arises in the disposal of the effluent from the scrubber when the washer or scrubber is applied to a gas containing any appreciable amount of dust. Since very few plants are so located that the effluent may be discharged directly into a stream, without serious results, it is necessary to separate the dust from the water.

The separating of the dust from the water presents a problem which is about as difficult as the original problem of separating the dust from the gas. When the washer or scrubber is applied to a gas containing a valuable dust, the dust so collected must be reprocessed, which further increases the cost of operation.

The process of eliminating dust from gases by means of a washer or scrubber consists of passing the dust-laden gas through a finely divided water spray to obtain a thorough mixture of the dust-laden gas and the water. The wetted gas leaving the spray chamber is passed over a series of vertical scrubber and eliminator plates. These plates are provided with a series of 30° bends to deflect the gas and impinge the dust particles against the wetted surface of the plates. The dust particles are entrained and flow down the surface of these plates into a tank or settling chamber, from which they are removed.

In addition to the spray nozzles in the spray chamber, the washer contains a series of flooding nozzles over the scrubber and eliminator plates to wash down the dust particles collected on the plates.

Fig. 4 shows a typical washer complete with recirculating water pump. Fig. 5 shows a centrifugal spray nozzle employed in the spray chamber and Fig. 6 shows a flooding nozzle employed to wash down the scrubber and eliminator plates. Fig. 7 shows several views of the scrubber and eliminator plates installed in a washer.



TYPICAL AIR WASHER.

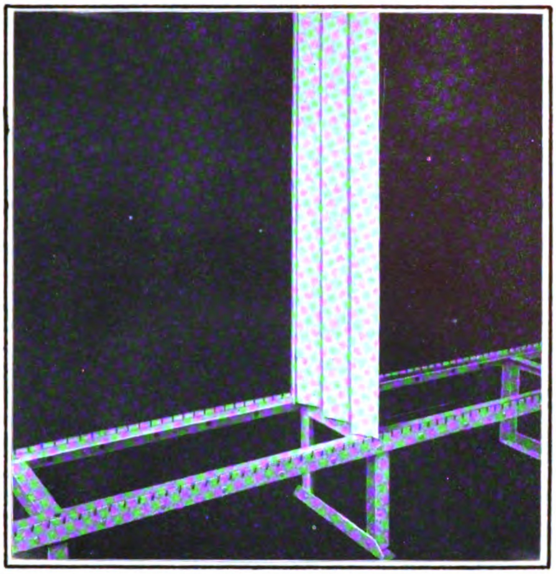
FIG. 4

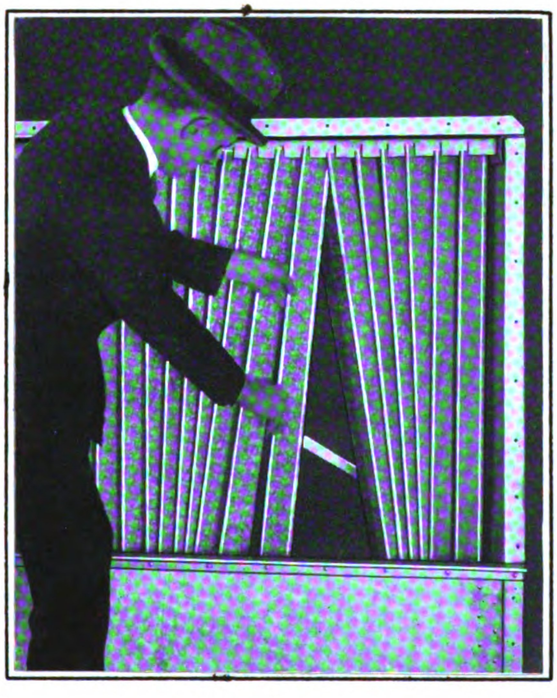
CENTRIFUGAL SPRAY NOZZLE

FIG. 5

FLOODING NOZZLE

FIG. 6





AIR WASHER ELIMINATOR PLATES

FIG. 7

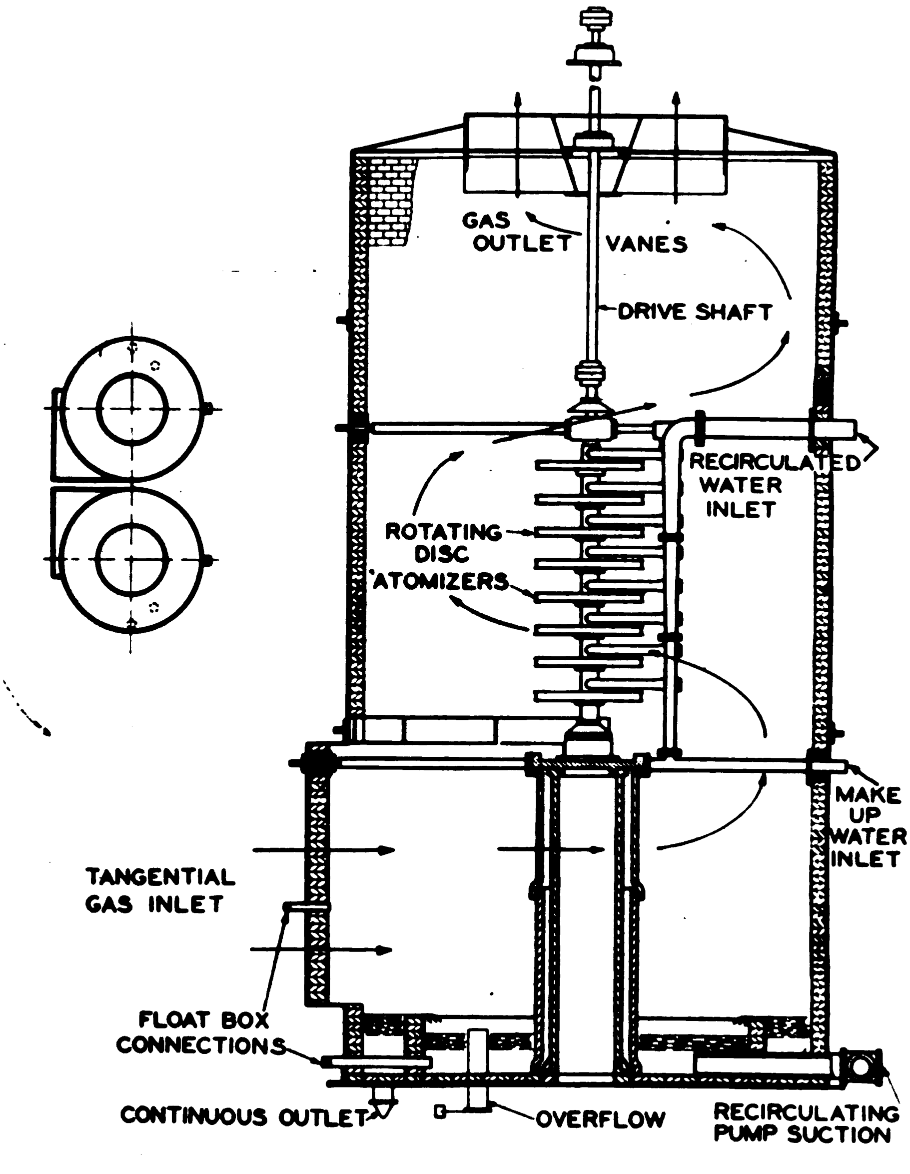
An article on "Smoke and Dust Abatement"* published in the "Heating, Piping and Air-Conditioning" magazine for February 1931, gives the following descriptions of several new types of gas scrubbers:

"Fig. (8) and Fig. (9) show the two types of vertical scrubbers installed in the new Kneeland Street Steam Heating Boiler Plant of the Edison Electric Illuminating Company of Boston, Massachusetts. Fig. 8 shows the design that utilizes the revolving disc atomizer. The gas is admitted tangentially at the bottom so as to give the gas a spin and is released at the top through straightening vanes which iron out the spin of the gas and reduce the pressure drop through the scrubber."

"The bottom of the scrubber forms a tank for the collection of the dust and water. A certain quantity of water is drawn off continuously to remove the dust and the remainder of the water is recirculated as the scrubbing medium. By spinning the gas with the tangential inlet the larger particles of dust are thrown out more readily by centrifugal action, and the water particles are thrown through the gas stream. Furthermore, the gas spin throws out all water particles and discharges moisture-free saturated gas from the scrubber."

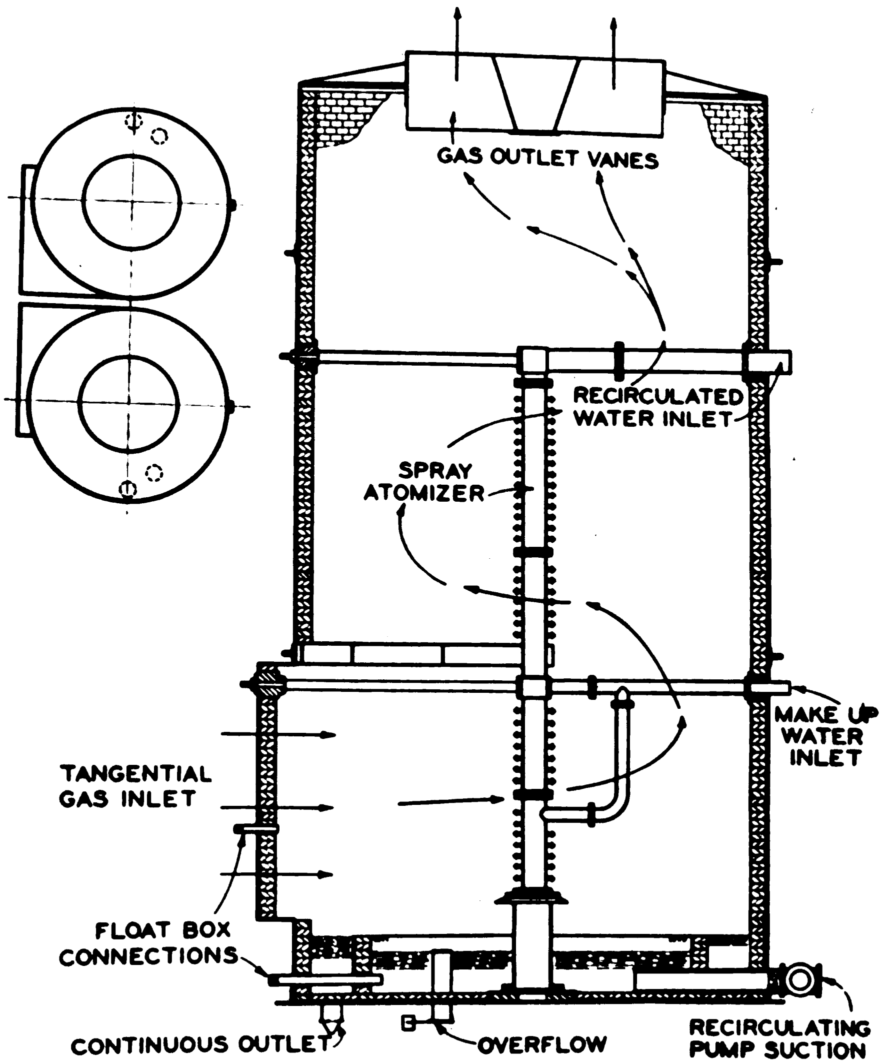
"Fig. 9 shows the design that utilizes the spray

*"Smoke and Dust Abatement" by Melvin D. Engle, Station Engineering Department, The Edison Electric Illuminating Company of Boston.



VERTICAL GAS SCRUBBER
DISC TYPE

FIG. 8



VERTICAL GAS SCRUBBER
SPRAY TYPE

FIG. 9

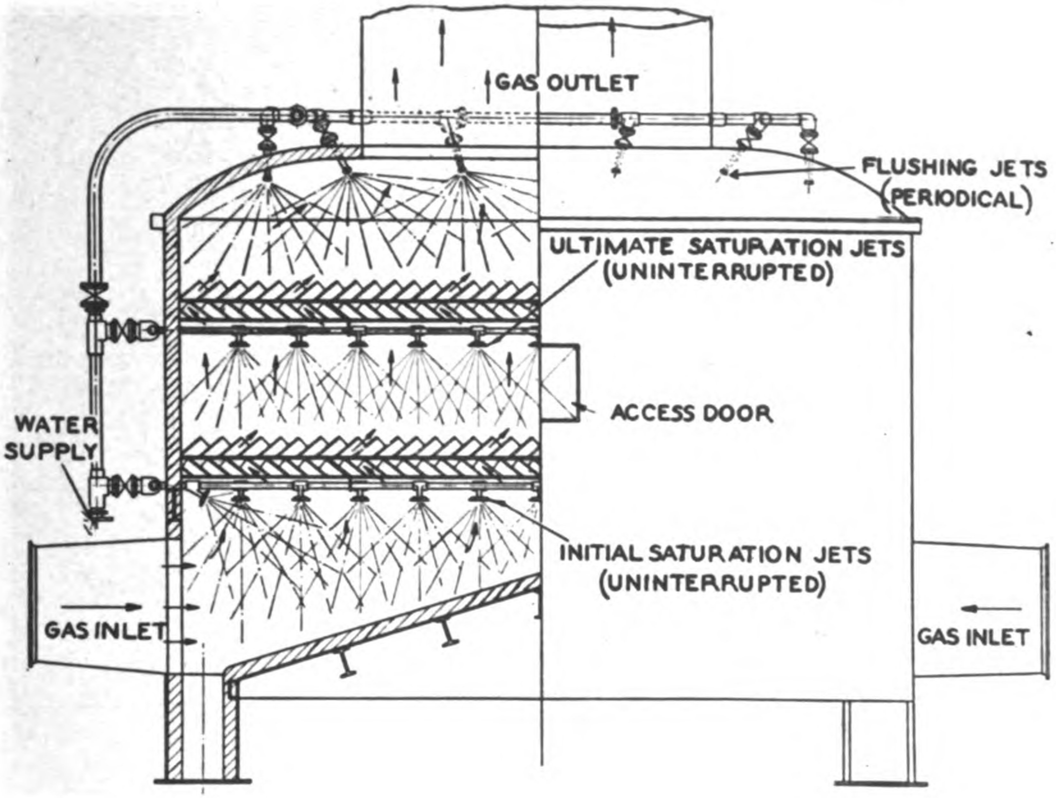
head type water atomizers. One boiler in the Kneeland Street plant is provided with the scrubbers equipped with the revolving disc atomizers, and the other boiler is provided with scrubbers equipped with the spray head type atomizers."

"The bottom or tank portion of each scrubber is lined with lead and the bottoms and shells are protected with a lining of acid-proof brick laid in acid-proof mortar. The discs, spray heads, and struts are constructed of special acid-resisting metal. Other parts are of cast iron painted inside with an acid-proof paint and protected on the outside with an acid-resisting plastic material."

"The rotating disc type of water atomizers undoubtedly give a finer spray than the spray heads. On the other hand, they are more expensive to install and maintain. The Kneeland Street plant installation in Boston should tell whether the more expensive atomizing device is necessary."

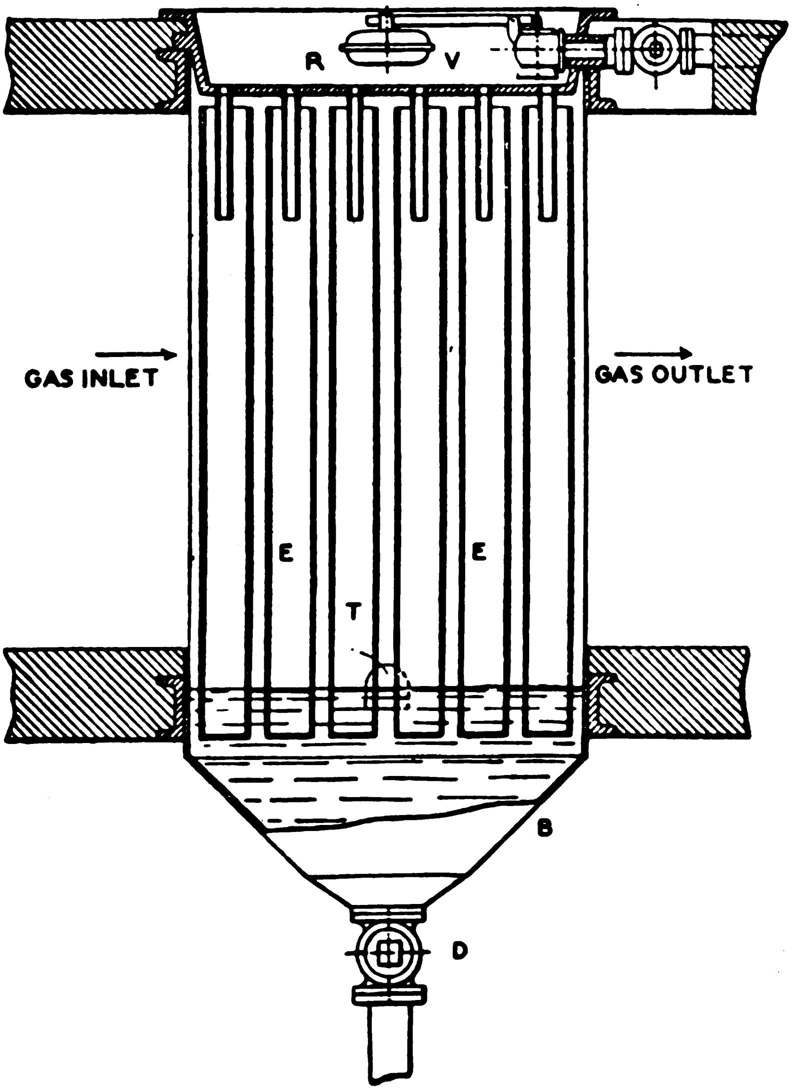
"Fig. 10 shows an English design of gas scrubber. As can be seen from the cut, the gas is admitted at the bottom and released at the top of a cylindrical shell. Inside the shell are arranged two sets of sprays which are operated continuously, and two sets of baffles. Above the top set of baffles is installed a set of flushing sprays for periodically flushing off the baffles. The water is drained away at the bottom."

"Fig. 11 shows a gas scrubber which differs



ENGLISH GAS WASHER

FIG. 10



FRENCH GAS SCRUBBER

FIG. 11

radically from the types of scrubbers described previously. In this scrubber the shell is rectangular and the gas flow is horizontal. Inside the shell are arranged large numbers of closely spaced pipes, rectangular in shape, which are closed at the bottom and open at the top. Water is admitted through calibrated orifices into the top of the vertical pipes and overflows and keeps the outside of the scrubber pipes wet with a film of water. The gas is split up into thin vertical sections as it passes through the scrubber, and these vertical strata are subjected to several abrupt changes in direction. The dust is impinged against the wet scrubber pipes where it is caught and carried away to the sump below which removes the water and dust. By splitting the gas into the narrow strata, the particles of dust are only required to pass through a thin strata of gas to the collecting elements, the same as in the case of some of the dust traps. The water prevents the reentrainment of the dust particles, and the water that is evaporated increases the relative humidity of the gas and aids in the separating action."

