

July 14, 1970

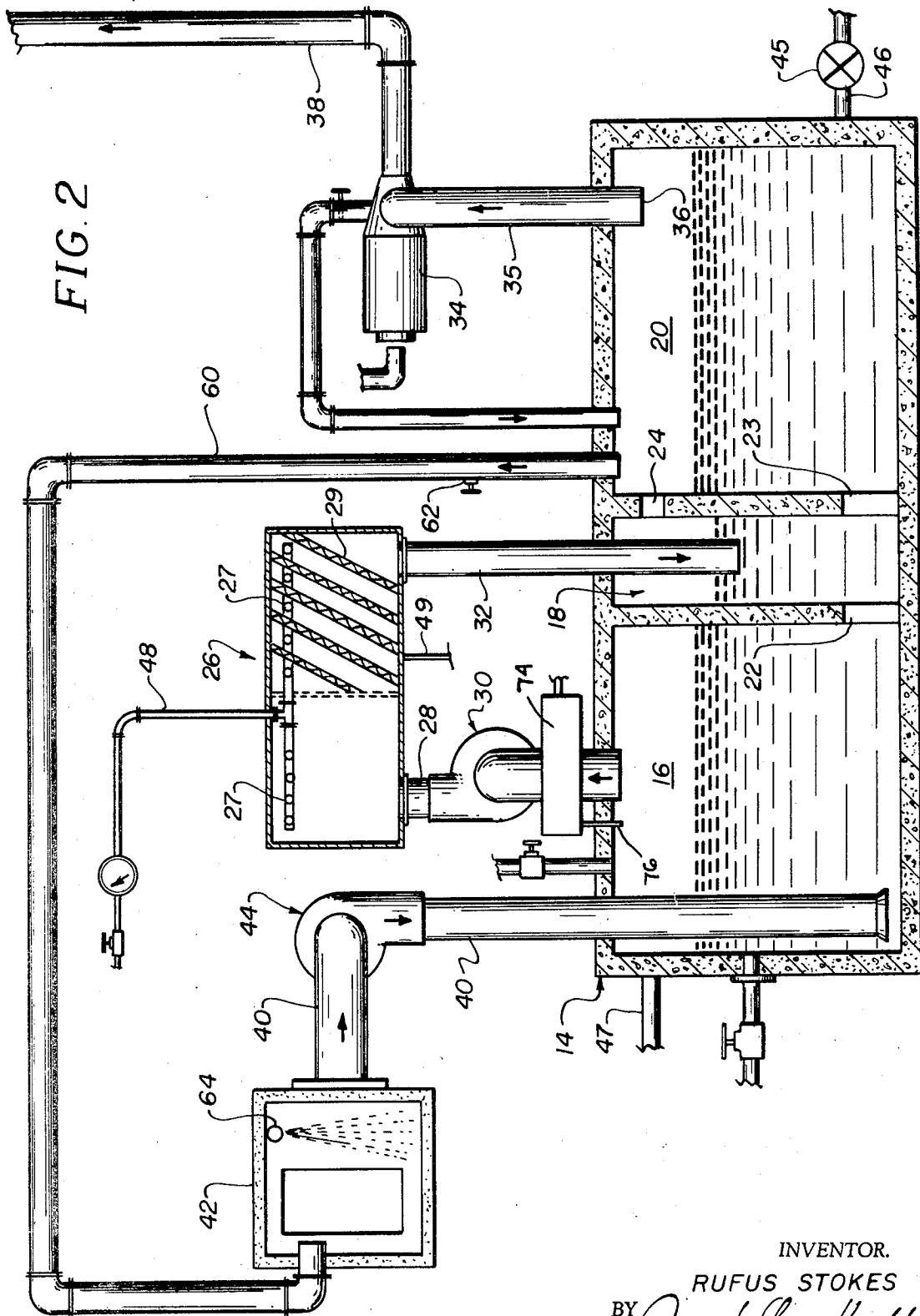
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3,520,113

