

Oct. 6, 1936.

J. P. IRWIN ET AL
APPARATUS FOR CLEANING GAS

2,056,789

Filed Sept. 13, 1933

5 Sheets-Sheet 1

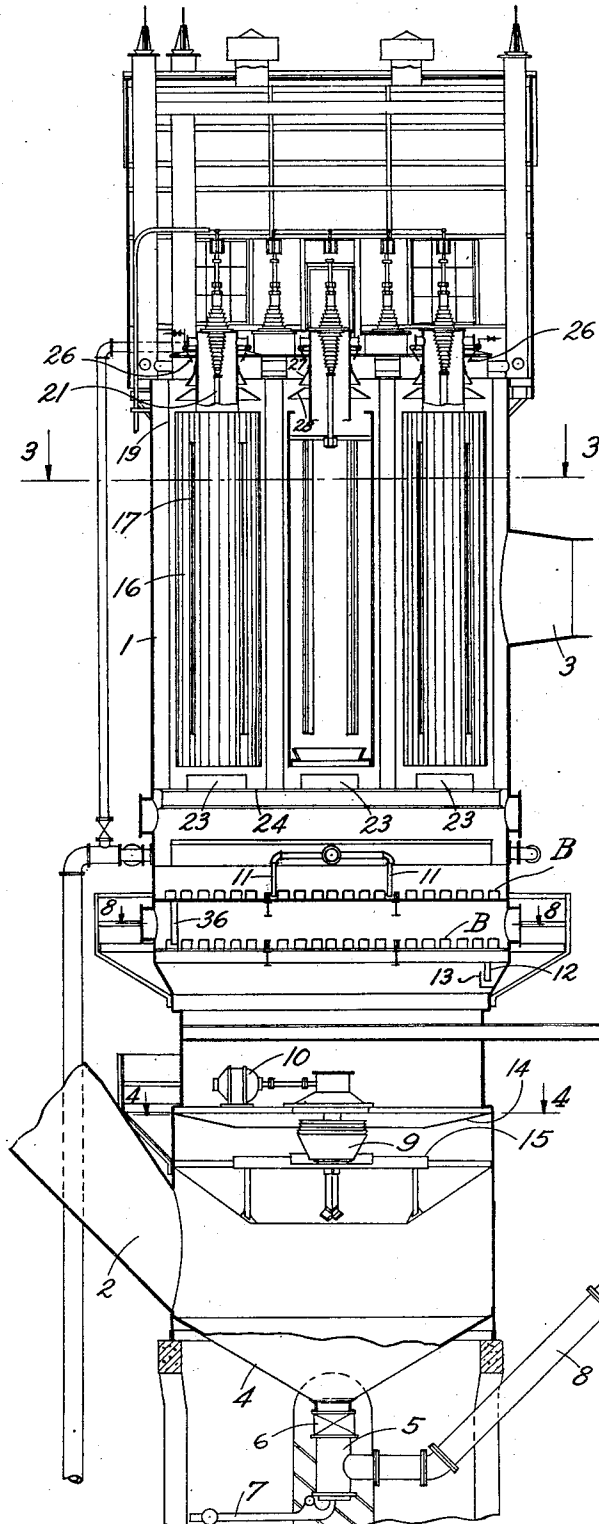


Fig. 1

Inventors
JOHN P. IRWIN
CHARLES B. THORNE
MERRILL COX.

BY *Richy & Watts*
Attorneys

Oct. 6, 1936.