AIR FILTERS

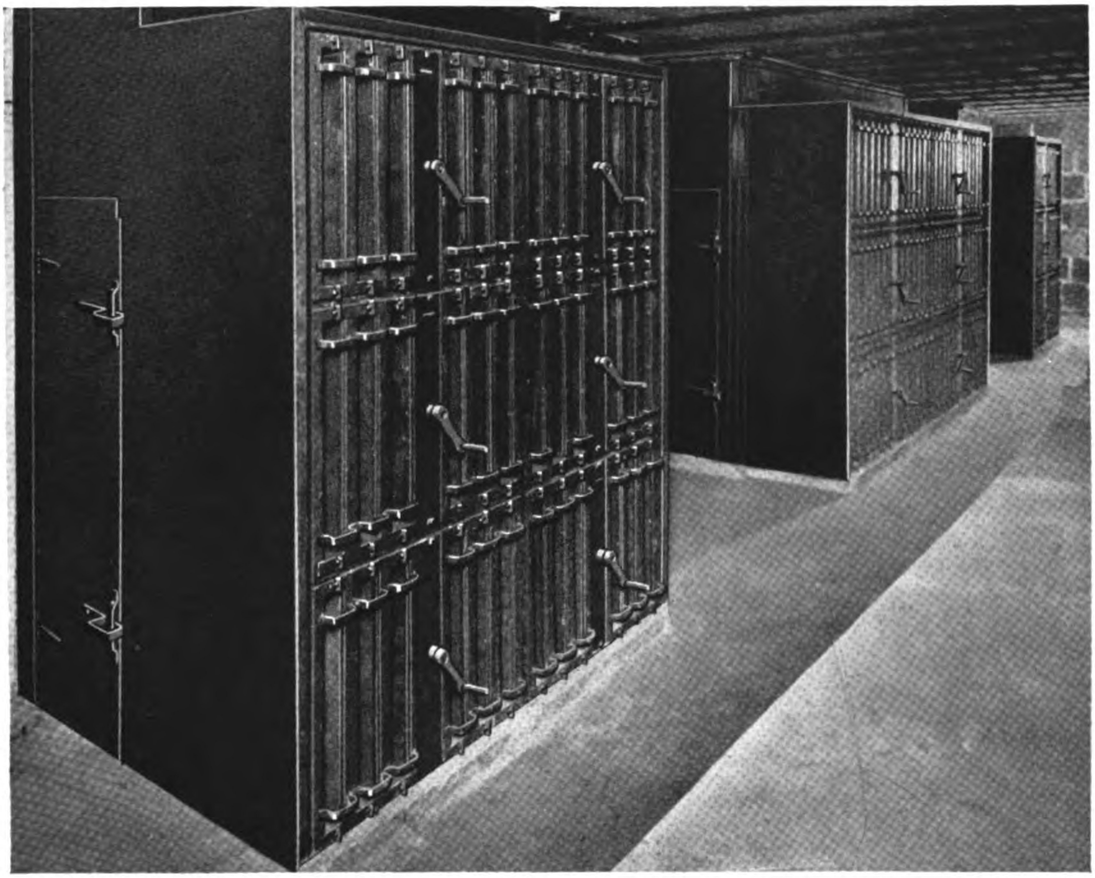
Air filters may be applied to advantage to remove the dust from a gas at a temperature of less than 250° F. with a light dust concentration.

When operating under proper conditions the air filter is, without a doubt, the most efficient mechanical collector. Filters may be divided into two main types.

The first is the dry type, which employs some form of screen to stop the passage of the dust particles and yet allow the cleaned gas to pass on. This type may be divided into three divisions: namely, collectors with porous paper, metal screens, and cloth screens or bags. The second type employs the principle of adhesion by means of surfaces coated with a viscous material which catches and holds the dust particles and yet allows the cleaned or dust free gas to pass on.

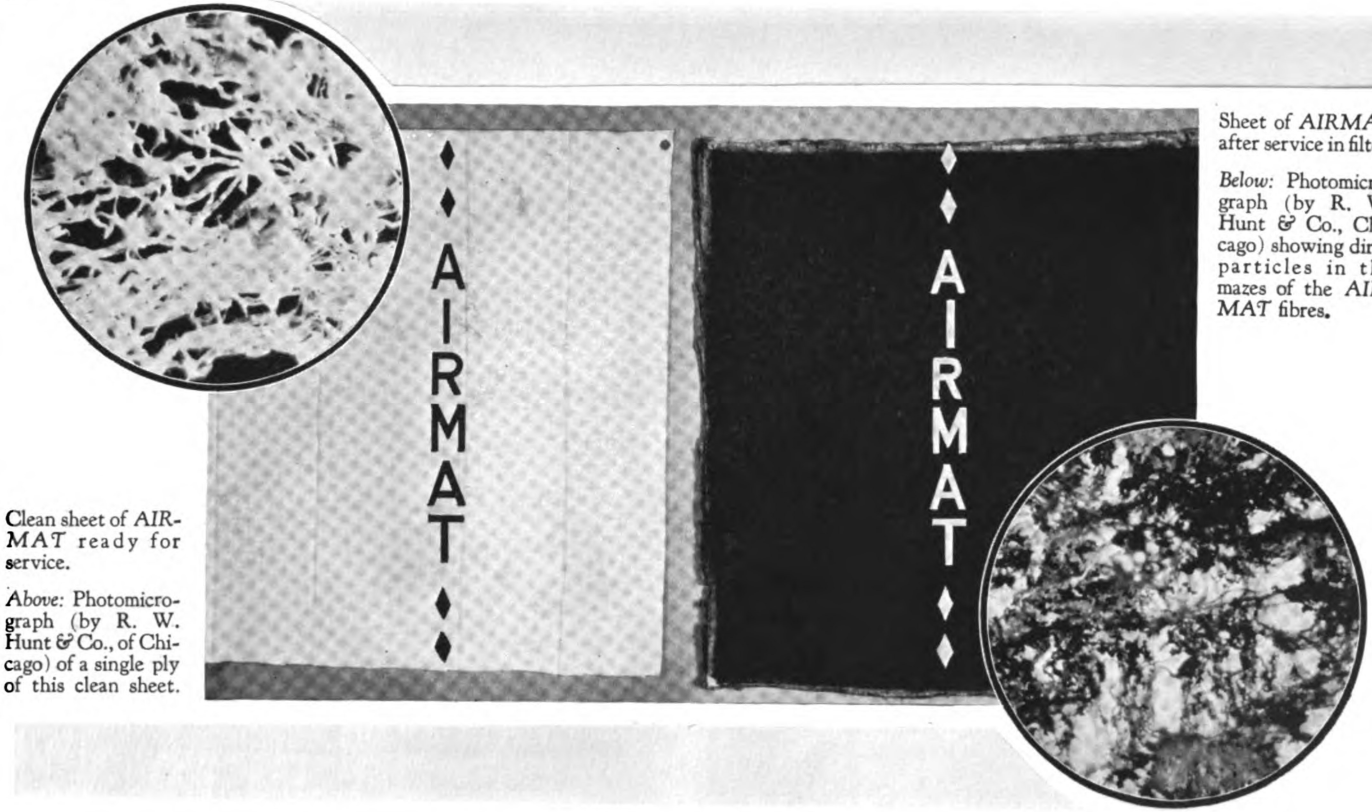
Fig. 12 shows a typical dry filter installation employing porous paper or AIRMAT as the filtering medium. This paper or AIRMAT as it is known commercially is an intermediate product in the processing of spruce wood fibres to make cellulose. Fig. 13 shows photomicrographs of a single sheet of AIRMAT before and after being placed in service. As can be seen by the photomicrograph, at the left of Fig. 13, the filtering medium is of a gauzy nature and is ideal for trapping the fine dust particles.

It is very important with the dry type of filter that the dust concentration be low since the pores in the filter fill very rapidly and become clogged. In some cases it is advisable to install some less efficient collector ahead of the dry air filter to remove the large particles of dust and thereby reduce the dust concentration reaching the dry air filter as shown by Fig. 14. It is also important that the temperature be kept above the dew point of the gas or air passing through the filter since the



Part of the Airmat Filter installation totaling 660,000 c. f. m. in the Western Union Building., New York City

FIG. 12



Clean sheet of *AIRMAT* ready for service.

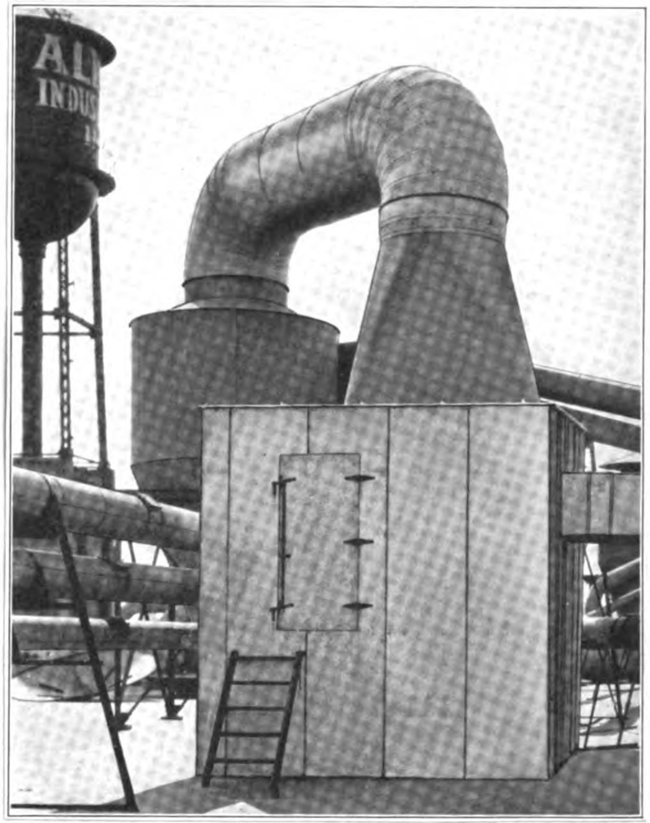
Above: Photomicrograph (by R. W. Hunt & Co., of Chicago) of a single ply of this clean sheet.

Sheet of *AIRMAT* after service in filter.

Below: Photomicrograph (by R. W. Hunt & Co., Chicago) showing dirty particles in the mazes of the *AIRMAT* fibres.

PHOTOMICROGRAPHS

FIG. 13



CYCLONE & AIRMAT FILTER
OPERATING IN SERIES.

FIG. 14

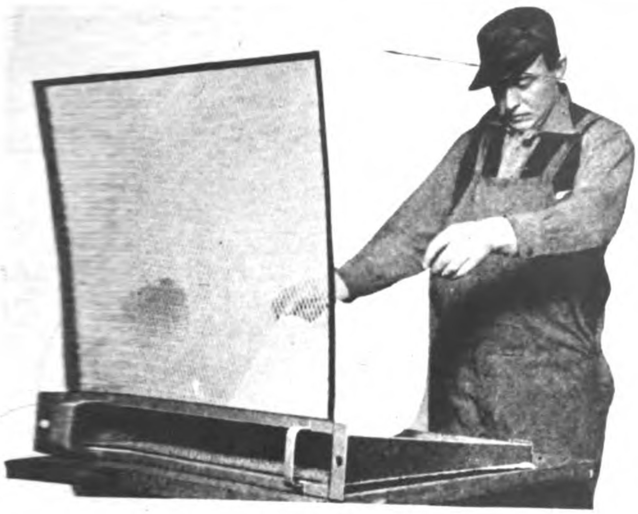
moisture would tend to clog the pores of the filtering medium.

In practice the filtering medium is placed against a wire screen support and is held fast by a second wire screen or a series of flat strips, as illustrated in Figs. 15 and 16. The detail of the filter pocket, Fig. 17, shows the detailed construction of the main filter element and the principle of operation.

The writer has had occasion to design and install a number of collector installations of this type and the results obtained were very satisfactory.

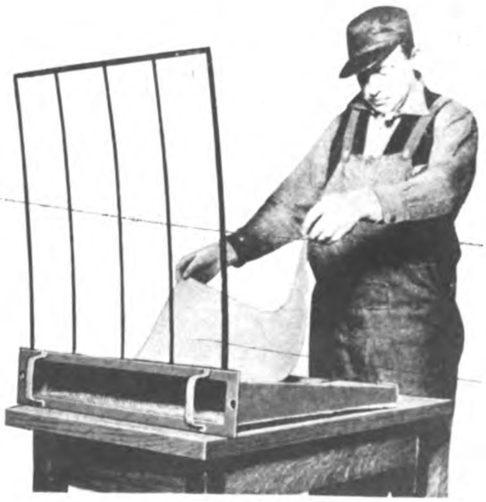
The screen type filter is very similar to the dry filter just described. It differs from it in that the filtering medium consists of a series of fine wire screens in place of the porous paper. This type of filter is readily adapted to installations where the dust particles are comparatively large but are not very satisfactory where very fine dust is encountered since the finest mesh obtainable, to the writer's knowledge, is a three hundred fifty mesh as manufactured by the Tyler Company of Cleveland, Ohio.

The writer has had considerable experience with the American Blower Corporation dry air filter, which is a dust trap employing a collecting medium similar in texture to that employed in the AIRMAT, and illustrated by the photomicrograph at the left of Fig. 13. In the case of the ABC filter the dust-laden gas or air is projected against



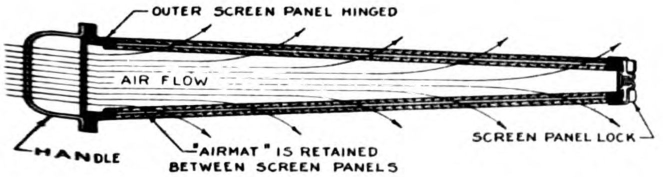
SCREEN TYPE HOLDER

FIG. 15



STRIP TYPE HOLDER

FIG. 16



Detail Pocket section through Pocket. Note direction of air flow, entering through its open end and passing outwardly through filter sheets on both sides.

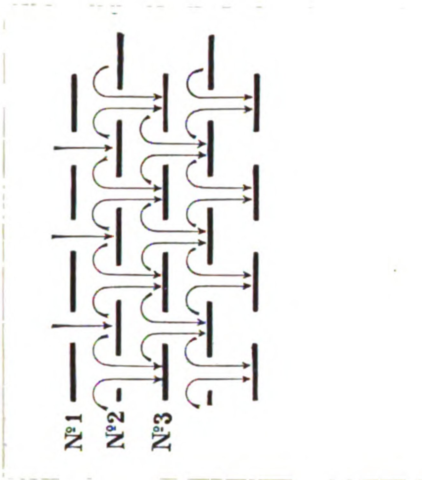
FIG. 17

the filament which seizes and retains the particles, while the cleaned gas or air rebounds from the surface, flows along the surface of the filament until it reaches an opening and then changes its direction and passes on through ten successive dust removal operations as illustrated by Fig. 18.

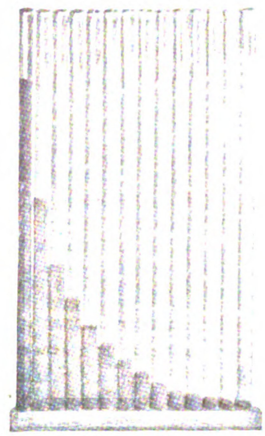
Fig. 19 shows the relative quantities of dust particles collected from plate to plate. As may be seen from the diagram the first plate collects the greater percentage of the dust. Fig. 20 shows one of the perforated plates used in the filter cell (Fig. 21).

Fig. 22 shows a fabric bag type of filter. The dust-laden gas is admitted at the bottom of the collector casing and is filtered through the bag filter elements. In this type of filter, the lower end of the bags are rigidly held in place, while the upper ends are fastened to a movable plate which is connected to a cleaning mechanism. When the cell is in operation, the upper ends are pulled up, holding the bags taut. When the bags are to be cleaned, the plate holding the upper ends of the bag is moved up and down, which motion shakes the dust particles from the bag down into the dust hopper. In practice this type of filter is readily adapted to any dust problem falling within the limits set up for the paper and screen filters.