AIR POLLUTION CONTROL DEVICE

Filed Jan. 8, 1968

3 Sheets-Sheet 2



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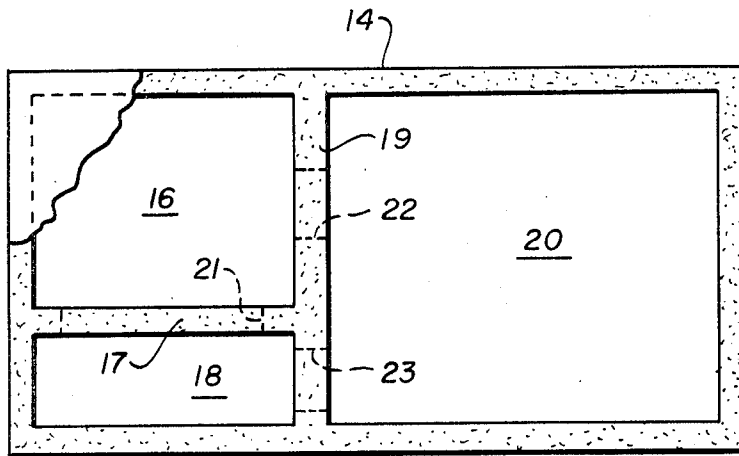


FIG. 3

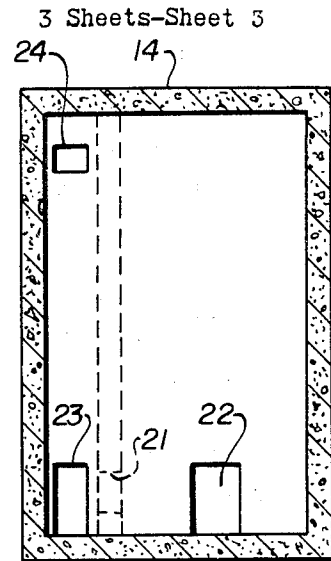


FIG. 4

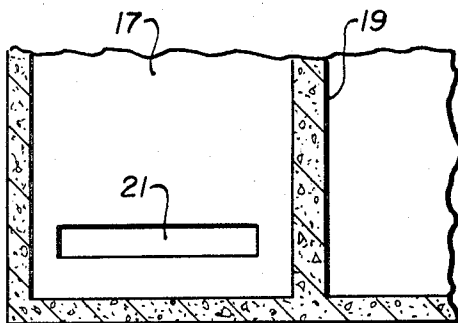


FIG. 5

FIG. 6

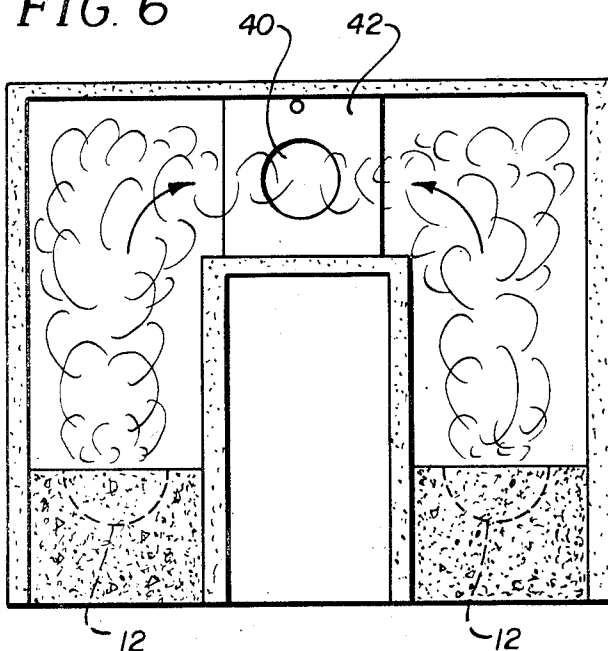
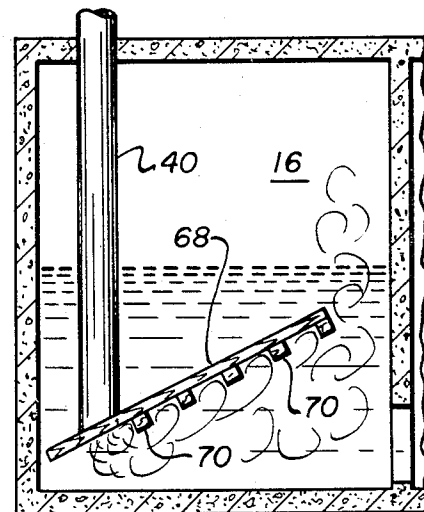