J. P. IRWIN ET AL

2,056,789

APPARATUS FOR CLEANING GAS

Filed Sept. 13, 1933

5 Sheets-Sheet 2

Fig. 2

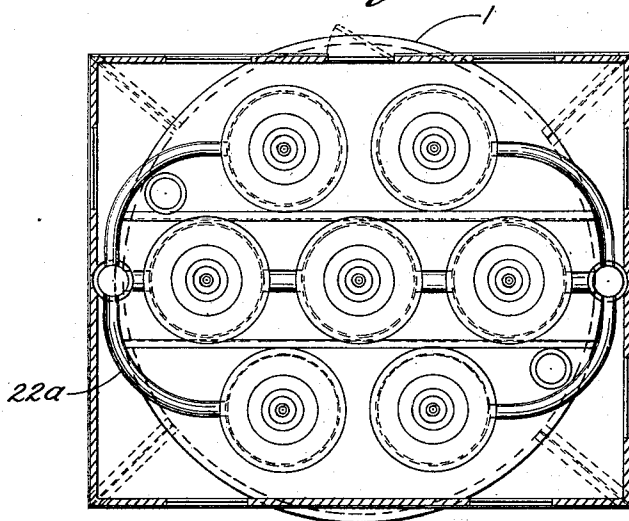


Fig. 3

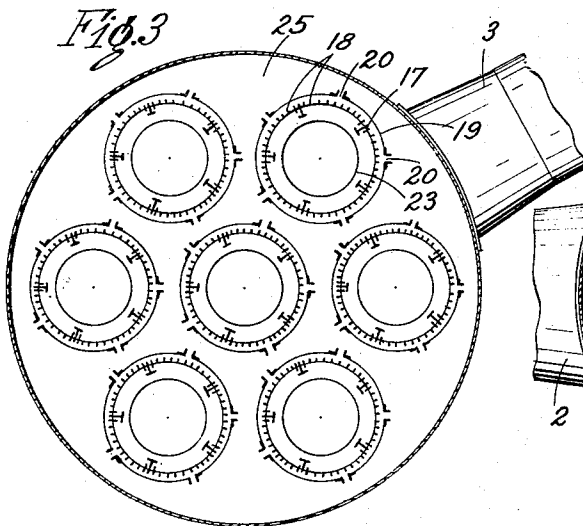
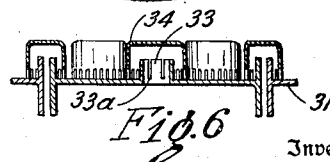
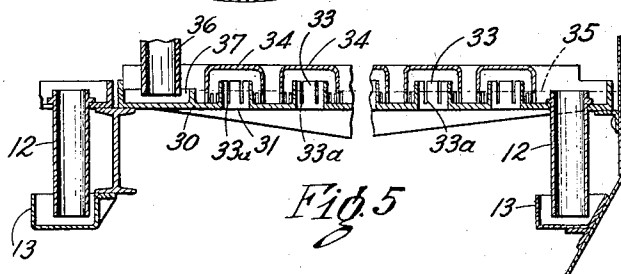
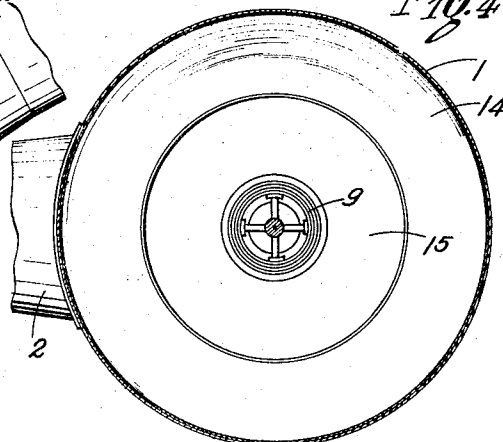


Fig. 4



Inventors
JOHN P. IRWIN
CHARLES B. THORNE
MERRILL COX.