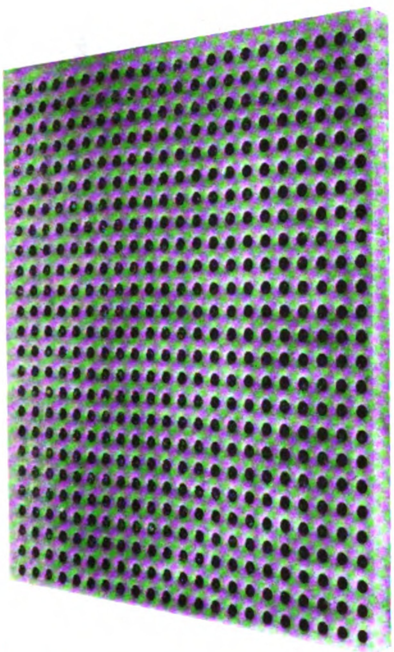
The writer spent some time testing this type of collector while in charge of the Dust Research Laboratory



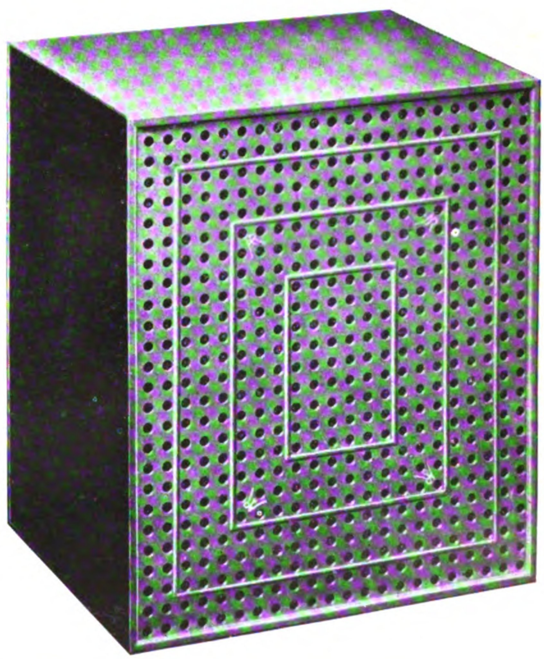
ACTION OF
A.B.C. FILTER
FIG. 18



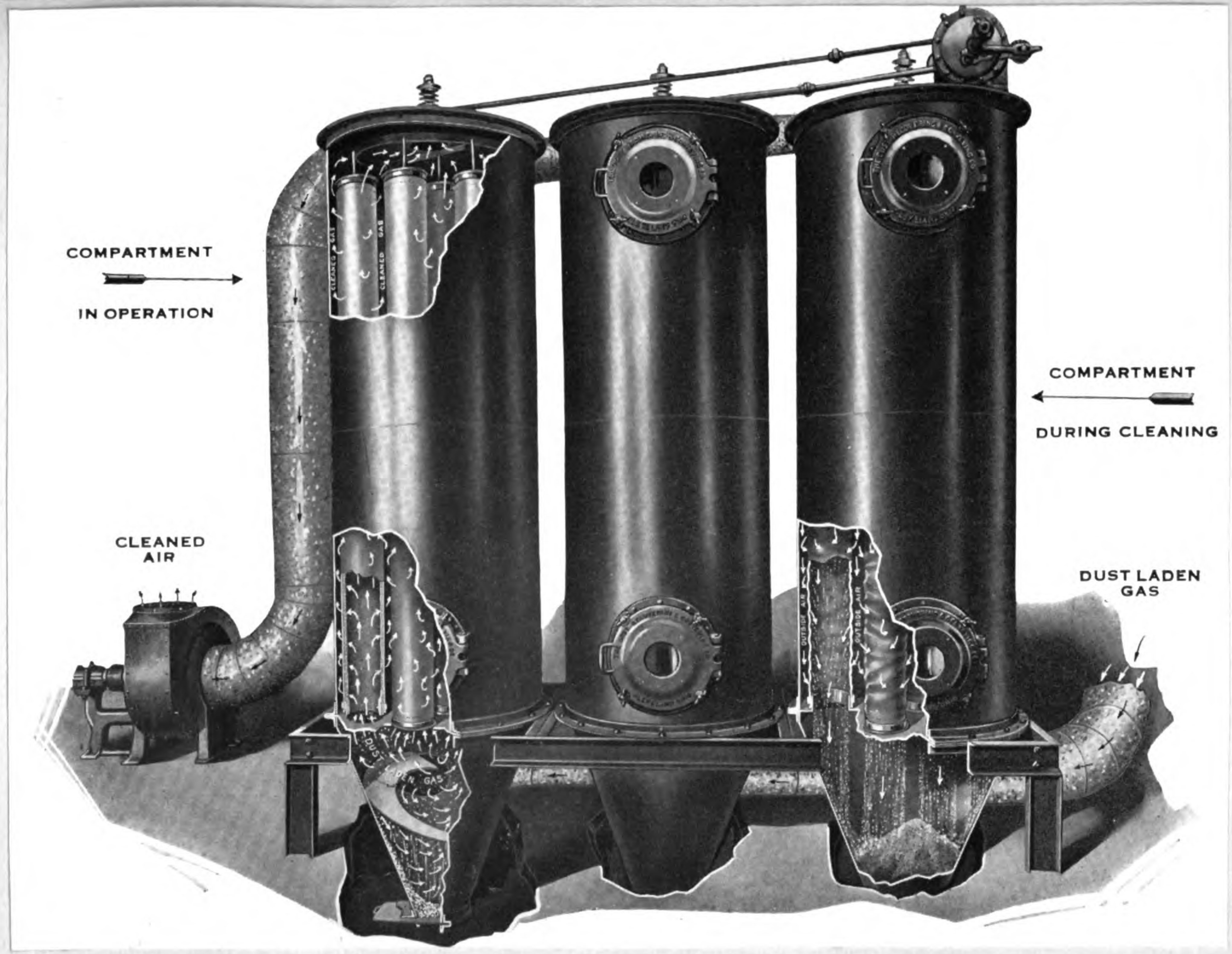
RELATIVE QUANTITIES
COLLECTED PER PLATE
FIG. 19



PERFORATED PLATE
FIG. 20



COMPLETED CELL
FIG. 21



BAG TYPE FILTER

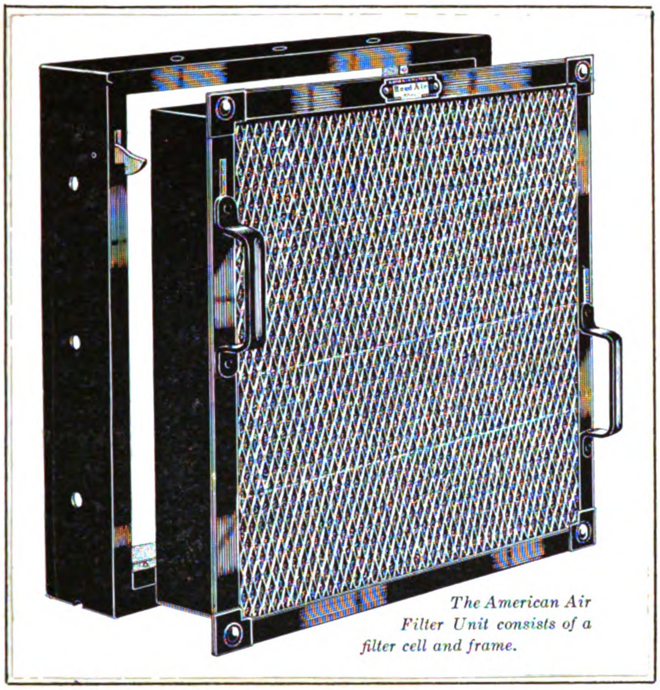
FIG. 22

of the American Blower Corporation and found it very satisfactory and very efficient. As in the case of the other filters its use is limited by temperature conditions.

The second main type filter employs the principle of adhesion by means of surfaces coated with a viscous material, which catches and holds the dust particles and yet allows the cleaned gas to pass on. This method of filtration is quite simple. The dust-laden gas is passed through a gas tight compartment containing a series of deflecting surfaces which are coated with a viscous material, usually oil. As the dust-laden gas impinges against these surfaces the gas is deflected and passed, while the inertia of the dust particles causes them to strike and enter the viscous film, which saturates and retains them in suspension within itself.

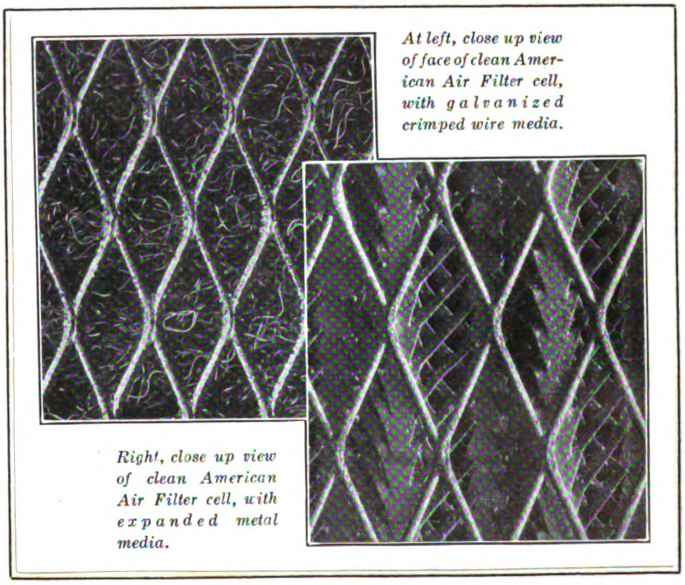
The first filters employing this principle were the unit or cell type which were non-automatic in cleaning. These units consisted of deflecting surfaces of metal, bent to various shapes, or of "steel wool" held in position between metal screens. Fig. 23 shows a cell of this type employing "steel wool". Fig. 24 is an enlarged section of this type cell showing the "steel wool" and the metal retaining screen.

This type filter proved very satisfactory, but its effectiveness depended upon the frequency of cleaning. Cleaning of this necessitates the removal of the cell in order to rinse out the dust particles and re-oil the



The American Air Filter Unit consists of a filter cell and frame.

FIG. 23



At left, close up view of face of clean American Air Filter cell, with galvanized crimped wire media.

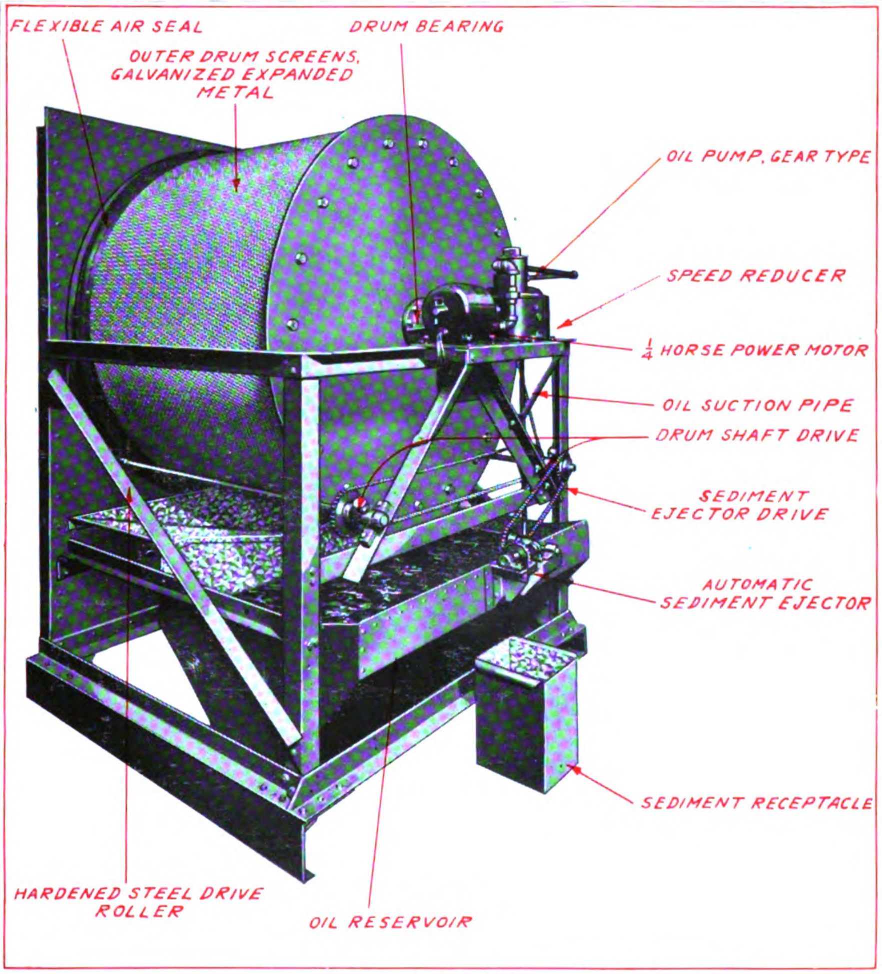
Right, close up view of clean American Air Filter cell, with expanded metal media.

FIG. 24

filtering surfaces. This process proved troublesome and expensive and lead to the development of the rotary oil filter shown in Figs. 25 and 26.

The filtering element of the rotary filter is composed of fine copper ribbon woven into a fabric wound layer upon layer upon a hollow cylindrical drum. This drum is mounted on a suitable framework and rotated slowly by means of a small motor. Oil is supplied by means of a small gear pump. The dust-laden gas enters the inside of the drum and passes out through the entire circumference of the cylindrical screen. In passing through this filtering medium the dust particles are caught and retained by the viscous material as in the case of the cell type filter. The drum is rotated periodically and flushed with oil on its inner surface at the lowest point. The oil stream filters through the screen to the reservoir below, completely washing away the dust particles and at the same time renewing the viscous film on the copper surfaces. On reaching the reservoir the dust particles, being heavier than the oil, settle to the bottom and are discharged by means of a small screw conveyor. Automatic oil filters possess the advantage that they require little attention over a long period of time,but may be applied only where the dust so collected is to be discarded.

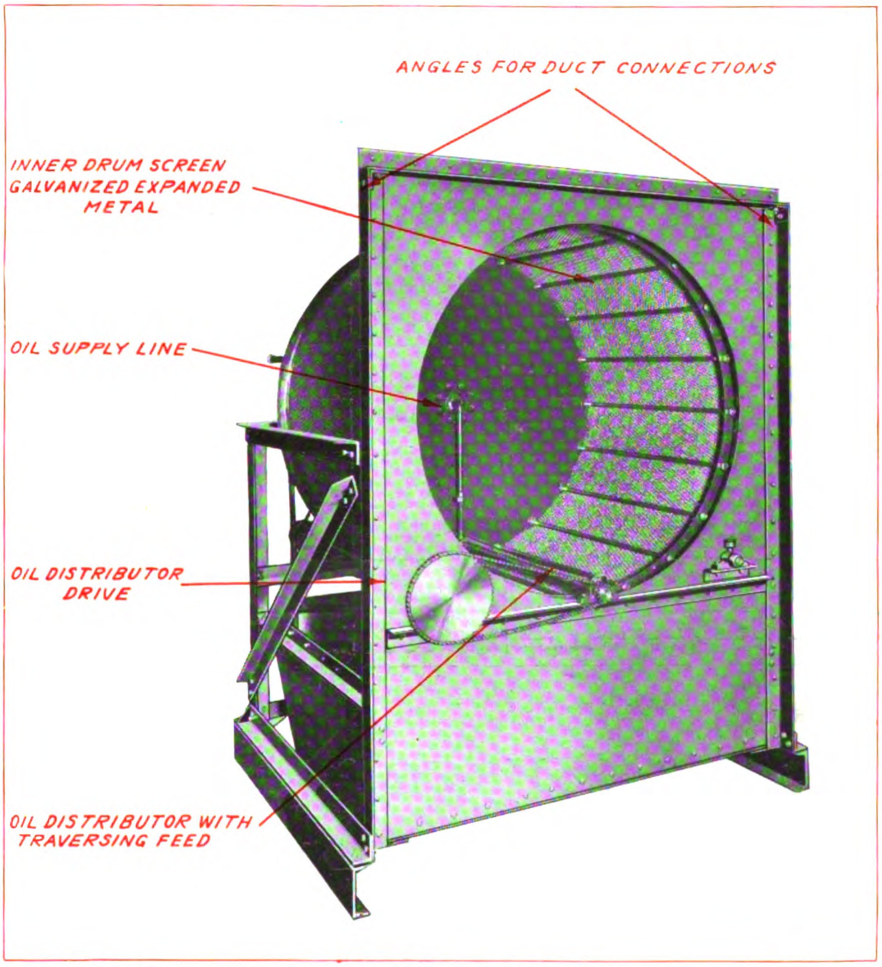
Figs. 27, 28 and 29 show cross-sections of some of the more recent types of automatic oil filters. Their operation is very similar to that described for the rotary