FIG. 7

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AIR POLLUTION CONTROL DEVICE

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8 Claims

ABSTRACT OF THE DISCLOSURE

An air pollution control apparatus which includes, generally, a high pressure blower system for forcing the exhaust gases into a primary mixing chamber which comprises one of three water containing chambers within a tank. The exhaust gases are blown into the primary mixing chamber, below the surface of the water, so that the fumes will bubble through the water upon rising to the top. As the fumes rise to the top of the water, additional high speed blowers draw them out of the primary mixing chamber and force them into a precipitator-filter unit. In the precipitator-filter unit, the fumes are "washed" by means of a water spray and are filtered to remove still additional particulate matter. From the precipitator-filter unit, the fumes are returned to another mixing chamber within the tank. This mixing chamber is of a construction such that the fumes are retained therein, under pressure, so that the gases are absorbed by the water within the chamber. From this mixing chamber, the gases flow into a settling chamber within the tank. The water in this chamber is generally quiescent, and the fumes are retained in this chamber, until the fumes are drawn out of it, by the draft of the exhaust stack.

This invention relates to an apparatus for removing particulate matter, gases, chemicals and odors from exhaust fumes or other gases, prior to exhausting them into the atmosphere.

In the smelting business, especially in the re-claiming of metals such as lead and zinc, a real problem exists where extraneous material such as, for example, rubber insulation on the metals, is burned by the heat of the molten metal. The fumes and smoke coming from this extraneous material is generally exhausted to the atmosphere. For the most part, there is no attempt made to clean the smoke and fume emission from the smelting pots, simply because the apparatus which is available to perform this function is ineffective. Apparatus including cyclone filters, bag filters, electrostatic precipitators and the like have been used in the past to remove these impurities, however, all of them are generally unsatisfactory, for one reason or another. Accordingly, a substantial amount of impurities in the form of particulate matter and gases is exhausted to and pollutes the atmosphere.

It is therefore an object of the present invention to provide an improved apparatus for removing impurities in the form of particulate matter, gases, chemicals and odors from exhaust fumes or other gases, prior to exhausting them into the atmosphere.

Another object is to provide apparatus of the above type which is relatively simple in construction, easily manufactured and installed, and adaptable for use in numerous applications.

Still another object is to provide apparatus of the above type which is far less complex than similar presently available apparatus, and is capable of removing more of the impurities from exhaust fumes or other gases than heretofore generally possible.

Other objects of the invention will in part be obvious and will in part appear hereinafter.

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The above objectives are accomplished with the air pollution control apparatus of the present invention which includes, generally, a high pressure blower system for forcing the exhaust gases from, for example, above a smelting pot, into a primary mixing chamber which comprises one of three chambers within a tank, fully described below. The primary mixing chamber, as well as the other two chambers within the tank, are filled with water which preferably is continuously circulated. The exhaust gases are blown into the primary mixing chamber, below the surface of the water, so that the fumes will bubble through the water upon rising to the top. As the fumes rise to the top of the water, additional high speed blowers draw them out of the primary mixing chamber and force them into a precipitator-filter unit. In the precipitator-filter unit, the fumes are "washed" by means of a water spray and are filtered to remove still additional particulate matter. From the precipitator-filter unit, the fumes are returned to another mixing chamber within the tank. This mixing chamber is of a construction such that the fumes are retained therein, under pressure, so that the gases are absorbed by the water within the chamber. From this mixing chamber, the gases flow into a settling chamber within the tank. The water in this chamber is generally quiescent, and the fumes are retained in this chamber, until the fumes are drawn out of it, by the draft of the exhaust stack.