BY *Richey & Watts*
Attorneys

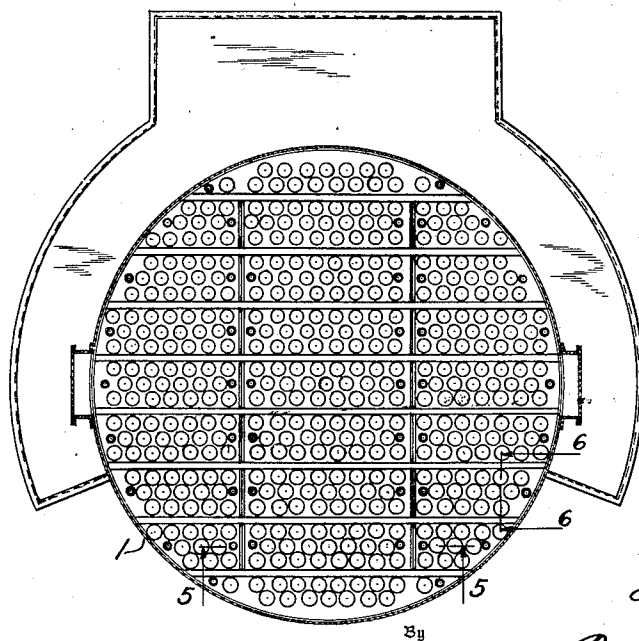
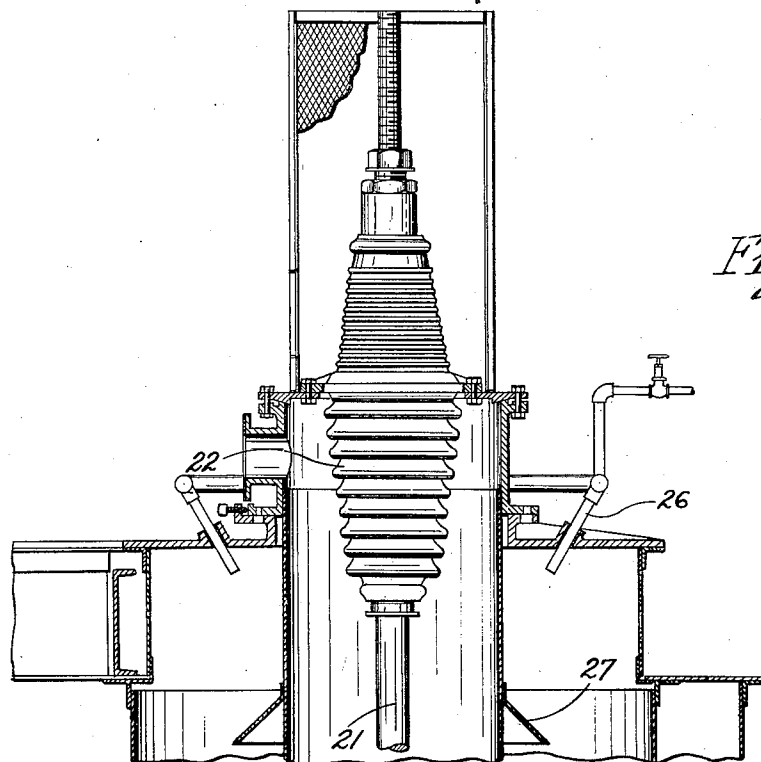
Oct. 6, 1936.

J. P. IRWIN ET AL
APPARATUS FOR CLEANING GAS

2,056,789

Filed Sept. 13, 1933

5 Sheets-Sheet 3



Inventors
JOHN P. IRWIN
CHARLES B. THORNE
MERRILL COX

Pichey & Watts
Attorneys

Oct. 6, 1936.

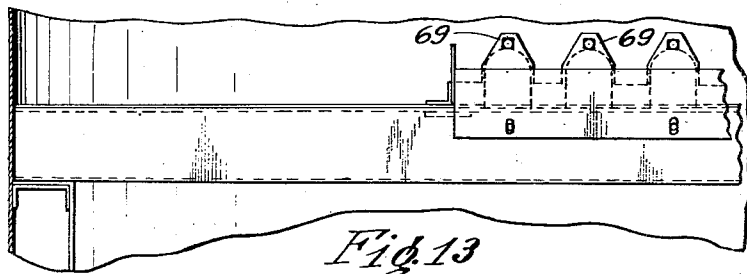
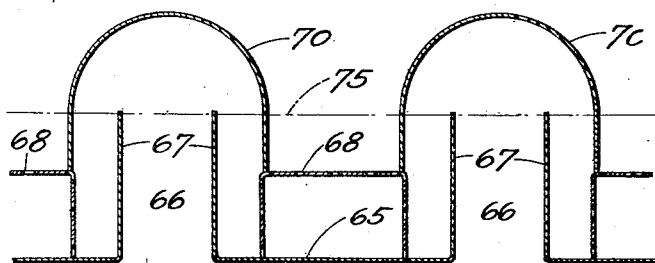
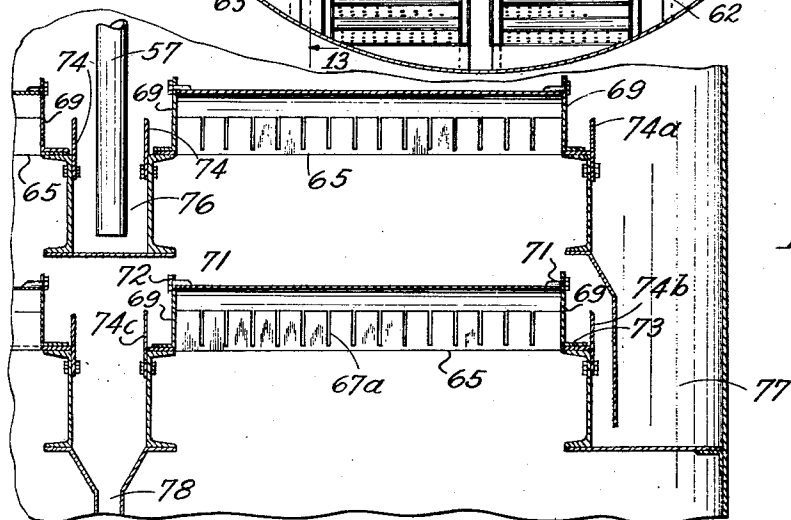
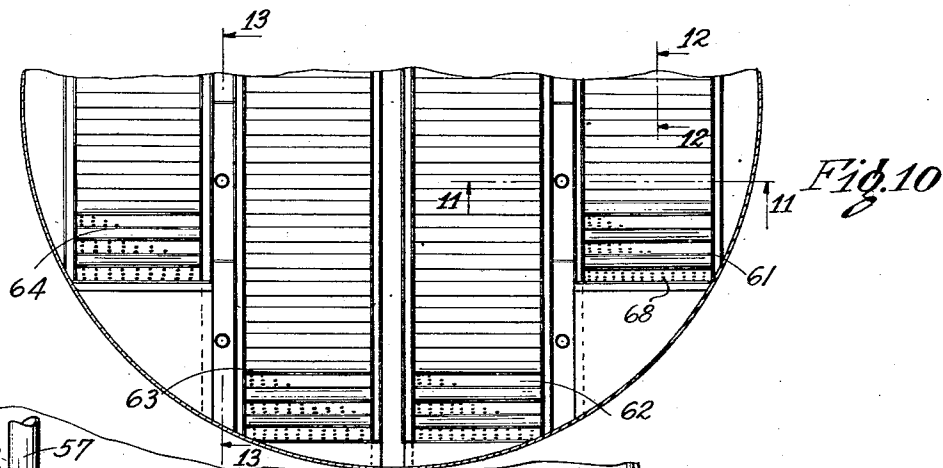
J. P. IRWIN ET AL