REAR VIEW
DIRTY AIR OR INLET SIDE

ROTARY OIL FILTER

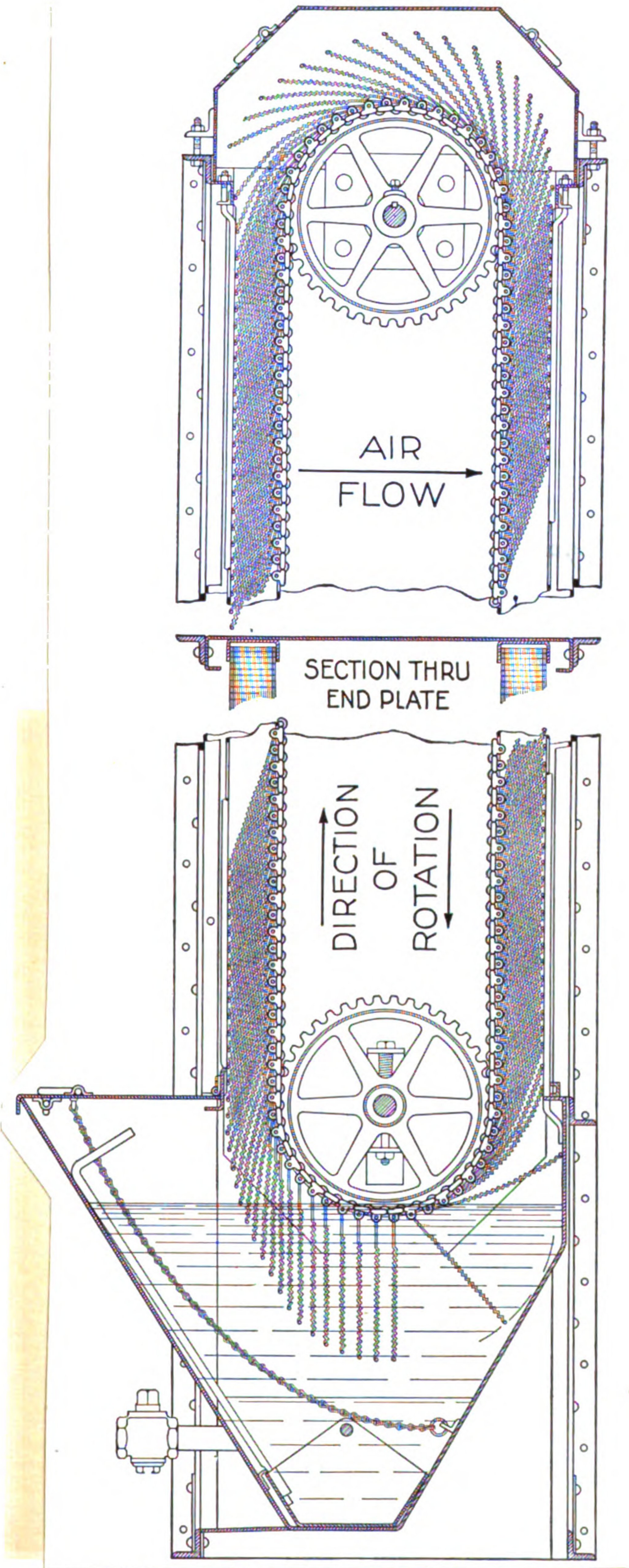
FIG. 25



FRONT VIEW
CLEAN AIR OR OUTLET SIDE

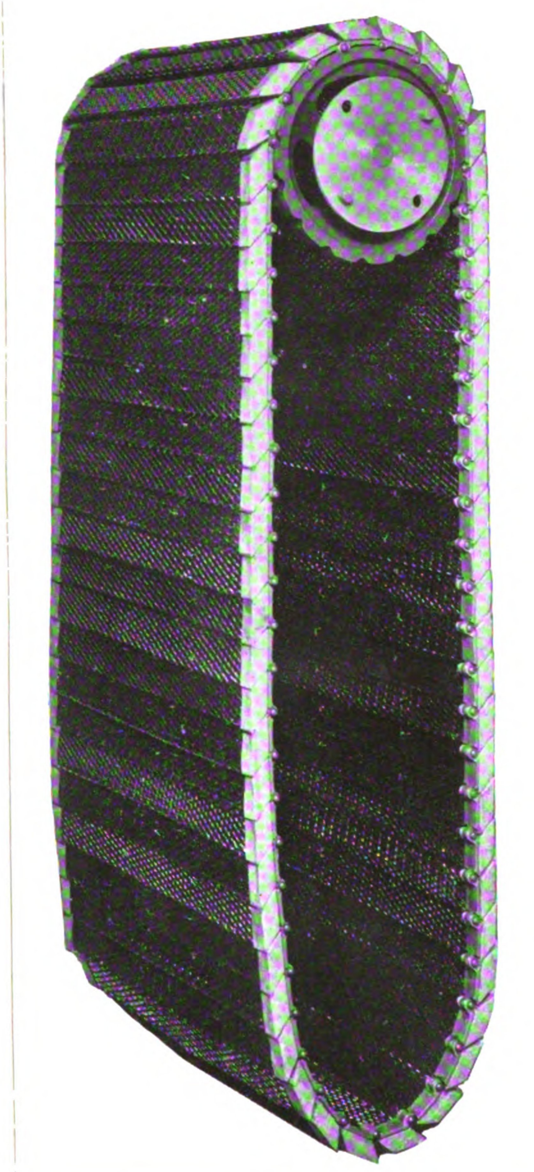
ROTARY OIL FILTER

FIG. 26



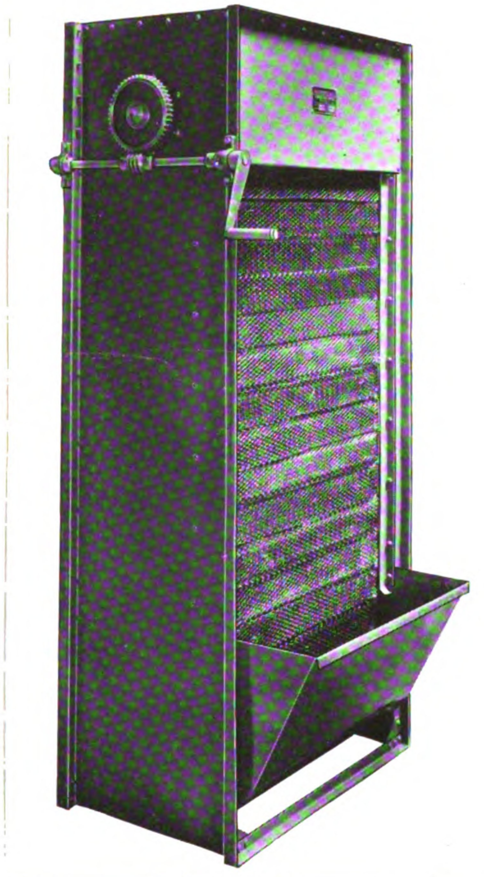
OIL
FILTER

FIG. 27



OIL FILTER

FIG. 28



OIL FILTER

FIG. 29

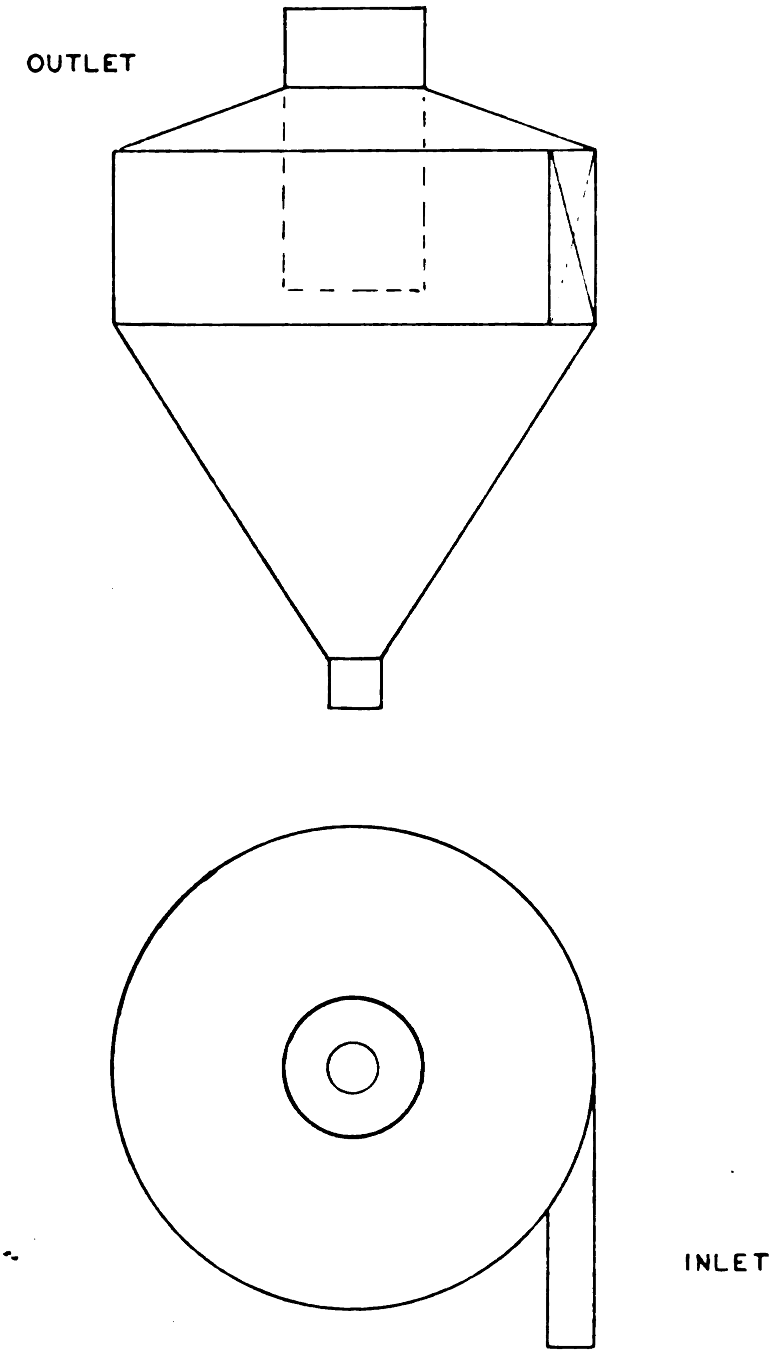
oil filter.

CENTRIFUGAL COLLECTORS

The centrifugal type of collector is, without question, the most commonly used dust collector in the industrial field. All centrifugal collectors, as their name implies, make use of the principle of centrifugal force to remove the dust particles from a dust-laden gas.

The simplest and most common centrifugal collector, generally called a cyclone, is shown by Fig. 30. The upper portion of this collector consists of a circular housing into which the dust-laden gases enter tangentially. Under this circular housing is a truncated cone. The dust-laden gas enters the collector tangentially and is subjected to centrifugal action by being forced to flow in a curved path. The dust, due to its density, tends to move radially outward and also downward, due to gravity. The dust upon reaching the collector housing, describes a helical path and finally comes to rest at the bottom of the truncated cone. The cleaned gas passes up and out of the collector through an outlet in the center of the top of the housing.

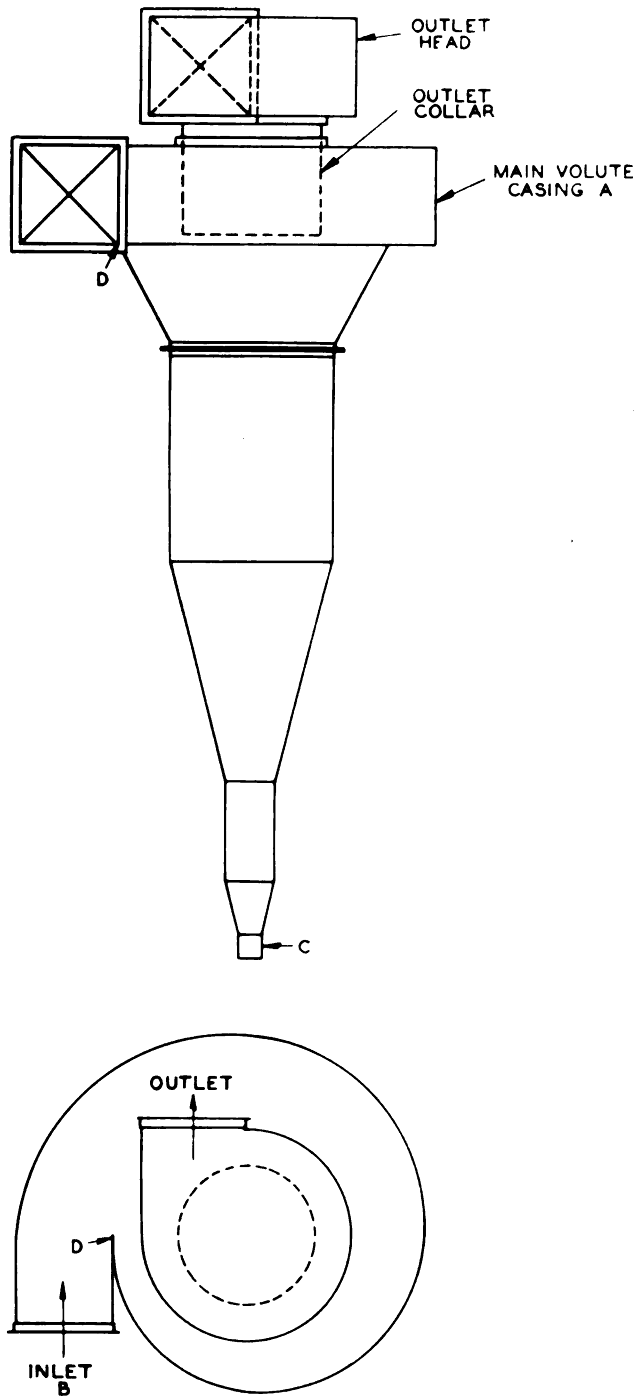
Figs. 31 and 32 show a Sirocco type collector which consists of a main casing of volute shape (A) through the inlet of which (B) the dust-laden gases enter tangentially. Below the volute casing are a series of truncated cones and cylinders which terminate in a dust outlet (C).



CYCLONE COLLECTOR

FIG. 30

3-7-31 C.W.B.



DIRECT PRESSURE COLLECTOR

FIG. 31

11-8-30 C.W.B.

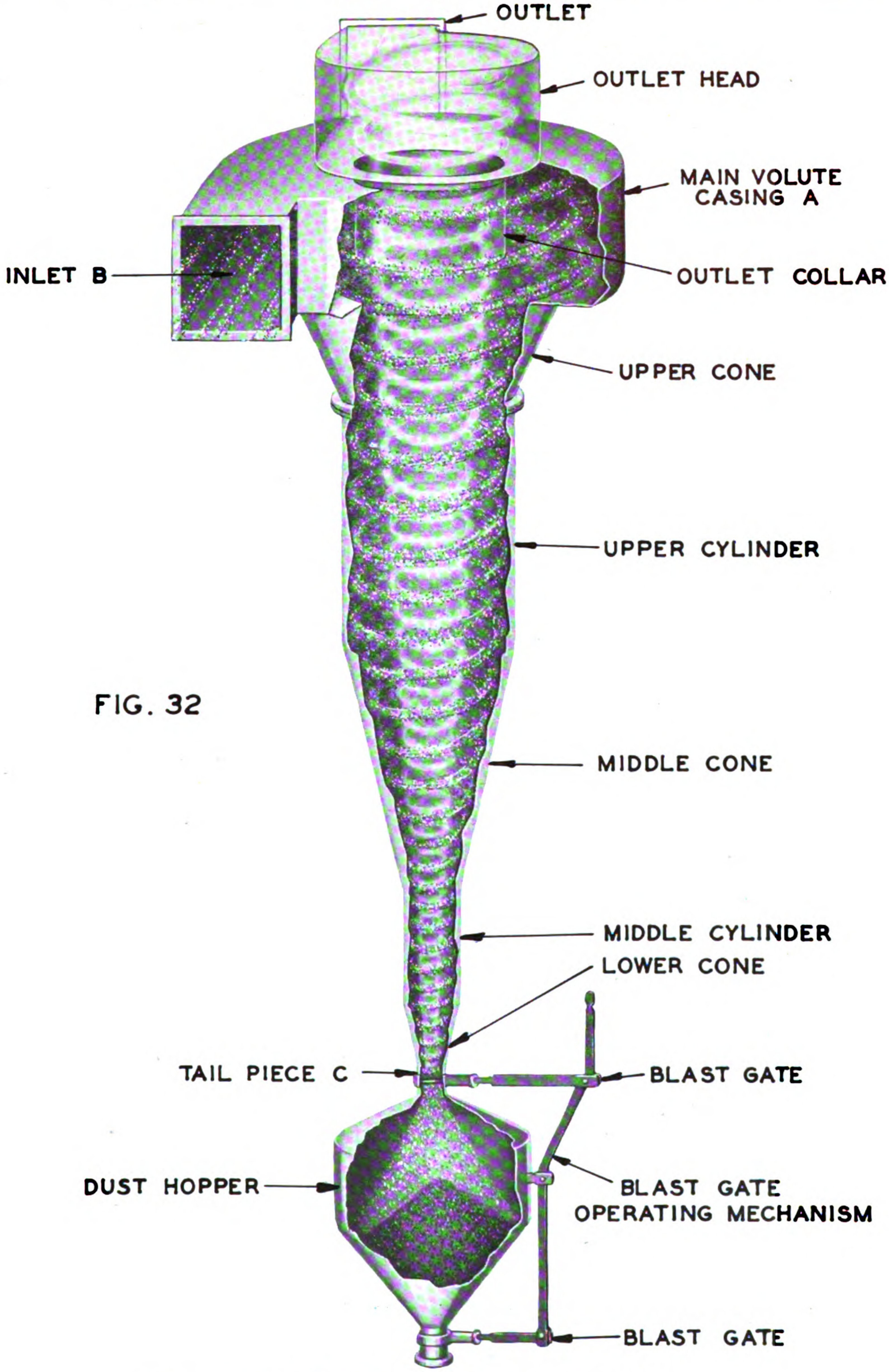


FIG. 32

Diagramatic drawing showing separating action within Type "D" Collector

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DETROIT. MICHIGAN. U.S.A.

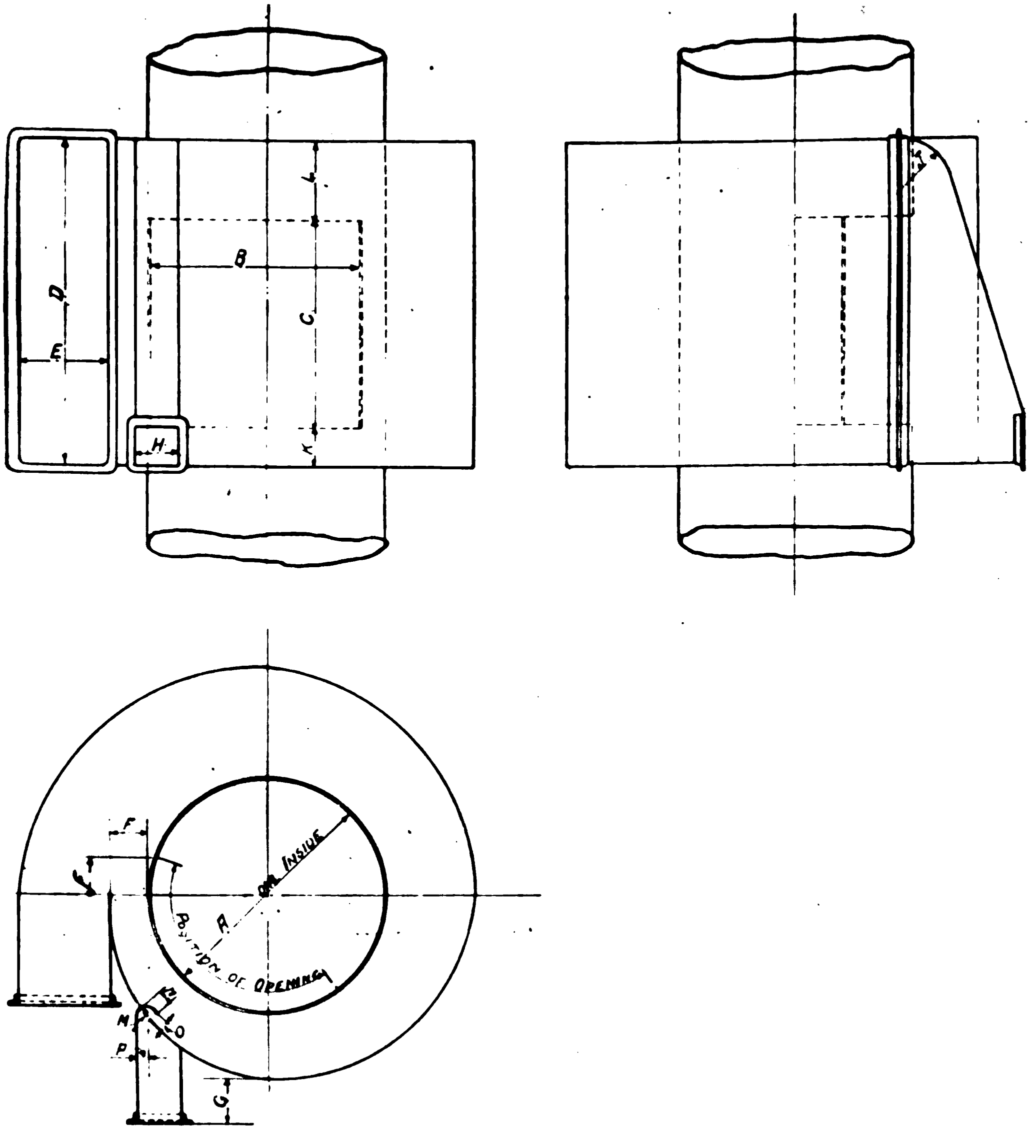
The dust-laden gases enter the collector through the inlet (B) and attempt to follow a straight line, but are forced to follow a path the shape of the casing. The radius of the casing at its maximum point is greater than the radius at the minimum point, due to the casing being of volute design. Due to centrifugal force the dust particles, which are heavier than the gases, are forced out against the periphery of the volute casing, and as the radius decreases the centrifugal force increases, until it reaches a maximum at the point of minimum radius. The dust particles, in addition to moving radially outward, are forced downward, due to gravity, so that they concentrate at the point D shown in Fig. 31, which is the point of least radius at the bottom of the main volute casing. After reaching this point the dust particles are further concentrated as they travel downward through the truncated cones and cylinders. The cleaned gases form a vortex in the center of the collector, and pass upwards through the outlet collar and out the collector outlet.