For a fuller understanding of the nature and objects of the invention, reference should be had to the following detailed description taken in connection with the accompanying drawings in which:

FIG. 1 is a perspective view of an air pollution control apparatus exemplary of the invention;

FIG. 2 is a diagrammatic view generally illustrating the apparatus of FIG. 1, and the flow of the fumes through it;

FIG. 3 is a top plan view of the tank of the apparatus, illustrating the three chambers formed in it;

FIG. 4 is a sectional view of the tank, taken along lines 4—4 of FIG. 3;

FIG. 5 is a partial sectional view of the tank, taken generally along lines 5—5 of FIG. 3;

FIG. 6 is a view generally illustrating the manner in which one or more smelting pots can be vented and coupled to the apparatus of FIG. 1; and

FIG. 7 is a sectional view illustrating a manifold which can be affixed to the end of the pipe line extending into the primary mixing chamber of the tank of the apparatus.

Similar reference characters refer to similar parts throughout the several views of the drawings.

Referring now to the drawings, in FIG. 1 there is illustrated an air pollution control apparatus 10 which is adapted to remove particulate matter, gases, chemicals and odors from exhaust fumes or other gases, such as the exhaust fumes emanating from the material being smelted in one or more smelting pots 12 (FIG. 6), prior to exhausting them into the atmosphere. The apparatus 10 includes a closed tank 14 which is fabricated of steel, concrete, or other appropriate material. The tank 14 can be formed as an integral, transportable unit, as illustrated, or alternatively, can be formed in situ, in the form of a poured concrete tank or cistern. The tank 14 is divided by means of walls 17 and 19 so as to provide three chambers therein which form a primary mixing chamber 16, a secondary mixing chamber 18 and a settling chamber 20, respectively. An opening 21 is provided in the wall 17 between the chambers 16 and 18, and openings 22 and 23 are provided in the wall 19 between the chambers 16 and 20 and between the chambers 18 and 20, respectively. These openings 21—23 permit water to be circulated between the three chambers 16, 18 and 20, as described more

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fully below, and they are preferably formed in the walls 17 and 19 at or near the lower edges thereof, so that the exhaust fumes blown into the chambers 16, 18 and 20 will not flow through them, from one chamber to another. The only opening between any one of the chambers 16, 18 and 20 through which the exhaust fumes can flow is a small window-like opening 24 formed in the wall 19 at or near its upper edge, above the water level maintained therein, for permitting the fumes to flow from the secondary mixing chamber 18 into the settling chamber 20.

A precipitator-filter unit 26 including a number of water jets 27 for "washing" the fumes and a number of filters 29 for filtering the "washed" fumes is mounted on the tank 14, as illustrated. Alternatively, the unit 26 can be supported some distance from the tank 14, in a convenient location, and coupled to the tank, in the manner described below. Fumes injected into the primary mixing chamber 16 are drawn therefrom and blown into the precipitator-filter unit 26, through a pipe line 28, by means of one or more high-speed blowers 30 included in the pipe line 28.

From the precipitator-filter unit 26, the fumes are blown into the secondary mixing chamber 18, through a pipe line 32, by means of the same high-speed blowers 30. The fumes blown into the secondary mixing chamber 18 enter the settling chamber 20, through the window-like opening 24 in the wall 19.

An after burner 34 preferably is included in the pipe line 35, coupling the outlet 36 of the settling chamber 20 to an exhaust stack 38 or the like. The after burner 34 is advantageously used when the exhaust fumes from the smelting pots 12 include a substantial amount of noxious gases, such as sulfur dioxide, zinc chloride and the like, generated in the smelting of lead, tin, zinc and tiny residues.

A pipe line 40 extending into a chamber or hood 42 coupled to its one end is provided to couple the exhaust fumes from, for example, the smelting pots 12 (FIG. 6), to the primary mixing chamber 16. One or more high-speed, high-pressure blowers 44 are included in the pipe line 40, for drawing the exhaust fumes through the pipe line 40 and for blowing them into the primary mixing chamber 16.