2,056,789

APPARATUS FOR CLEANING GAS

Filed Sept. 13, 1933

5 Sheets-Sheet 5



Inventors
JOHN P. IRWIN
CHARLES B. THORNE
MERRILL COX
BY *Richey & Watts*
Attorneys

UNITED STATES PATENT OFFICE

2,056,789

APPARATUS FOR CLEANING GAS

John P. Irwin, Charles B. Thorne, and Merrill Cox, Cleveland, Ohio; Estelle T. Thorne administratrix of said Charles B. Thorne, deceased

Application September 13, 1933, Serial No. 689,212

6 Claims. (Cl. 183—7)

This invention relates to gas cleaning and more particularly to an improved apparatus for removing entrained solid or liquid particles from a moving stream of gas.

5 In the United States patent application of John P. Irwin and George B. Garrett, Serial No. 539,234, filed May 22, 1931, there is fully described and claimed an improved method of and apparatus for cleaning gas in which primary and
10 secondary gas cleaning apparatus are arranged in superimposed relation within a shell, the primary gas cleaning apparatus comprising means for passing the gas through a liquid spray or the like and the secondary cleaning apparatus comprising an electrical precipitator. In the United
15 States patent application of Charles B. Thorne, Serial No. 596,943, filed March 3, 1932 there is fully described and claimed an improved type of electrical precipitator which is particularly
20 adapted to clean blast furnace or other gases containing entrained solid and liquid particles.

The invention herein described and claimed includes certain improvements in the general type of gas cleaning apparatus disclosed in the
25 above identified patent applications which improvements will appear from the accompanying drawings and the description thereof.

Before describing our apparatus in detail we wish to point out that washers of the well known
30 Feld type, in which water is sprayed through a relatively slowly moving stream of gas, are only effective in removing the larger particles of foreign matter in the gas, and in simultaneously cooling it. An electrical precipitator on the other
35 hand is most effective in removing the exceedingly fine particles of near molecular size comprising the fume, and which are not caught to any extent by the Feld type apparatus. There is a very definite gap in the range of particles
40 capable of being caught in the Feld type washer which can be classed as wettable, and those most readily caught in a precipitator which may be termed non-wettable, which for lack of a better
45 term we choose to call semi-wettable. It will be appreciated that the Feld type washer discharges drops of water at fairly high velocity into the relatively slowly moving gas stream. If one of these water drops happen to strike a
50 dust particle having sufficient inertia to break the surface tension of the water drop, it will become engulfed. Also should it strike particles of easily wettable character they will likewise be engulfed. However, should they strike small
55 particles of low inertia or of non-wettable nature the particles are only brushed aside. In

an electrical precipitator the electrostatic charge on the particle causes it to adhere to the water film on the collecting electrode and break through the surface tension to be caught and removed. In the process we are about to describe, we divide the gas flow into a great many small streams
5 of high velocity which reverses the operation of the Feld type washer described above and causes the dust particles to be driven at high velocity against relatively slow moving water drops and
10 in very intimate contact with them, so that a large percentage of the semi-wettable type of dust particles will be caught.