This type of collector may be operated with approximately equal efficiency on the suction or discharge side of the fan handling the gases. When the collector is on the discharge side of the fan, it is said to be a direct pressure collector, and when on the suction side, is termed a direct suction collector. Since abrasive dusts are detrimental to the fan handling the dust-laden gases it is preferable to place the collector ahead of the fan and operate it as a direct suction collector. The collector outlet head serves as an efficient elbow and must discharge in the direction the gas in the collector is traveling. This head is essential when the collector is operating shunt suction, but when the collector is operating direct pressure the head may be omitted, and the cleaned gas discharged vertically.

Fig. 33 shows a shunt pressure type collector which consists of two elements, namely a primary separator and a secondary collector. The centrifugal separating action is the same as that described for the centrifugal collector, except that at the point of minimum radius a tangential vertical slot is cut, connecting with a secondary dust collector of the direct pressure type. As the name implies, a portion of the gas is shunted from the primary separator to the secondary collector where the method of separation is the same as that for the direct pressure collector.

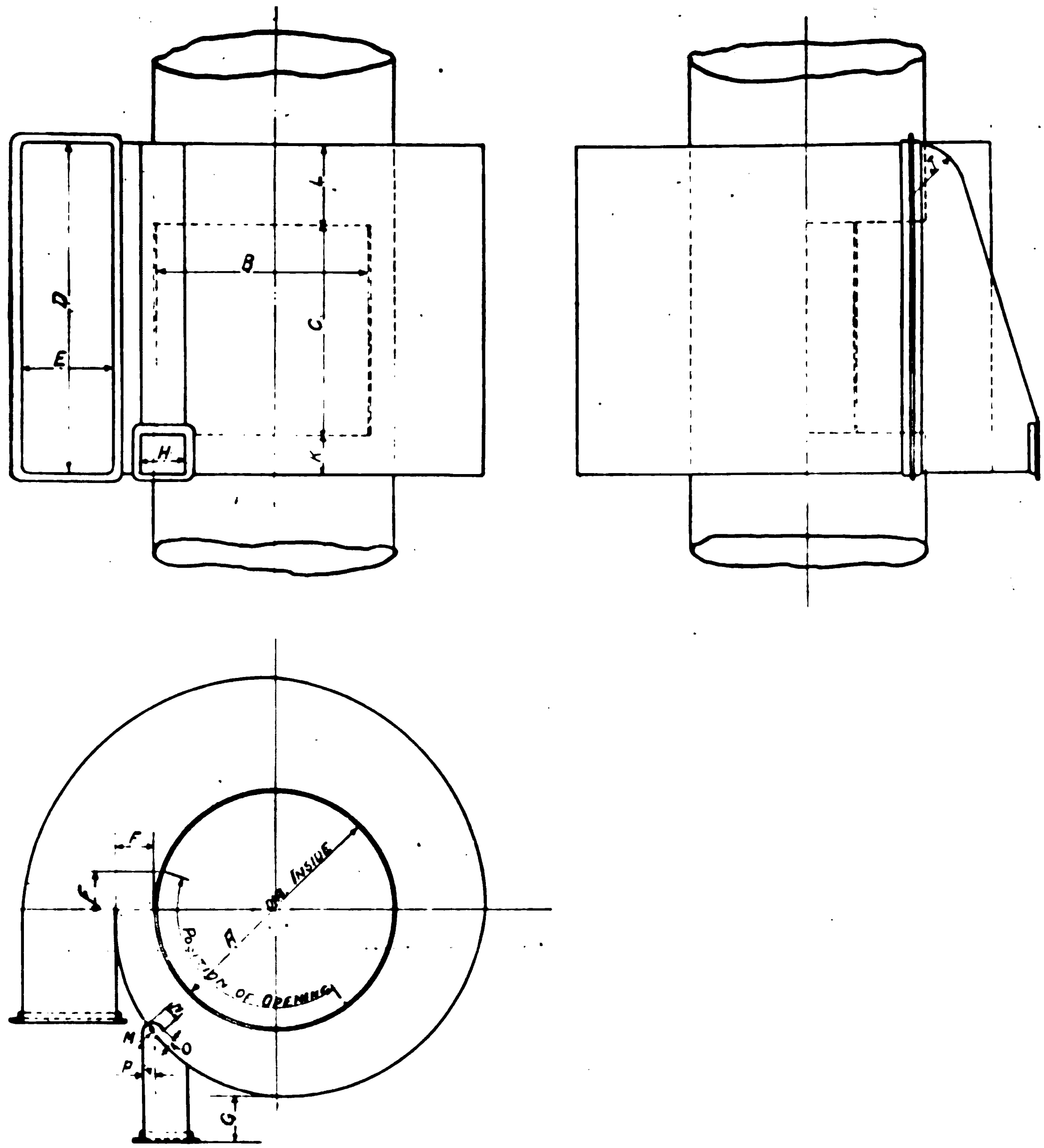
Fig. 34 shows the detailed construction of the primary collector. The dust-laden gas enters the separator through inlet (A) and is concentrated by means of the volute casing (B) at point (C) where it is skimmed off and passed on to the secondary collector. The cleaned gas passes out through the opening in the inner wall, then passes up and out of the separator.

This type of collector (shunt pressure) is only adaptable to the discharge side of the fan handling the



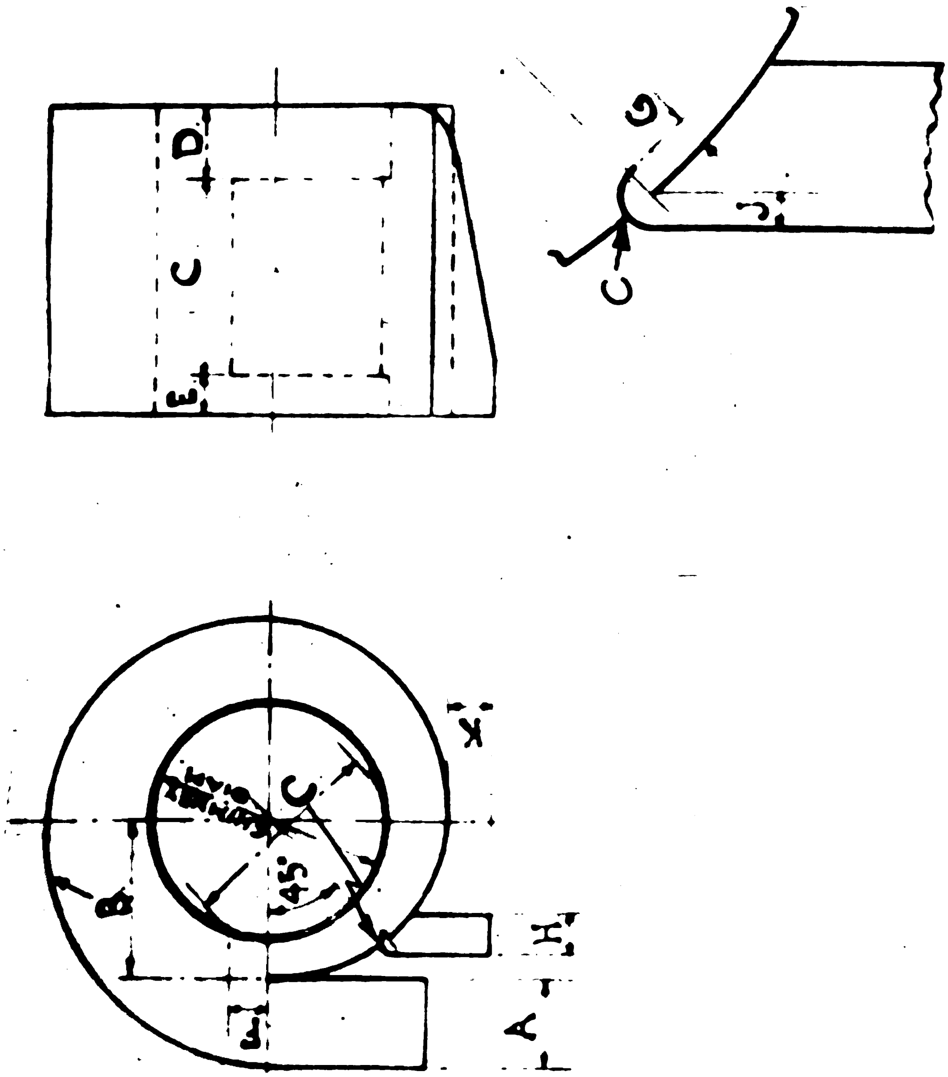
SHUNT PRESSURE COLLECTOR

FIG. 33



SHUNT PRESSURE COLLECTOR

FIG. 33



PRIMARY SEPARATOR

FIG. 34

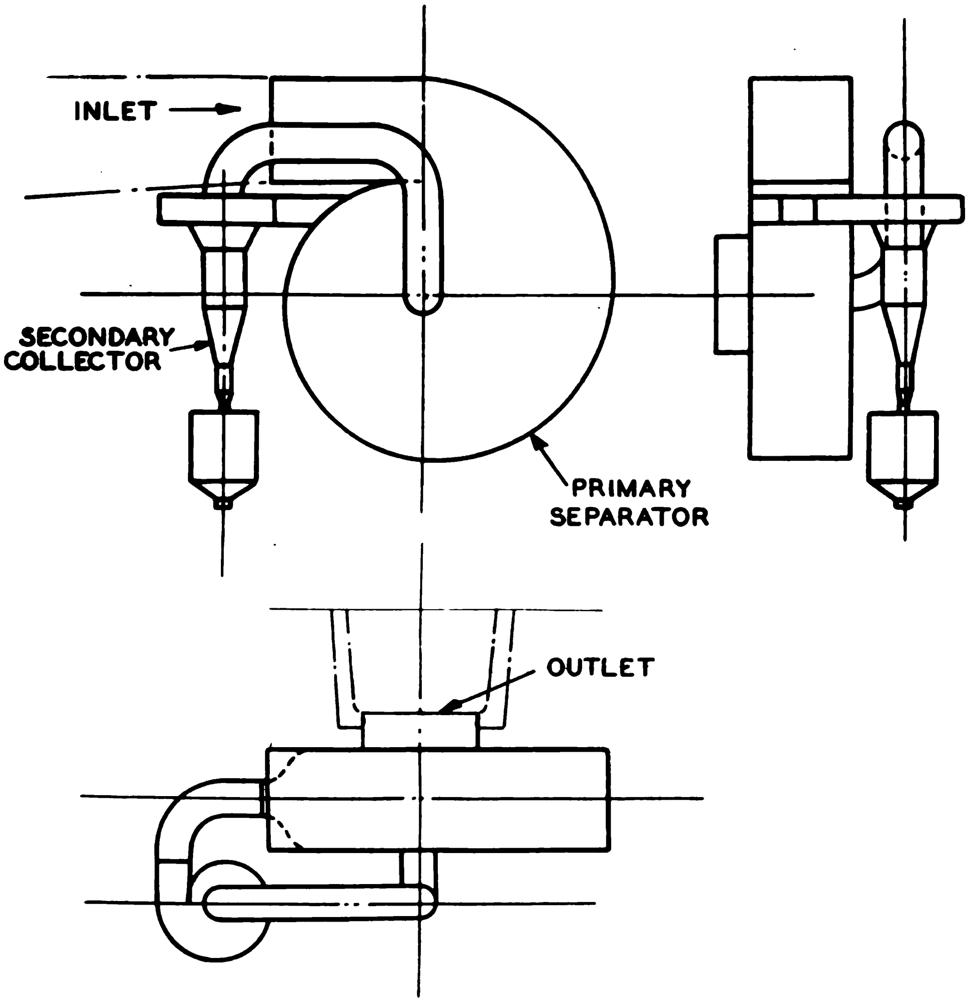
dust-laden gases.

Fig. 35 shows a shunt suction type collector, which consists of two elements, namely a primary separator, and a secondary collector. The action is exactly the same as in the shunt pressure, except that the primary separator is located on the suction side of the fan handling the gases. The shunted portion of gas containing the concentrated dust passes through the secondary collector, and after being separated from the dust, passes on and joins the main gas stream from the primary separator at the fan suction inlet.

Fig. 36 shows an English type of collector, which consists of a number of triangular shaped volutes arranged side by side about a gas-tight dust hopper. Slots are arranged in the apex of the volutes to allow the dust to enter the dust hopper along with a small percentage of the gas.

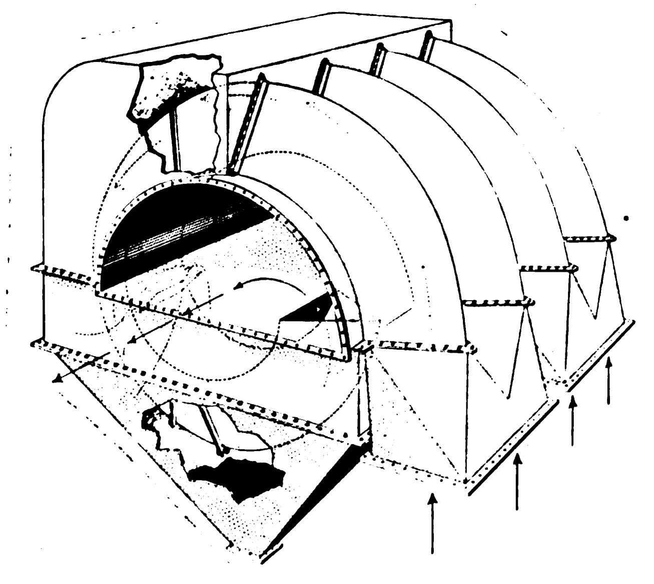
Fig. 37 shows a T.V.M. collector arranged for the upward flow of the gases, as manufactured by the French firm, Tirage et Ventilation Mechaniques de Paris. Fig. 38 shows a similar collector arranged for the downward passage of the gases. These collectors are designed primarily for operating in connection with Ejector Draft Systems.

The T.V.M. collector is inserted into a vertical duct through which the dust-laden gas passes. A fixed distributor changes the vertical motion of the gas into a gyratory motion, in which the dust is thrown out to the periphery of the collector, from which it falls into a



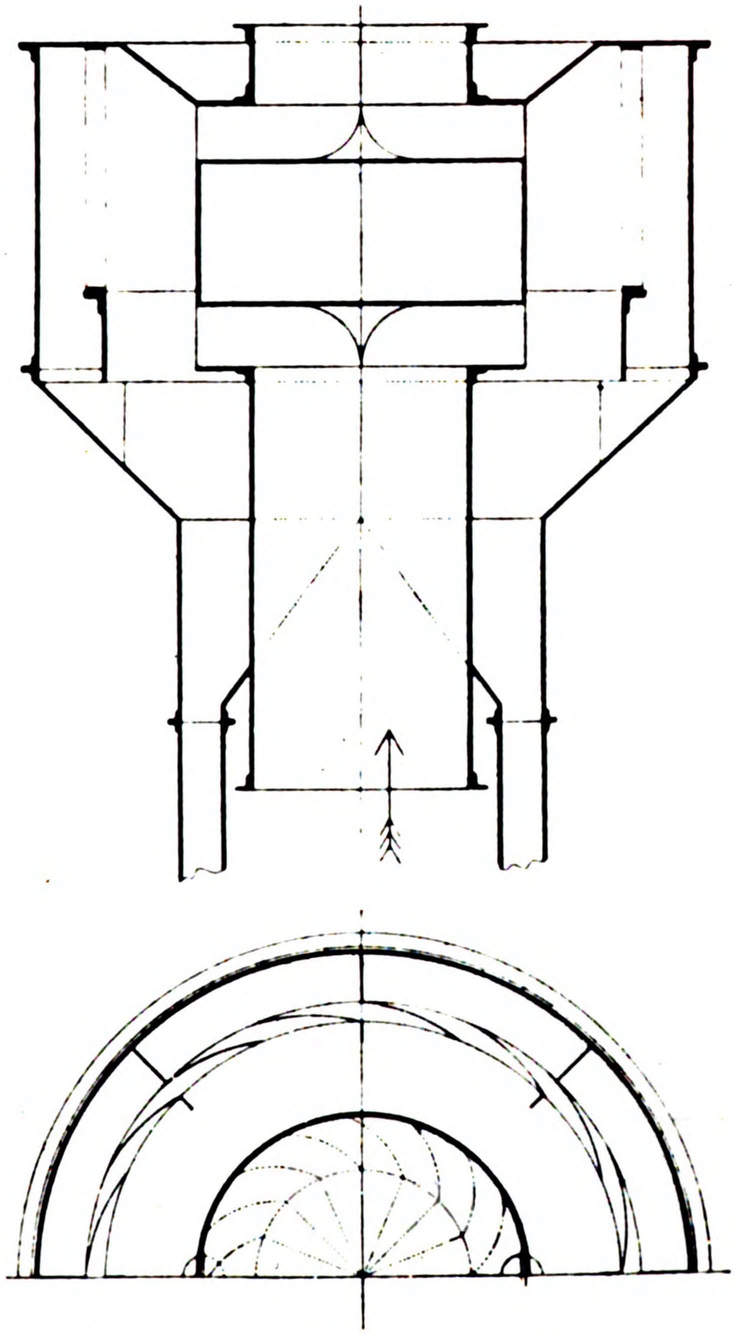
SHUNT SUCTION COLLECTOR.

FIG. 35



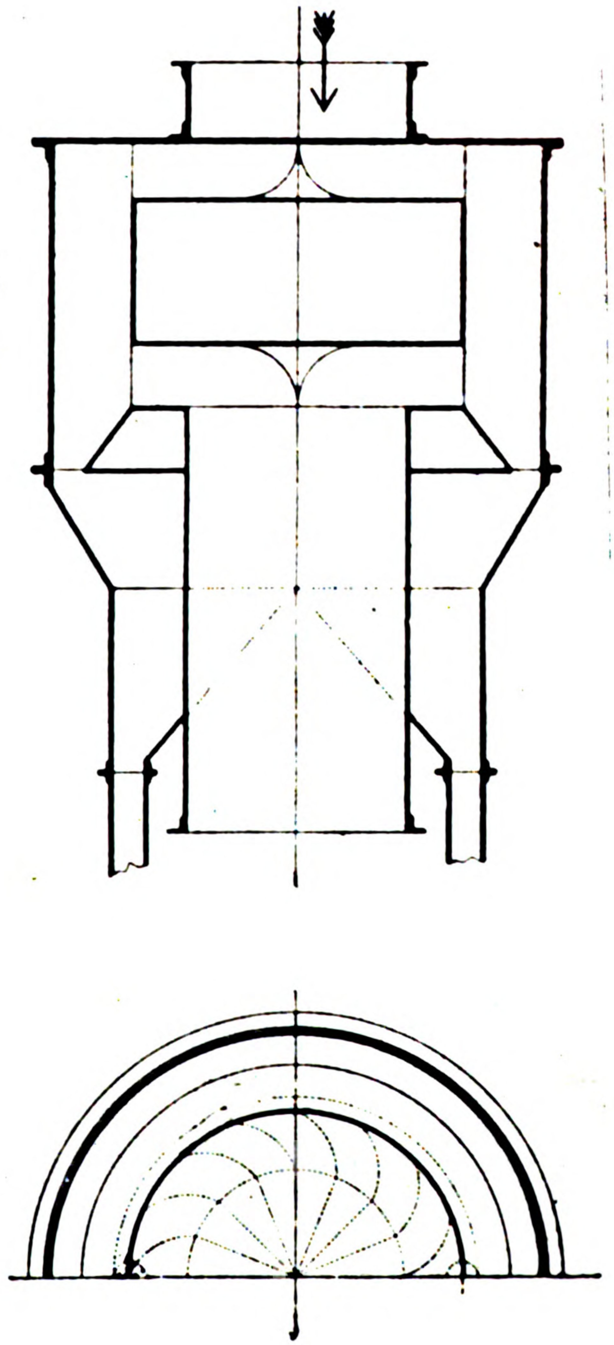
ENGLISH CENTRIFUGAL COLLECTOR

FIG. 36



T.V.M. COLLECTOR ARRANGED
FOR GASES FLOWING UPWARD.