Having now described the construction of the apparatus 10, its operation can be described as follows. The apparatus 10 is energized, and the high-speed, high-pressure blowers 44 draw the exhaust fumes generated in the smelting pots 12 through the pipe line 40 and blow them into the primary mixing chamber 16. The end of the pipe line 40 extends below the surface of the water within the primary mixing chamber 16, so that the exhaust fumes are caused to bubble up through the water, to the top of the chamber 16. The bubbling of the water creates a scouring action which tends to cause the large particles to settle in the chamber 16. Also, gases, chemicals and odors in the fumes are absorbed, to some extent, in the water in the chamber 16.

The fumes which rise to the top of the primary mixing chamber 16 are drawn out of it by the high-speed blowers 30, and are blown through the pipe line 28 into the precipitator-filter unit 26. During the operation of the apparatus 10, a constant spray of water is emitted by each of the water jets 27 within the unit 26 so as to create a fine mist within the unit. The fumes flow through this mist and the fine particles are saturated with water so as to form droplets. In other words, the fine particles are absorbed in a fashion such as to "wash" the fumes. Prior to exiting from the unit 16, the fumes and the droplets pass through a number of filters 29. In passing through these filters, the larger particles which escaped from the primary mixing chamber 16 and the fine particles absorbed by the water droplets are filtered so as to further clean the fumes.

From the precipitator-filter unit 26, the fumes are blown through the pipe line 32 into the second mixing chamber 18. It may be noted that the same high-speed blower

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30 used to force the fumes into the precipitator-filter unit 26 also are used to blow or force the fumes from the unit 26 into the secondary mixing chamber 18. As indicated above, the only exit from the chamber 18, at its top, is the small window-like opening 24. The fumes are blown or forced into the chamber 18, at a far greater rate than the fumes can flow through the opening 24, into the settling chamber 20, so that a pressure is created within the chamber 18, stop the water therein. This pressure tends to prevent the fumes from bubbling up to the surface of the water, so that the fumes are again agitated or scoured to a greater extent. This action tends to break up any air bubbles having fine particles trapped in them, so that these fine particles are collected within the chamber 18.

The pressure within the chamber 18 also prevents the gases from rising to the surface of the water so that the gases are absorbed in the water and thereby removed from the fumes flowing into the settling chamber 20. Accordingly, by the time that the fumes reach the settling chamber 20, the particulate matter, chemicals, noxious gases and odors are substantially removed from the fumes.

The fumes reaching the settling chamber 20 remain therein for a relatively long period of time in comparison to the time the fumes remain in either of the chambers 16 and 18. This is due to the fact that no blowers are provided to draw these fumes out of the settling chamber 20. The fumes are merely drawn out of the settling chamber 20, by the draft created by the exhaust stack 38. A substantial pressure therefore is built up in the settling chamber 20 since the volume of fumes forced into it, from the chamber 18, is greater than the volume drawn out of it, by the draft. This pressure in combination with the period of time that the fumes remain within the settling chamber 20, provides an opportunity for any particulate matter which managed to escape from the chambers 16 and 18 to settle in the water in the chambers 20, before being exhausted into the atmosphere through the exhaust stack 38.

As indicated above, the chambers 16, 18 and 20 in the tank 14 have water in them. Preferably, these chambers are only partially filled, to approximately $\frac{1}{2}$ - $\frac{3}{4}$ of their volume so that there is sufficient area above the water level in them, in which the fumes can collect. This water is circulated through the chambers, through the openings 21-23 therein, by means of a water pump 45. The water pump 45 is coupled to the tank 14, by means of water lines 46 and 47, preferably in a fashion such as to draw the water out of the secondary mixing chamber 18 and to pump it into the settling chamber 20. The water preferably is drawn out of the secondary mixing chamber 18 so as to create a flow into it, from both the primary mixing chamber 16 and the settling chamber 20. The reason for this is the fact that the gases such as sulfur dioxide and zinc chloride in the fumes are absorbed, in the water in the chamber 18, to a far greater extent than in either of the other two chambers 16 and 20. In order to prevent the water in the chamber 18 from becoming saturated to the extent that its ability to absorb more of the gases in the fumes is impaired, the water in the other two chambers is drawn into it so that the water in the chamber 18 always is relatively "fresh" water.