To accomplish the above we prefer to utilize a construction somewhat similar to that used in
15 the oil industry for heat exchange work and commonly known as bubble caps. The usual bubble tray construction, however, is preferably modified to adapt this device to gas cleaning by cutting slots or suitable openings in the chim-
20 neys through which the water in the pans can flow back into the ascending gas stream where it is broken up into a spray thus serving to wash down the interior of the chimneys and the under-
25 side of the bubble caps.

Tests have proven that our method is very efficient in removing dust particles that were not caught in preliminary washing by washers of the
30 standard tower or Feld type, and by so doing remove a large percentage of the dust that would otherwise have to be removed subsequently by the precipitator in the complete gas cleaning unit described in this specification.

It will be seen from the above that one of the important results of our invention is a decided
35 gain in the overall efficiency of the complete gas cleaning unit due to the interposition of our improved bubble trays before the final precipitation stage which we have found removes a class of dirt which cannot be removed by the Feld
40 type washer, and would otherwise have to be removed by the precipitator. Since the precipitator is the most heavily loaded unit in the combination gas cleaner and the largest and most
45 expensive one to build, the interposition of one or more of our improved bubble trays which are of compact dimension and relatively cheap to construct yet capable of removing a class of dirt and entrained matter that could otherwise only
50 be removed by more elaborate and expensive precipitator equipment, makes a very decided gain in the overall effectiveness and utility of the complete unit.

Among the more specific objects of our invention is the provision of a unitary gas cleaning ap-
55

paratus which will occupy a minimum of ground space and which is adapted to efficiently remove both solid and liquid particles which may be entrained in a moving stream of gas; the provision of a combined mechanical and electrical gas cleaning apparatus in which bubble trays are employed to assist in the removal of entrained solid material from the gas and to also more effectively distribute the gas into the electrical precipitator section of the cleaning unit; and the provision of an improved means for causing intimate contact between a gas and a liquid whereby solid particles entrained in the gas will be removed by the liquid.

The above and other objects of our invention will appear from the following description of several forms thereof, reference being had to the accompanying drawings, in which—

Figure 1 is an illustrative vertical cross section through a gas cleaning tower incorporating the features of our invention.

Figure 2 is a plan view of the apparatus shown in Figure 1.

Figure 3 is a horizontal cross section of the apparatus shown in Figures 1 and 2 taken on line 3—3 of Figure 1.

Figure 4 is a horizontal cross section taken on line 4—4 of Figure 1.

Figure 5 is an enlarged vertical cross section taken through a portion of the lower bubble tray shown in Figure 1.

Figure 6 is a fragmentary vertical cross section of one of the bubble trays taken on line 6—6 of Figure 8.

Figure 7 is an enlarged vertical cross section of one of the precipitator insulator and flushing water supply arrangements.

Figure 8 is a horizontal cross section taken on line 8—8 of Figure 1.

Figure 9 is an illustrative vertical cross section through a modified form of our improved gas cleaning apparatus.

Figure 10 is a fragmentary horizontal cross sectional view taken on line 10—10 of Figure 9.

Figure 11 is an enlarged fragmentary vertical cross sectional view of the bubble trays shown in Figure 9.

Figure 12 is an enlarged vertical cross section taken on line 12—12 of Figure 10.

Figure 13 is an enlarged vertical cross section taken on line 13—13 of Figure 10.

Referring now to Figure 1 of the drawings, our improved gas cleaning apparatus comprises a generally cylindrical shell 1 having a gas inlet conduit 2 extending into the lower portion thereof and a clean gas outlet conduit 3 extending from its upper portion. The bottom 4 of the shell 1 is of cone shape and is provided with an outlet pipe 5. A valve 6, which may be operated by the lever 7, controls the flow of water through the outlet pipe 5 and the discharge pipe 8 is shaped to form a water seal and prevent the exit of gas from the bottom of the shell 1. Just above the point where the inlet pipe 2 enters the shell 1 is a liquid spraying device 9 which is driven by the motor 10 and which is adapted to throw a spray of cleaning fluid, preferably water, outwardly against the walls of the shell 1 thus forming a spray or film of water through which the dirty gas which enters the pipe 2 must pass on its upward path through the cleaner. The water spraying device 9, which is illustrated in Figure 1, is of the general type shown and described in United States Patent No. 1,797,271 issued on March 24, 1931 to Arthur G. McKee, but it will

be understood that any suitable type of spraying apparatus may be used.