FIG. 37



T.V.M. COLLECTOR ARRANGED
FOR GASES FLOWING DOWNWARD.

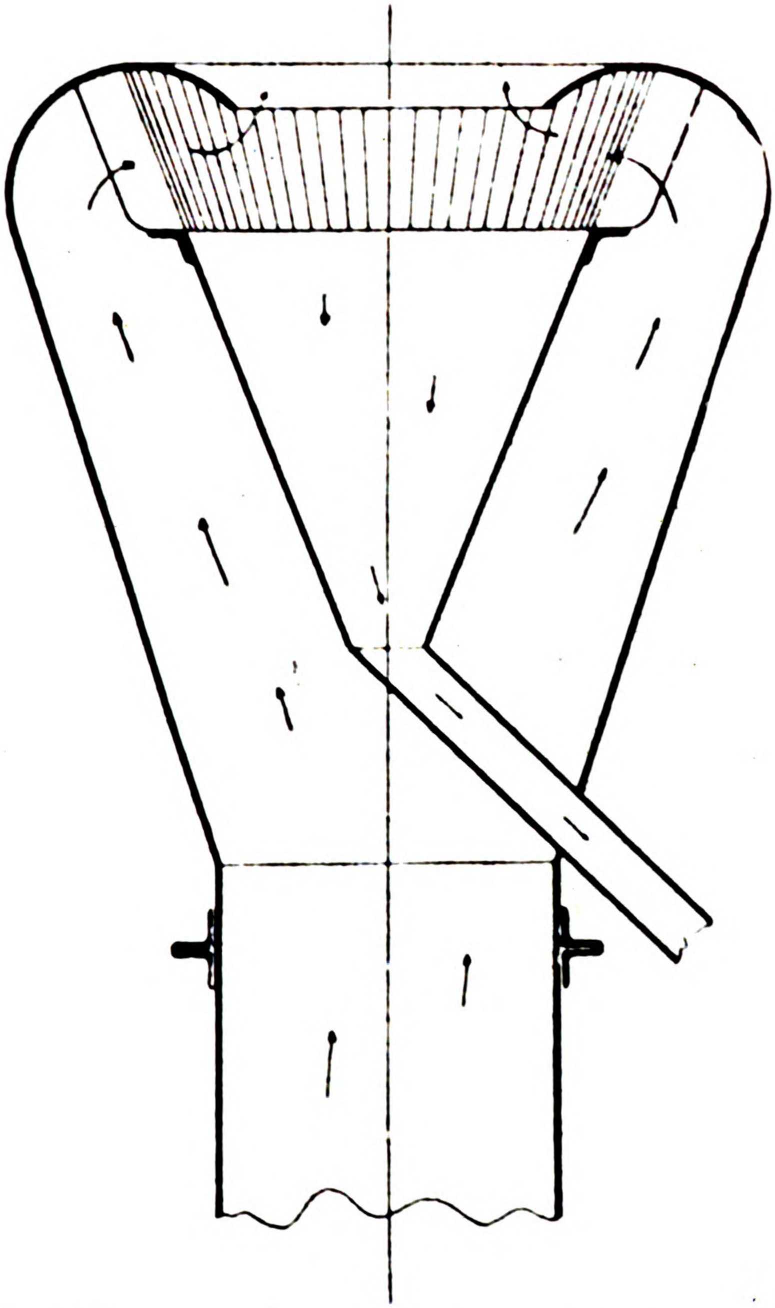
FIG. 38

hopper. The gas is then taken back by a second stationary distributor, which changes the revolving motion into a vertical motion.

The T.V.M. collector possesses the advantage that it may be readily installed in an existing plant without redesigning the flue ducts. While the manufacturers make great claims for the merits of this collector, the actual installations have not substantiated their claims. Actual installations have shown a relatively low recovery of dust, and in addition have shown that the resistance the collector offers to the system is prohibitive.

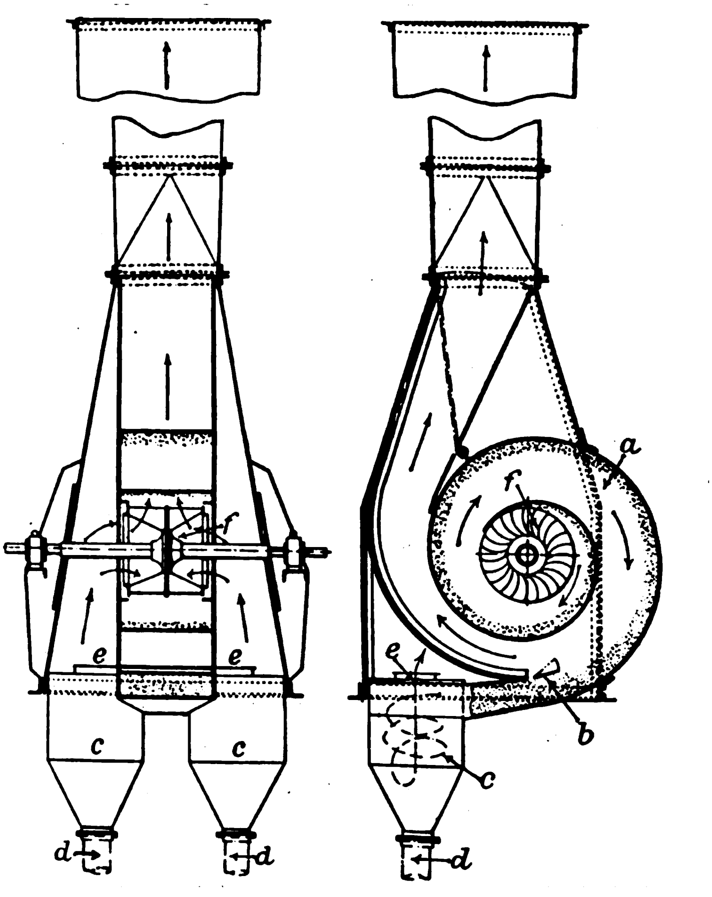
Fig. 39 shows a Tipton Grit Arrestor as manufactured by the Tipton Tub Company of England. This collector, as its name implies, is purely a grit arrestor to trap the heavy particles of ash and grit that find their way to the top of the power plant stack. The Tipton Grit Arrestor is mounted on top of the stack, which adds to the weight and increases the area exposed to the wind pressure. Aside from these structural faults it is very inefficient and has met with small favor on the continent, and to the writer's knowledge no installations have been made in this country.

Fig. 40 shows a cinder-collecting fan which is a combination of an induced draft fan and a shunt pressure collector, as shown in Fig. 33. The writer has not had the opportunity of inspecting one of these cinder-collecting



TIPTON GRIT ARRESTER

FIG. 39



CINDER COLLECTING FAN
FIG. 40

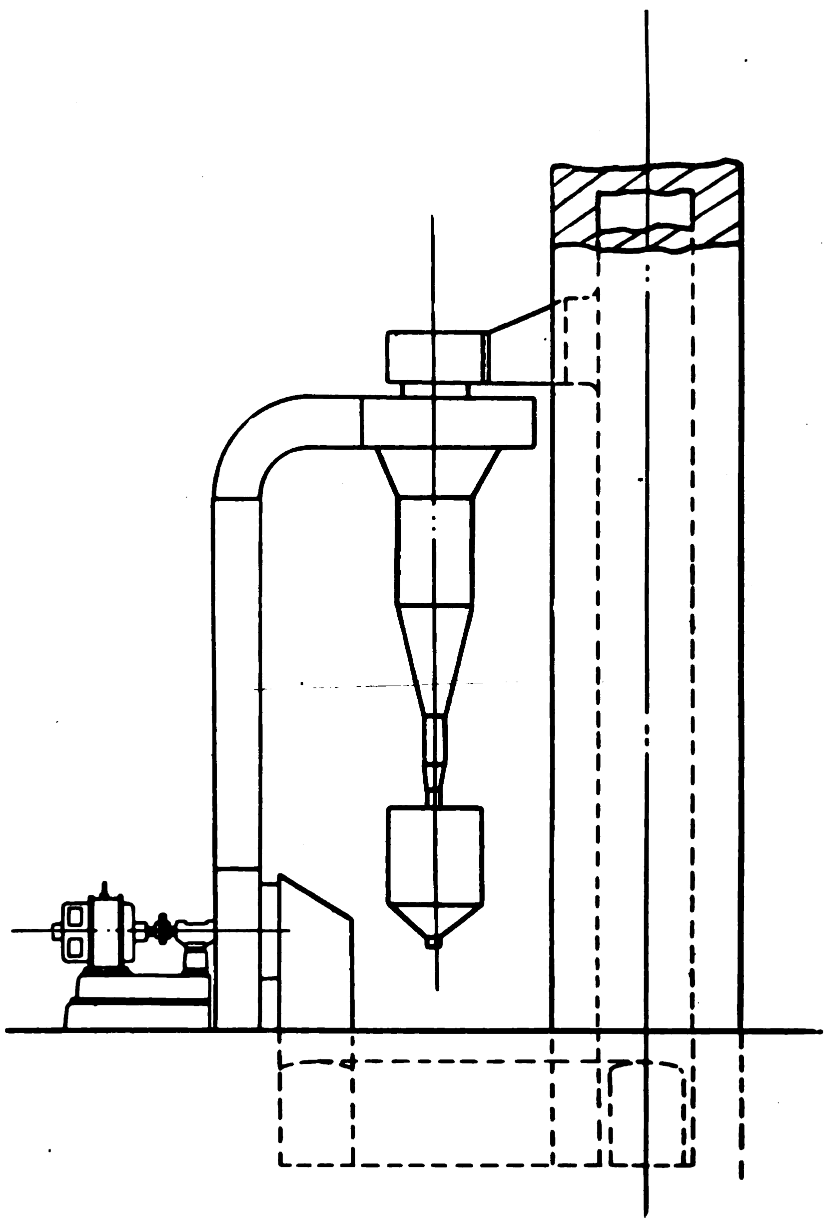
fans in operation, but from the information available, it would seem that the loss in fan efficiency would more than offset any possible gain that might be derived from the cinder-collecting attachment.

Actual tests show that the direct pressure and the direct suction type centrifugal collectors are the most efficient and the most practical to apply. Fig. 41 shows a typical installation employing a direct pressure collector with an outlet head used as an efficient elbow. Fig. 42 shows an installation employing a direct pressure collector, without an outlet head, discharging direct to the atmosphere from the outlet collar.

EFFICIENCY TESTS OF COLLECTORS

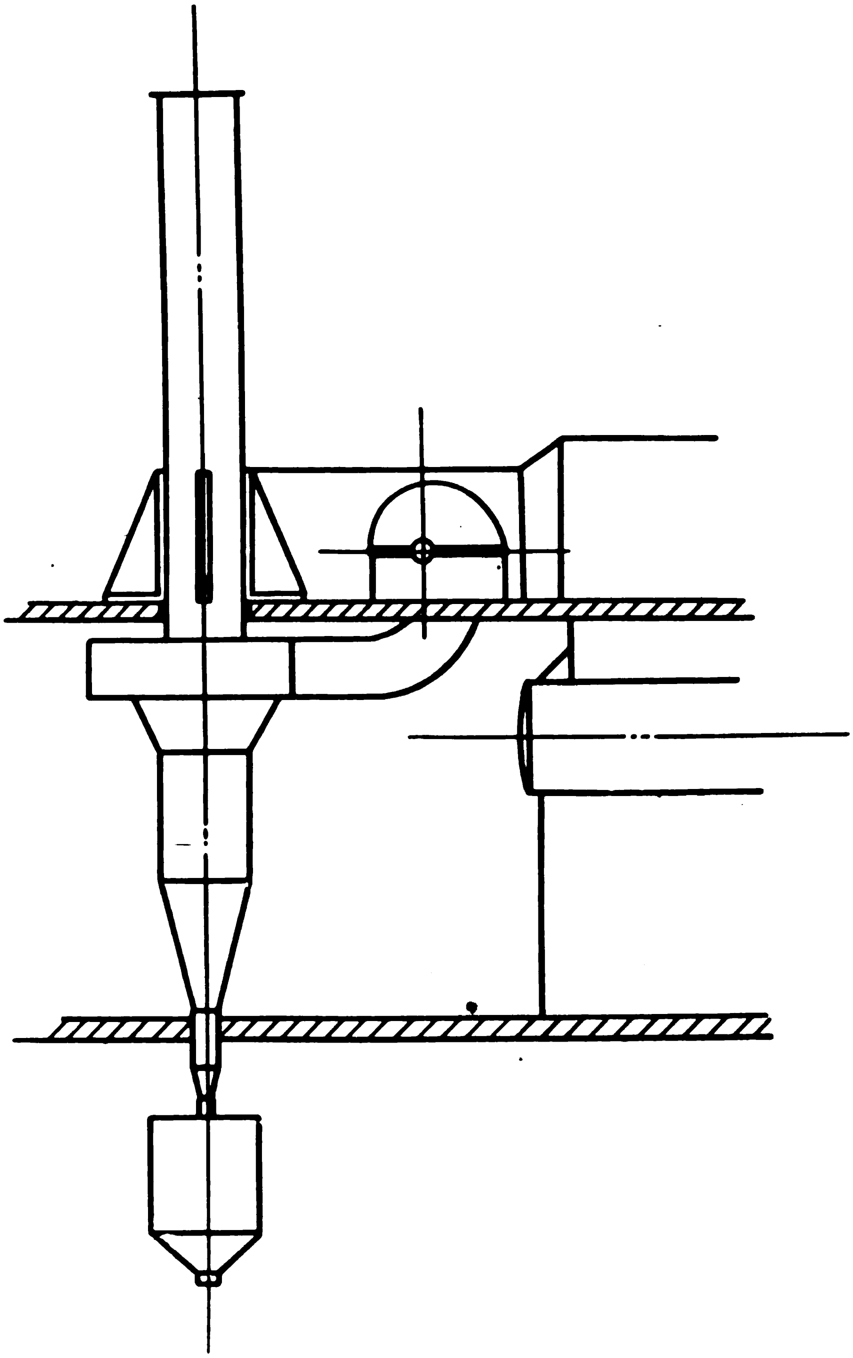
The determination of the dust concentration, or the grains of dust per cubic foot of air, is the first and most important point to determine before attacking any dust problem. Therefore, it is well to have a general knowledge of the various methods that may be employed.

The principle of electrical precipitation may be employed on a small scale by means of a glass tube 15" long with an internal diameter of 1". The two electrodes consist of a metal foil wrapped around the glass tube, and a fine wire centered in the tube. The two electrodes are connected to a high voltage direct or unidirectional current supply. The dust-laden air or gas to be tested is passed through the tube at the rate of one cubic foot per minute. The dust particles collect on the inner surface of the tube.



DIRECT PRESSURE COLLECTOR
WITH OUTLET HEAD.

FIG. 41



DIRECT PRESSURE COLLECTOR
WITHOUT OUTLET HEAD.

FIG. 42

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In making the test it is necessary to keep track of the volume of gas, the duration of the test, and the weight of the dust collected. With this data, the grains of dust per cubic foot of air may be determined.

Another method of test is the impinger method. The set-up for this test consists of a glass nozzle and flat plate, supported in a 16 ounce bottle filled with water. Air is forced through the nozzle at the rate of one cubic foot per minute, and discharged in the water against the flat plate which is held 5 mm. from the end of the nozzle. In this method it is necessary to weigh the apparatus before and after the test to determine the weight of the dust collected, and to keep track of the volume of air passed through the impinger. With this data the grains of dust per cubic foot of air may be calculated.

The remaining methods of testing which are in general use employ a dry filtering medium. The Bureau of Mines formerly employed a sugar-tube method, which consisted of passing the dust-laden air through 100 grams of granulated sugar held in a glass tube 2-3/8" in diameter. The sugar retained the dust particles and allowed the dust free air to pass on. This method has been discarded, since with certain types of dust the sugar filter was found to be inefficient.

The Steere Engineering Company of Detroit have developed a filter paper method which consists of a paper filter through which the dust-laden gas is passed. The

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amount of dust in the air is determined by weighing the filter before and after the test. The writer has used this method and has found it very practical and accurate.

Any of the methods just described may be employed to determine the dust concentration of the gas at hand with excellent results. However, while the dust concentration of the dust-laden gas or air passed through any of the set-ups may be accurately determined, it is another, and more difficult, problem to accurately determine the dust concentration of any dust-laden gas passing through a duct or collector, since the errors in sampling the gas offset the results obtained by the dust concentration test set-ups.

In practice, where large volumes of gas are encountered, it is necessary to extract a small volume of gas from the main stream and determine the dust concentration of this sample. The percentage of gas tested should be at least one percent of the total volume, greater if possible, since the accuracy of the test depends upon the accuracy of the sampling.

To determine the dust concentration of a gas in the field, it is necessary to insert a sampling tube into the main gas stream, and pass this small stream through any one of the set-ups described. The intake of the test duct should be placed directly in and facing the flow of gas in the main duct. The velocity of the gas entering the intake of the test duct must be the same as the velocity in t

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in the main duct, otherwise the resulting concentration will not be correct. If the velocity in the sampling duct is greater than in the main stream, a suction would be created, which would draw the gas over the edges of the intake and allow the heavier dust particles to pass on with the main stream. This would result in a lower dust concentration in the sampling duct than in the main duct. Should the velocity in the sampling duct be less than the velocity in the main duct, the dust concentration in the sampling duct would be greater, since a portion of the dust traveling at a higher velocity in the main stream would be projected into the slower stream, and thus increase its dust concentration.