The water in the chamber 18 also becomes acidic, as a result of absorbing the gases in the fumes. For this reason also, the water in the chamber 18 is constantly circulated and mixed with the water in the other two chambers 16 and 20. It may be noted that the settling chamber 20 is relatively larger in volume than the other chambers 16 and 18. Its volume could be reduced, however, it is made intentionally large so that it also functions as a relatively large reservoir of generally "fresh" water, for diluting the water within the tank 14 so that its acidity does not become too great. Caustic chemicals also can be added to the water in the tank 14, to maintain a relatively neutral pH.

It is apparent that the water within the primary mixing chamber 16 would heat quite rapidly due to the high temperature of the fumes being forced into it, if the water was not circulated. The settling chamber 20 also acts as a large reservoir of cool water, for cooling the water within the tank 14. In large volume systems, it may be advantageous to circulate the water in the tank 14 through cooling coils, rather than enlarging the volume of the settling chamber 20, so that the water within the tank 14 is prevented from ever reaching a boiling temperature and evaporating.

Water also is coupled to the precipitator-filter unit 26 through a water line 48, and is drained therefrom through drain line 49. The water line 48 can be coupled to a source of water or, alternatively, both the water line 48 and the drain line 49 can be coupled to a supply tank (not shown) and the water circulated through the supply tank and the precipitator unit 26, by means of a circulating pump (not shown). Means (not shown) also are provided to maintain the water level in the tank 14 and, if used, in the supply tank for the precipitator-filter unit 26.

Tests have shown that the apparatus 10 is extremely effective in removing all of the particulate matter from the fumes which are caused to flow through it. Furthermore, these tests also have shown that substantially all of the noxious gases, chemicals and odors likewise are removed, during ordinary operating conditions. Under extreme operating conditions, for example when cleaning the exhaust fumes emanating from smelting pots in which metal having a large concentration of extraneous foreign matter combined with it is being re-claimed, the after burner 34 is advantageously placed in operation to burn up any of the gases which are not absorbed in the chambers 16, 18 and 20. If tests indicate that fumes being exhausted through the exhaust stack 38 still contain some gases, the after burner is ignited. The fumes leaving the settling chamber 20 are coupled through the after burner 34, as can be best seen in FIG. 2, and the gases are burned before entering the exhaust stack 39. Tests again have shown that the apparatus 10, when operated with the after burner 34, is extremely effective even under extraordinary adverse conditions.

As indicated above, the apparatus 10 is adaptable for use in numerous applications, and with various size installations. Generally, it is only necessary to provide blowers 30 and 44 having sufficient capacity to force the exhaust fumes through the apparatus 10, at the same or faster rate than the fumes are being generated in the system. In some cases, it may be found that the volume of fumes blown into the settling chamber 20 is so large that the pressure therein increases until it equals or exceeds the pressure in the secondary mixing chamber 18. The effectiveness of the system would be impaired if this were to occur. Accordingly, to prevent such an occurrence, a by-pass pipe line 60 is coupled from the settling chamber 20 back to the hood 42 above the smelting pots 12, or other source of fumes, being exhausted to the atmosphere, as illustrated in FIG. 2. A pressure relief valve 62 is included in the by-pass pipe line 60, and is adjustable so that it can be set to open to permit the fumes in the settling chamber 20 to flow through the by-pass pipe line 60, back to the hood 42, when the pressure within the settling chamber 20 exceeds a predetermined value. These fumes then are again forced through the apparatus 10, in the above-described fashion.

The hood 42 also is advantageously provided with one or more water jets 64, for creating a water spray or mist in the hood through which the fumes flow before entering the apparatus 10. This water spray or mist functions to absorb some of the fine particles, in generally the same fashion as they are absorbed in the precipitator-filter unit 26. Some of these fine particles are thereby caused to settle in the primary mixing chamber 16. This water spray or mist also functions to cool the fumes, to some degree, before the fumes are blown into the primary mixing

chamber 16, so that the temperature of the water within the tank 14 is not raised quite so rapidly. In exceptionally large systems or installations, it may be desirable to use a larger capacity tank 14, or to use two or more of the apparatus 10.