Extending across the shell 1 immediately above the spraying device 9 are the bubble trays B. Water is supplied to the upper of these trays B through the pipes 11. The overflow from the lower bubble tray B passes downwardly through the pipe 12 into the sealing trough 13 from whence it may overflow and pass downwardly through the shell 1 to the inwardly extending deflecting flange 14. The water is deflected by this flange 14 so that it drops down into the pan or trough 15 from which it is picked up by the sprayer 9 and thrown out against the sides of the shell 1. The sprayed water passes down the walls of the shell 1, collects in the bottom 4 thereof and is removed through the discharge pipes 5 and 8. It will be understood that additional cleaning water may be supplied to the sprayer 9 to augment the water from the tray B if desired.

The electrical precipitator units are disposed within the shell 1 above the bubble trays B. As is best seen in Figure 3 seven of these units are arranged in parallel relation in this embodiment of our invention. Each of the seven units comprises a tubular discharge electrode 16, closed at its upper end and open at its lower end and provided with a plurality of vertically extending radial fins 18 and each discharge electrode is surrounded by the tubular collecting electrode 19. The collecting electrodes 19 are also provided with gas outlet slots 20 disposed midway between the slots 17 of the discharge electrodes. The discharge electrodes 16 are supported by rods or bars 21 which also serve as the electrical conductors which carry the high potential current required for proper operation of the precipitators. As is best seen in Figures 2 and 7 the supporting and conducting bars 21 extend through insulators 22 and may be connected at their upper ends to bus bars 22a which are in turn connected to a suitable source of electrical current. Thus, it will be seen that the discharge electrodes 16 are supported solely by the rods 21 and the insulators 22 and do not have direct contact with any other part of the apparatus.

The gas which passes up through the bubble trays B is directed into the lower ends of the discharge electrodes 16 by the nozzles 23 which are mounted on and extend upwardly from a transversely extending baffle plate 24. The gas which enters one of the discharge electrodes 16 through a nozzle 23 passes upwardly there-through and then out through the vertically extending slots 17 into the space between the concentric discharge and collecting electrodes 16 and 19. When the discharge and collecting electrodes are connected to the opposite sides of a suitable source of supply of high potential current vertically extending corona discharge zones will be created between each of the fins 18 and the inner wall of the collecting electrode 19. As the outlets 20 of the collecting electrodes 19 are displaced laterally (see Figure 3) from the outlets of the discharge electrode, the gas which passes out through the slots 17 must pass through a plurality of corona discharge zones before it reaches the outlet slots 20 and passes into the chamber or space 25 within the shell 1 and around the collecting electrodes 19. As the gas passes through the corona zones the entrained particles of solid and liquid material will be precipitated out upon the inner walls of the collecting electrodes. These inner walls of the collecting electrodes 19 are preferably continuously

flushed with water which may be supplied through a pipe 26 and is directed on to the inner wall of the electrode 19 in a uniform film by suitable plates 27 and 28. This water passes downwardly over the inner surface of the collecting electrodes 19 carrying with it the material precipitated out of the gas, and is conducted by means of downflow pipes having water seals (not shown) through the shell 1 and drops upon the upper bubble trays B where it mingles with the water supplied through the pipes 11 and eventually passes on down through the cleaner and out through the discharge pipes 5 and 8.

Referring now particularly to Figures 5, 6, and 8, each of the bubble tray arrangements shown in Figure 1 comprises a transversely extending plate portion 30 having a plurality of apertures 31 extending therethrough and defined by upwardly extending pipes or chimneys 33. Over each of the upwardly extending pipes 33 is a bubble cap 34 which consists of an inverted cup shaped member having a serrated or notched lower edge. As is clearly seen in Figures 5 and 6 these bubble caps 34 rest upon the trays 30 and are adapted to deflect gas which passes upwardly through the pipes 33 downwardly through the liquid on the tray 30. The gas then passes out through the slots in the bottom edges of the caps 34 and bubbles up through the liquid which is preferably maintained at approximately the level indicated by the dotted lines 35 in Figure 5. In order to more effectively remove entrained particles from the gas the chimneys 33 are preferably slotted as seen at 33a. These slots permit water to flow into the upwardly moving stream of gas, a considerable portion of this water being picked up by the gas and carried up against the underside of the bubble caps 34. The impact of the particles in the gas against the wet underside of the caps 34 and the inner walls of the chimneys 33 assists in causing the particles of dirt, etc. to be removed from the gas and carried away in the cleaning water. The liquid which overflows from the upper tray B passes down to the lower tray through a pipe 36 which discharges into a liquid seal chamber 37 and the discharge from the lower bubble tray passes downwardly through the pipes 12 into the liquid seal chambers 13 from whence it overflows and passes on down to the spraying device 9. If found desirable or necessary more or less than two bubble trays may, of course, be provided.