In order to maintain a constant velocity condition in field tests, it is necessary to use an induced draft fan with the test apparatus to overcome the resistance set up by the test ducts and filter.

Before starting a test, the main duct should be divided into as many equal areas as practical, and test samples should be taken from the center of each of these areas. When possible, there should be a straight run of duct of at least ten diameters ahead of the sampling tube. This would give an almost ideal condition, and the division of the main duct into four equal areas should give excellent results. Where it is impossible to have a straight run of duct of ten diameters directly ahead of the sampling tube, the main duct should be divided into at least nine equal

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areas and samples taken from the mid-point of each. This would apply to a rectangular duct. In the case of a circular duct, it should be divided into ten equal areas similar to the method prescribed for taking pitot tube readings, by the "Fan Testing Code".

The simplest and most commonly used method of testing in the field is the "Bag Method". This method consists of passing the gas from the sampling tube through a bag filter. The bag is weighed before and after each test. This method is not 100 per cent efficient but has been found to be sufficiently accurate for all industrial tests. The filter bags may be made of 8 ounce Canton flannel, unbleached muslin, or asbestos cloth, depending upon the temperature of the gas handled. The bag should be made up with the fuzzy side on the inside, next to the gas. One square foot of bag surface should be allowed for each five cubic feet of gas handled per minute. This ratio will give excellent results, and will prevent the building up of a high resistance to the system. If the gas tends to cool to a point below its dew point while in the filter bag, it will be necessary to thoroughly dry the bag before weighing after each test, to remove the moisture deposited in the filter.

The writer has had the privilege of testing the collector installations at the Calumet Power Plant at Chicago (Fig. 49), Trenton Channel Plant at Detroit (Fig. 3), Hudson Motor Car Company at Detroit (Fig. 50), East River

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Station of New York Edison Company at New York (Fig. 51), The American Sugar Refining Company Plant at New York, and numerous others, and during the course of these tests observed the comparative merits of the various testing methods. While the filter paper method was the most accurate, the bag filter showed very little loss in efficiency and was much more practical due to ease of operation and the ease with which it was adapted to large volumes of gas.

When sampling and testing the high temperature gases in the flues leaving the pulverized fuel boilers, the writer found it necessary to insulate the sampling ducts from the flue to the filter, in order to prevent condensation in the duct. This would cause the dust particles to collect on the sides of the duct, and thereby cause an incorrect reading in the dust concentration as computed from the dust collected in the filter.

When testing a collector in the field it is necessary to take test readings at the collector inlet and outlet simultaneously. The dust concentration at the inlet, minus the concentration at the outlet, divided by the concentration at the inlet will give the overall efficiency of the collector. In addition to determining the dust concentration at the collector inlet and outlet, the dust collected by the collector during the test is weighed, and this figure checked against the amount computed by multiplying the volume of gas that passed through the

collector during the test by the difference in concentration between the inlet and outlet. As in the case of any testing connected with a gas, it is necessary to take temperature and barometer readings and make the necessary corrections to standard conditions.

The writer had the privilege of running a series of tests at the Security Cement Plant, located at Security, Maryland, in connection with their cement dust problems. Figs. 43 and 44 show two views of a direct suction "Sirocco" collector and fan connected to a sampling duct inserted into the base of the stack from Kiln #5. The purpose of these tests were twofold. First, to collect a representative sample of the dust passing up the stack, and second, to determine the efficiency of the Sirocco collector in actual operation, as compared with laboratory tests made with the same collector and a similar dust. Fig. 44 shows a close up of the test equipment. The sampling duct consisted of a 10" round duct with one end connected to the inlet of a #8 Type D Sirocco Collector (a collector with an inlet and outlet 8" x 8") and the other inserted into the gas stream at a point calculated to give a representative dust sample. A twenty foot run of 10" duct was used to connect to collector outlet to the blower inlet. All pitot tube readings were made in this duct, since the gas passing through this duct was relatively free from dust, the collector having removed the greater portion of dust picked up in the stack. Both the paper filter and bag method were

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FIG. 43

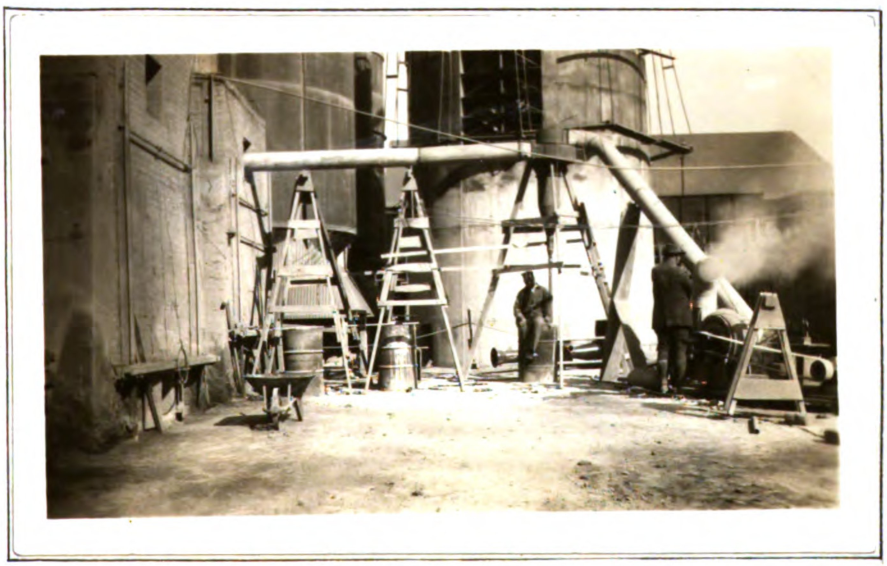

FIG. 44

TEST EQUIPMENT
AT SECURITY CEMENT PLANT

used, and the variation between the results obtained by each was less than 3%. Fig. 45 shows part of the paper filter apparatus. When using the paper filter, method it was necessary to sample the gas in the duct connecting the collector outlet with the blower inlet. This gave us the dust concentration at the collector outlet. The concentration at the collector inlet was determined as follows. The dust collected by the collector was weighed, and with this weight and the volume of gas handled, by pitot tube test, we computed the grains of dust collected per cubic foot of gas passing through the collector. This, added to the grains per cubic foot of gas leaving the collector, equaled the grains of dust per cubic foot of gas entering the collector. As stated before, this concentration minus the concentration at the outlet, divided by the concentration at the collector inlet, gave us the efficiency of the collector.

When testing by the bag method we attached a 12" diameter Canton flannel bag, of sufficient length to give one square foot of surface to each five cubic feet of gas handled, to the elbow on the blower discharge (Fig. 44). Around this we placed a 16" diameter open end duct to prevent the window from shaking the bag and carrying away a portion of the dust collected by the bag. The results obtained were very satisfactory, and checked closely with tests made in the laboratory. This is one of the few field tests that the writer found

FIG. 45

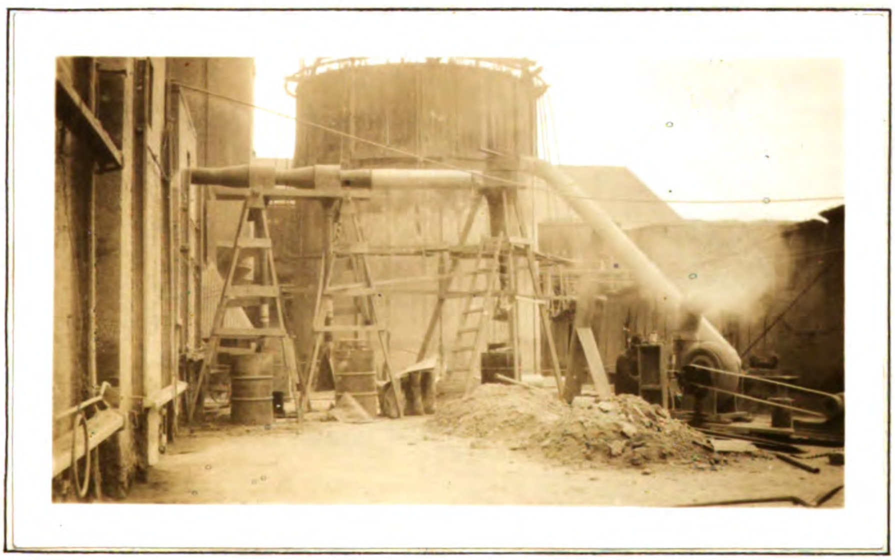

FIG. 46

TEST EQUIPMENT
AT SECURITY CEMENT PLANT

to give satisfactory results. The reason for this is that in this case it was possible to check the filter paper method by means of the bag method, with the bag method testing the total volume of gas, and not a sample of the whole as the filter paper method did. In testing large volumes of gas it is impractical to attempt to test the total volume of gas by means of the bag method. In the case of testing large volumes of gas the bag method is applied only to the gas obtained through the sampling tube. In this case the 10" duct acted as the sampling tube.

Fig. 46 shows an experimental collector installed ahead of, and in series with, the Type D Collector.

Since it is impractical to test collectors in the field, and practically impossible to be sure of the results obtained, the American Blower Corporation, with whom the writer was formerly connected as Manager of the Dust Research Laboratory, maintained a complete dust laboratory in which all dust samples from prospective customers might be tested under conditions similar to actual conditions encountered in practice.

Since it is impractical, if not impossible, to accurately test a collector in the field, it should not be sold with a guarantee as to its efficiency of collection. The prospective user should submit a representative sample of dust for laboratory test, and be guided in his purchase by the results obtained.

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the first step was to make a screen analysis. A Tyler Ro-Tap machine for determining the screen analysis is shown at the left of a photo (Fig. 52) taken in the American Blower Laboratory. Fig. 47 shows a typical test report sheet with a screen analysis recorded. Fig. 48 shows an English Screen analysis report. The next step was to determine the type of collector best adapted to the dust at hand and the efficiency of collection.

Fig. 53 is a photo of another section of the laboratory, showing three direct suction collectors connected to a common header leading to the suction side of an exhaust blower.

It would be well at this point to clear up a number of false ideas and common statements relative to a centrifugal collector. The statement that the efficiency is directly proportional to the density of the dust particles, the velocity of the gas entering the collector, and inversely proportional to the fineness of the dust, was not borne out by tests conducted by the writer. Actual tests show that the density of the dust plays an important part in the efficiency of collection, but the shape and structure of each particle is more of a determining factor. Thus some heavy dusts are harder to collect than lighter dusts. Laboratory test curves show that the efficiency of collection increases as the velocity at the collector inlet increases up to a certain point, then flattens out, and finally drops off as the velocity continues to increase.

LABORATORY REPORT FOR Western Electric Co

MATERIAL Sander Dust

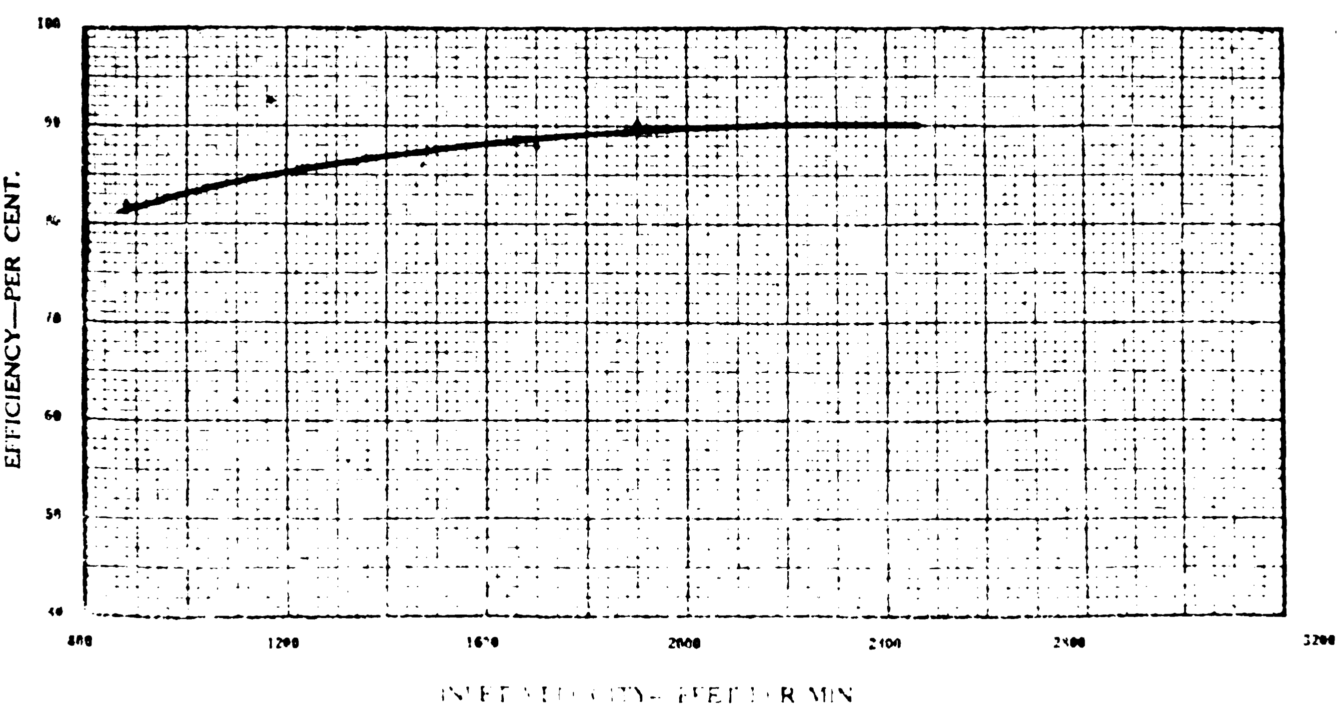
TYPE 8D9 COLLECTOR

TESTED Exhausting

CONCENTRATION 1 GRAINS PER CU. FT.

DATE 1/30/28 BY C.W.B. H.G.C.

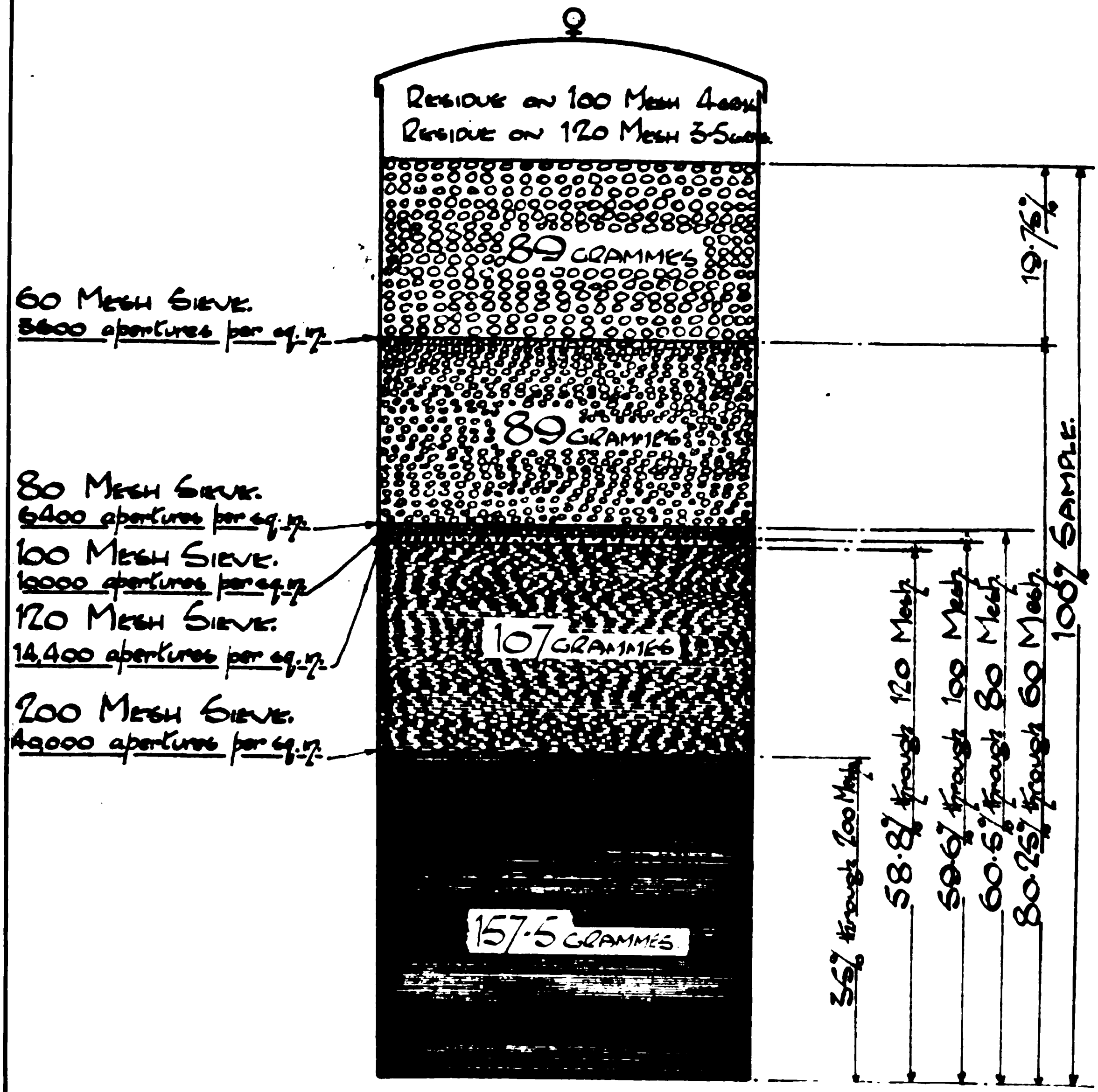
SCREEN ANALYSIS	
MESH	% PASSED
325	31
200	45
150	68
100	86
60	98
40	99



AMERICAN BLOWER CORPORATION

FIG. 47

No. 151-A



GRADING OF FLUE DUST - WEIGHT OF SAMPLE 460 GRMS.

SHOREDITCH POWER STN.

'D' TYPE COLLECTOR

L.4476/1 APRIL 7th 1926

FIG. 48

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The reason for this is the time element. The dust particles require a given time to pass through all the cycles of collection, and if this time is decreased by increasing the velocity through the collector, then a portion of the particles will be carried on and out of the collector with the gas. Still further laboratory tests show many cases where the collecting efficiency is fairly constant for both coarse and fine particles of a given dust. This, again, is due to the structure of the dust particles. When the finer particles retain the same structure as the larger ones, then the efficiency of collection remains about the same. The outlet collar, as indicated in Fig. 31, is the most important point in connection with the collecting efficiency. The efficiency of collection varies, very nearly, inversely as the diameter of the outlet collar. At the same time the pressure loss over the collector varies, very nearly, inversely as the diameter of the outlet collar. From this we may say that the efficiency of an improved cyclone collector varies directly as pressure loss over the collector.