A drain tank 74 also is advantageously included in the pipe line 28, as illustrated in FIG. 2, for water which is drawn out of the primary chamber 16 by the force of the blowers 30 to collect in. The water drains back into the primary chamber 16, through a drain line 76. A source of water also can be coupled to the drain tank 74, for creating a water spray through which the fumes pass, for saturating the fumes with water. This water spray can be drained into the primary tank 16, to replenish water which is evaporated.

In FIG. 7, the pipe line 40 extending into the primary mixing chamber 16 is illustrated having a manifold 68 affixed to its end submerged in the water within the chamber. The manifold 68 is disposed so as to extend angularly upwardly and has a number of ports 70 in spaced relation along its length. When a manifold of this construction is used, the water in the chamber 16 is agitated to a far greater degree so as to enhance the mixing of the fumes and the water.

Set forth below are the results obtained during a test of a prototype apparatus of the above described construction. The apparatus is not what would be considered a well-engineered installation or unit, but simply one designed to determine its effectiveness and to prove its principal of operation.

HISTORY

Samples of the gases evolved on burning of the following materials were taken:

Sample "O": Bunker oil
Sample "S": Raw sulfur
Sample "R": Rubber cable

The samples were collected, packed and sealed with metal tags, and delivered for testing.

SAMPLING

The sampling was conducted in the following manner:

(1) 500 cc. glass gas collection bulbs were evacuated and held under vacuum for 5-10 minutes.
(2) Two samples of each gas evolved from the burning were collected:

(a) Sample "+": Sampled directly over the furnace.
(b) Sample "-": Sampled from a port after the gas had passed through the apparatus 10.

DATA

The data was collected from analyses performed on a mass spectrometer and a gas chromatograph, and is presented as follows:

SAMPLE-BUNKER OIL

Components	Before apparatus	After apparatus
Nitrogen, percent.....	78.0	79.2
Argon, percent.....	0.93	0.95
Carbon dioxide, percent.....	0.3	1.8
Oxygen, percent.....	20.8	18.0
Carbon monoxide, percent.....	0.02	0.02
Methane (p.p.m.).....	57	None
Ethylene (p.p.m.).....	30	None
Propylene (p.p.m.).....	40	None

SAMPLE-RAW SULFUR

Components	Before apparatus	After apparatus
Nitrogen, percent.....	76.5	80.3
Argon, percent.....	0.92	0.97
Carbon dioxide, percent.....	0.2	3.0
Oxygen, percent.....	17.7	13.7
Sulfur dioxide, percent.....	4.7	2.0
Carbon disulfide (p.p.m.).....	15	3
Hydrogen sulfide (p.p.m.).....	160	72
Carbonyl sulfide (p.p.m.).....	66	31

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SAMPLE—RUBBER CABLE

Components	Beore apparatus	After apparatus
Nitrogen, percent	78.4	80.5
Argon, percent	0.95	0.97
Carbon dioxide, percent	2.6	5.6
Oxygen, percent	17.9	12.8
Carbon monoxide, percent	0.08	0.08
Acetylene (p.p.m.)	58	14

ANALYSIS OF DATA

The raw data is analyzed in light of those contaminants which produce adverse physiological effects, and in terms of their removal via the apparatus 10.

Component	Before		After		Removal, percent
	Percent	p.p.m.	Percent	p.p.m.	
Carbon monoxide	0.02	200	0.02	200	0.00
Methane	0.0057	57	0.00	0	100.00
Ethylene	0.0030	30	0.00	0	100.00
Propylene	0.0040	40	0.00	0	100.00
Sulfur dioxide	4.7	47,000	2.0	20,000	57.44
Carbon disulfide	0.0015	15	0.0003	3	80.00
Hydrogen sulfide	0.0160	160	0.0072	72	55.00
Carbonyl sulfide	0.0066	66	0.0031	31	53.03
Acetylene	0.0058	58	0.0014	14	75.86