The modified form of our improved gas cleaning apparatus which is shown in Figures 9 to 13 inclusive comprises a generally cylindrical shell 45 having a conical bottom 46 and a water discharge pipe 47 which is shaped to form a water seal in the same manner described above in regard to the water discharge of the apparatus shown in Figure 1. The gas inlet pipe 48 enters the bottom portion of the shell 45 and the clean gas outlet pipe 49 is preferably located at approximately the horizontal center line of the electrical precipitator units. The bubble trays B' extend across the shell 45 immediately above the inlet pipe 48 and a transverse wall 50, corresponding to the wall 24 of Figure 1, extends across the shell 45 immediately above the upper bubble tray B'. As this embodiment of our cleaner is provided with four precipitator units, four nozzle members 51 extend upwardly through the wall 50 and are adapted to direct the gas into the interior of the discharge electrodes of the precipitator units P. As these precipitator units are substantially the same as those shown in

Figures 1 to 8 they will not be further described here and it will suffice to say that the gas which passes into the precipitator units P through the nozzles 51 is discharged into the space 52 which is defined by the shell 45, the plate 50 and the upper baffle plate 53. From the chamber 52 the clean gas is conducted through the pipe 49 to suitable storage tanks or apparatus in which the gas is to be used.

The insulators, electrical connections and other associated parts of the precipitators P are also substantially the same as those described above in connection with the apparatus of Figure 1, and the collecting electrode flushing water which is supplied through the pipes 54 passes downwardly over the baffles 55 and 56 to the inner walls of the collecting electrodes of the precipitator units P. This water collects on the wall 50 and is preferably conducted down to the upper bubble trays B' through the pipes 57. A vent pipe 58 extends upwardly from the chamber 52 and is provided at its upper end with a valve 59 for controlling the flow of gas therethrough. This vent pipe 58 is adapted to permit gas from the interior of the cleaner to be allowed to escape to the atmosphere when desired.

The bubble trays B' are of a somewhat different type than the bubble trays B of Figure 1 and are illustrated in detail in Figures 10, 11, 12, and 13. Each of the trays B' comprise a series of tray sections 61, 62, 63, and 64 (Figure 10) and each of these tray sections is provided with a bottom plate member 65 having a plurality of elongated slots 66 which are defined by the pipes or chimneys 67. These chimneys 67 are provided with vertically extending slots 67a which permit a part of the cleaning water to flow into the gas as it passes up the chimneys. The function of the slots 67a is the same as that of slots 33a of the apparatus shown in Figures 1 to 8. Perforated plates 68, of inverted U-shaped cross section, lie between each pair of chimneys 67 and extend between the end plates 69 of each of the bubble tray units.

In this form of our invention the bubble caps are elongated imperforate members 70 of inverted U-shape cross section, which, as is clearly seen in Figure 12, are adapted to bridge over each of the chimneys 67 and which have their bottom edges supported by the perforated baffles 68. These members 70 also extend between the end plates 69 and are provided with lugs 71 which extend through suitable apertures in the end plates 69 and are threaded at their outer ends to accommodate nuts 72 which are adapted to hold the caps in position. The end plates 69 are provided with bottom flanges 73 (Figure 11) which may be welded or otherwise suitably secured to the plates 65.

The water on the plates 65 is maintained at the proper level by means of weir members 74. A suitable water level is indicated by the dot and dash line 75 of Figure 12, and it will be seen from an inspection of this view that the gas which passes up through the chimneys 67 will be deflected downwardly by the member 70 through the water immediately adjacent the chimneys 67, through the perforations in the side walls of the members 68, and will then bubble up to the surface of the water on the trays 65. With this apparatus a very intimate mixing and agitating of the gas with the water is obtained. As has been noted before this division of the gas into a number of relatively small, high velocity streams and the intimate mixing and agitating caused by

the bubbling of the gas through the water is very effective in removing certain of the entrained solid material from the gas which cannot be removed by the ordinary gas cleaner of the Feld type.