Fig. 53 shows three collectors that appear alike. However, the outlet collar of each is of a different diameter. The collector nearest the fan has a collar 11" in diameter, the next a 9" and the last one a 7". After the screen analysis has been determined the dust is first tested in the collector with the 11" collar, then in the

9" and then in the 7".

Since the writer is not at liberty to quote the actual pressure drop over the various collectors mentioned, the figures used in the following example are purely arbitrary. When testing with the collector with the 11" collar the blast gate in the duct leading to the common header is opened and the gates for the other two are closed. Blast gates may be seen in Fig. 54. Directly over the blower, Fig. 53, are three monometers, each connected so as to indicate the pressure loss over its respective collector. Since the pressure loss for each collector has been determined for all velocities, then each reading of the monometer indicates a given velocity through the collector. The next step in testing is to set the speed of the blower to give the desired velocity of air through the collector as indicated by the monometer. Then a given amount of dust is weighed out. If a given dust concentration is desired, then the rate of feeding the dust into the inlet must be calculated. The dust is then fed into the collector inlet. Fig. 53 shows the writer feeding a dust sample into the collector having a 9" outlet collar. The dust is collected in the glass bottles at the bottom of the collector. At the end of the test the dust collected in the bottle is weighed. This weight, divided by the weight of the dust fed into the inlet, gives the collecting efficiency of the collector.

A given dust may show an efficiency of 70 percent in the 11" collector with a pressure loss of 1" W.G., 80 percent in the 9" with a loss of 2" W.G., and 90 percent in the 7" with a loss of 3" W.G. At first it would appear that the 7" collector should be recommended. However, after the above figures have been determined it is then a question of balancing the increased efficiencies against the increased losses. Increased collection may mean a saving of additional valuable material, but this must be balanced against the increased cost of operation, since an increase in the pressure loss means an increase in the power required to drive the blower, and this too must be converted into dollars and cents. All this data is passed on to the sales engineer who goes over the figures in detail with the prospective user. The laboratory may recommend which collector to use, but the user must make the final selection.

Fig. 47 shows the completed report sheet for a test run on the collector with the 9" outlet collar.

It may be noted that the ideal collector has yet to be developed in spite of the developments made in the last few years. The ideal collector should possess the following points of merit:

1. Low pressure loss.
2. Constant efficiency over a wide range dust concentrations.
3. Constant efficiency with dusts of varying

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degree of fineness.

4. Operate independent of varying temperature conditions.

As yet no one collector fulfills all of these requirements, although these conditions may be very nearly met by combining two or more of the collectors we have discussed.

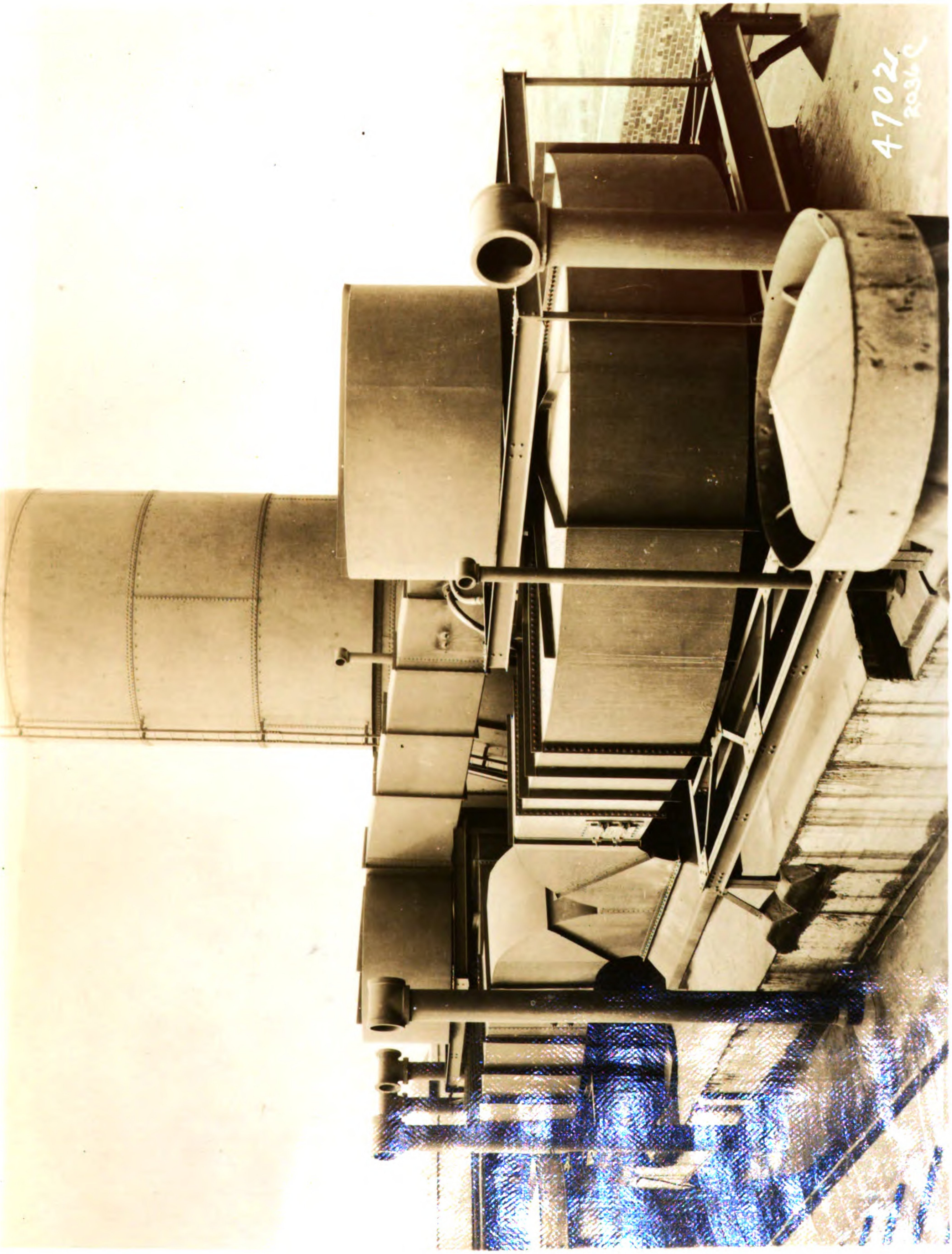

FIG. 49

Dust Collectors.

1 No. 56 R.H. Type "D" Sirocco Dust Collector.
1 No. 56 L. H. Type "D" Sirocco Dust Collector.

Installed at the Calumet Station, Commonwealth Edison Co., E. 100th & Commercial Ave., Chicago, Ill.,

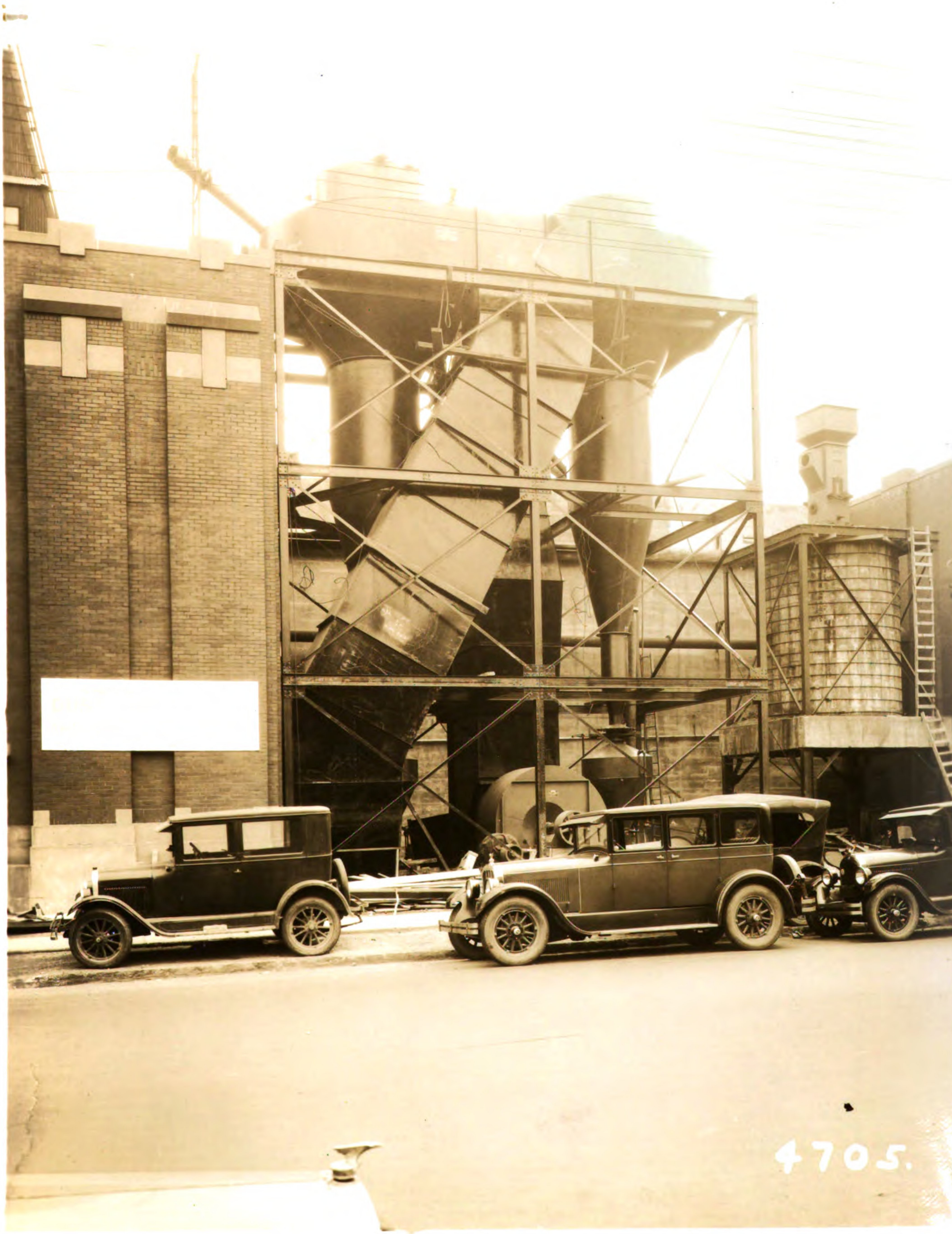

FIG. 50

Dust Collectors.

2 No. 48 Type "D" Sirocco Dust Collectors installed at the Main Plant Power House of the Hudson Motor Car Co., Detroit, Michigan - Used for Cinder Collection

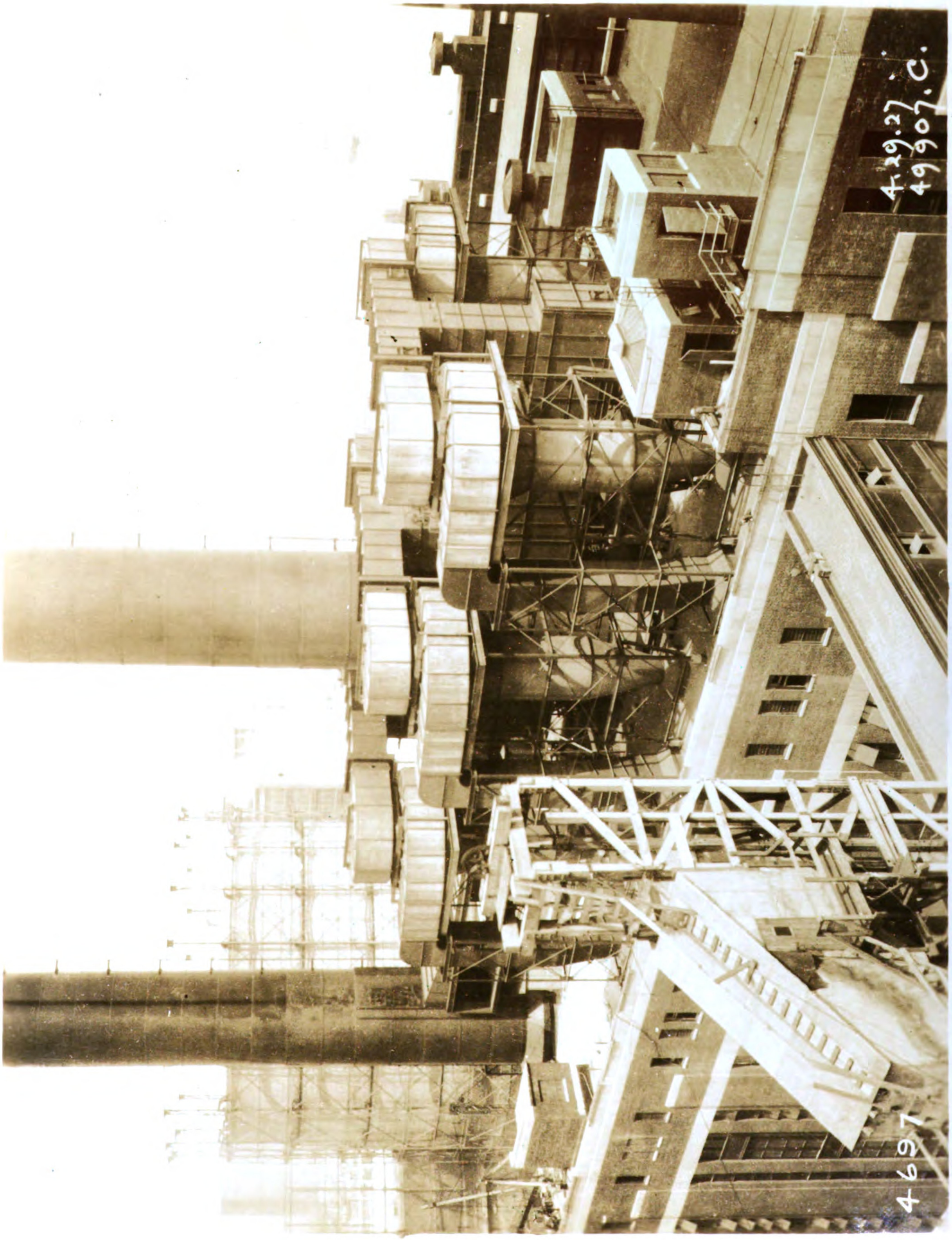

FIG. 51

Dust Collectors.

6 No. 32 Type "D" Dust Collectors.
6 No. 78 Type "D" Dust Collectors.

Installed at the East River Station, New York E dison Co., New York, N.Y.

(View taken from Mill House on pent house roof).

FIG. 52

Views taken in Dust Laboratory

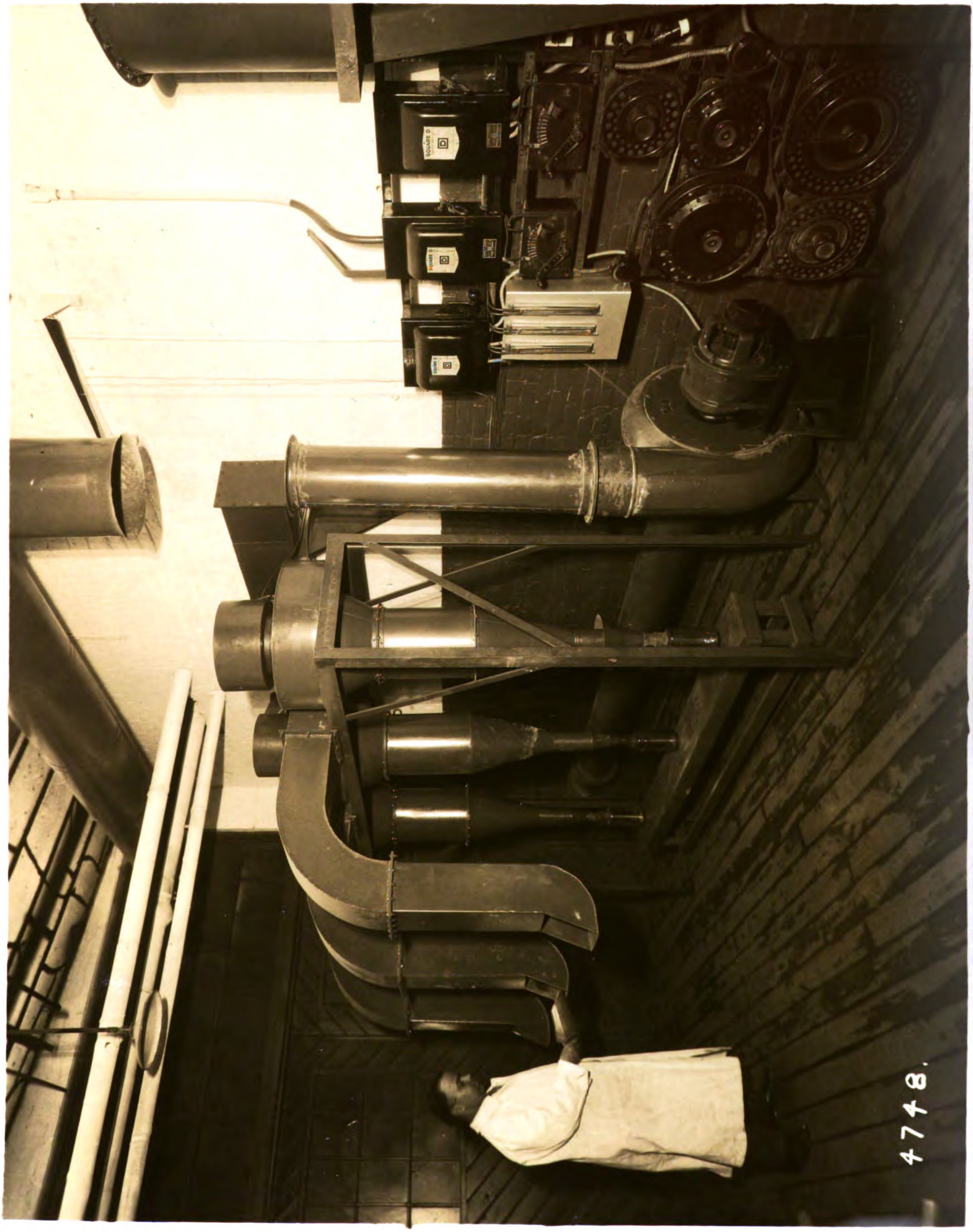

FIG. 53

Views taken in Dust Laboratory

FIG. 54

View taken in Dust Laboratory,
A.B.C. Factory, Detroit.