CONCLUSIONS

From the data presented and the observations made during sampling, the following conclusions are made:

- (1) All hydrocarbons, irrespective of source, are significantly reduced in concentration after passing through the apparatus 10.
- (2) All hydrocarbons are removed by the apparatus on the burning of bunker oil.
- (3) Sulfides, resulting from the burning of sulfur are significantly reduced in concentration after passing through the apparatus 10, but not eliminated.
- (4) Carbon monoxide is not reduced or removed by the apparatus 10.
- (5) Elevated levels of oxygen before elimination and elevated levels of carbon dioxide after elimination are a result of the combustion process and are not attributable to the apparatus 10.

From the test results set forth above, it can be seen that the apparatus 10 used during the subject test proved to be extremely effective in removing the most intolerable and irritating gases from the exhaust fumes, even under the extreme operating conditions used during the test. While data was not recorded on its effectiveness in removing the other impurities, such as particulate matter, in the exhaust fumes, the observed results were entirely satisfactory. It is fully anticipated that improved results can be obtained with apparatus which is properly engineered and installed.

Now that the invention has been described, what is claimed as new and desired to be secured by Letters Patent is:

1. Air pollution control apparatus comprising, in combination: a primary mixing chamber, a secondary mixing chamber and a settling chamber, each of said chambers being partially filled with water; conduit means including first blower means therein for coupling exhaust fumes from a source generating said fumes to said apparatus and for blowing said fumes into said primary mixing chamber below the surface of the water therein; conduit means including second blower means therein for drawing said exhaust fumes from said primary mixing chamber and blowing said fumes into said secondary mixing chamber below the surface of the water therein; coupling means for conveying fumes from said secondary mixing chamber to said settling chamber; said second blower means, said secondary chamber and said coupling means being proportioned to create a pressure within said secondary

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mixing chamber to impede the flow of gases to the surface of the water therein so as to cause said gases to be absorbed in the water, said pressure also causing fumes within said secondary mixing chamber to flow through said coupling means into said settling chamber; an exhaust stack coupled to said settling chamber through which the fumes in said settling chamber can flow to the atmosphere; and means for circulating the water in each of said chambers.

2. The apparatus of claim 1 including a tank having a top wall, a bottom wall, side walls, a first and a second interior wall within said tank dividing said tank so as to provide said primary mixing chamber, said secondary mixing chamber and said settling chamber, an opening in said first wall near said bottom wall providing a water circulation passage between said primary and said secondary mixing chambers, a pair of openings in said second wall near said bottom wall providing a water circulation passage between said settling chamber and respective ones of said primary and secondary mixing chambers, and a window-like opening in said second wall near its top between said secondary mixing chamber and said settling chamber, said window-like opening comprising said coupling means for conveying fumes from said secondary mixing chamber to said settling chamber.

3. The apparatus of claim 2 further including precipitator-filter means included in said conduit means extending between said primary mixing chamber and said secondary mixing chamber, said precipitator-filter means including means for providing a water spray therein and means for filtering fumes flowing through said water spray.

4. The apparatus of claim 3, wherein said second blower means comprises at least one high-speed blower means coupled in said conduit means between said primary mixing chamber and said precipitator-filter means.

5. The apparatus of claim 4 wherein said fumes are drawn out of said settling tank by the draft of said exhaust stack.

6. The apparatus of claim 5 wherein said means for circulating the water in said tank is adapted to draw water out of said secondary mixing chamber and to inject water into said settling chamber.

7. The apparatus of claim 2, further including an afterburner included in the coupling between said settling chamber and said exhaust stack.

8. The apparatus of claim 2, further including bypass conduit means for coupling fumes from said settling chamber to the inlet for said conduit means extending to said primary mixing chamber, and a pressure relief valve included in said bypass conduit means which is adaptable to open to permit fumes to flow through said by-pass conduit means when the pressure within said settling chamber exceeds a predetermined value.

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U.S. Cl. X.R.

55—233, 256, 259; 261—121; 23—2; 110—119; 266—15