Referring now to Figure 11, the water from the precipitator units flows downwardly through the pipe 57 into the well 76. When the water level in the well 76 rises to the top of the weir plates 74 it will overflow onto the adjacent plates 65 and the level of the water thereon will rise until it reaches the top of the weir members 74a. When this occurs the water will overflow into the well 77. The water will now collect in this well 77 until it reaches the top of the weir member 74b when it will overflow onto the plates 65 of the lower bubble tray. The weir member 74c will, of course, control the depth of liquid upon the tray 65 and the overflow over the weir 74c will pass downwardly through the conduit 78 into the conical bottom portion 46 of the shell 45.

The above described bubble tray arrangement provides a very efficient means for intimately mixing the gas with water or other cleaning fluid. By providing the slotted elongated chimneys and bubble caps together with the perforated baffle plates 68 maximum agitation and intermingling of the gas and liquid is effected with a minimum resistance to flow of the liquid. As the gas passes through the bubble trays certain of the solid particles are removed from the gas and remain in the liquid. We have found that, by using bubble trays of the type described, the degree of cleaning which is to be accomplished in the primary cleaning portion of the apparatus, can be secured in a relatively small space. In other words, the gas can be cleaned to a predetermined degree in a tower in which our improved bubble trays are used in a much smaller vertical distance than that required in a tower in which any other primary cleaning means with which we are familiar is employed. This advantageous result, that is, more effective cleaning in small distance of gas travel, is due largely to the extremely intimate mixing and agitation of the gas and cleaning fluid as the gas passes through the bubble trays.

Although we have described the illustrated embodiment of our invention in considerable detail it will be understood by those skilled in the art that modifications and variations may be made in the form of apparatus employed without departing from the spirit of our invention. We do not, therefore, wish to be limited to the specific arrangement shown and described but claim as our invention all embodiments thereof coming within the scope of the appended claims.

We claim:

1. Gas cleaning apparatus including a shell, a gas inlet conduit leading to said shell and a gas outlet conduit leading from said shell, a bubble tray in said shell extending across the path of the gas between said inlet and outlet, said bubble tray being adapted to direct the gas in a tortuous path through a body of liquid on said tray whereby entrained solid material is removed from the gas by the liquid, means for supplying liquid

to said tray, and an electrical precipitator disposed in said shell between said bubble tray and the gas outlet.

2. In gas cleaning apparatus of the class described, the combination of a housing, bubble tray means within said housing adapted to direct gas passing through the housing into and through a body of liquid, an electrical precipitator disposed above said bubble tray means and having discharge and collecting electrodes, means for supplying flushing liquid to said collecting electrode, and means for conducting said flushing liquid from said collecting electrode to said bubble tray means.

3. Gas cleaning apparatus including a bubble tray, means for directing the gas to be cleaned through the bubble tray, said bubble tray including baffle walls adapted to cause the gas to pass in a tortuous path through a body of liquid, an electrical precipitator having a collecting electrode, means for supplying flushing water to said collecting electrode, means for conducting gas from the bubble tray to said precipitator, and means for conducting flushing water, from said precipitator collecting electrode to said bubble tray.

4. In combination in gas cleaning apparatus, a housing, a gas inlet to said housing, a gas outlet from said housing, primary gas cleaning apparatus in said housing including a bubble tray, secondary gas cleaning apparatus including an electrical precipitator and means for supplying electrode flushing liquid from an external source to said precipitator, said precipitator being disposed in the gas path between said bubble tray and gas outlet, and means for directing flushing liquid from said precipitator to said bubble tray.

5. In combination in gas cleaning apparatus, a bubble tray having a plurality of upwardly extending chimneys and bubble caps disposed over said chimneys and adapted to direct gas into and through a body of liquid on the tray, means for supplying liquid to said bubble tray, means for directing gas to be cleaned through said bubble tray, an electrical precipitator and means for directing the gas being cleaned from said bubble tray through said precipitator.

6. In combination in gas cleaning apparatus, a shell having a gas inlet, a bubble tray in said shell extending across the path of gas through said shell, said bubble tray being adapted to direct the gas in a tortuous path through a body of liquid on said tray whereby entrained solid material is removed from the gas by the liquid, means for supplying liquid to said tray, an electrical precipitator having a discharge and a collecting electrode, means for supplying flushing liquid to said collecting electrode, means for conducting gas from said bubble tray to said electrical precipitator, means for conducting flushing liquid from said collecting electrode to said bubble tray, and means for conducting cleaned gas from said precipitator.

JOHN P. IRWIN.
CHARLES B. THORNE.
MERRILL COX.