

Oct. 17, 1933.

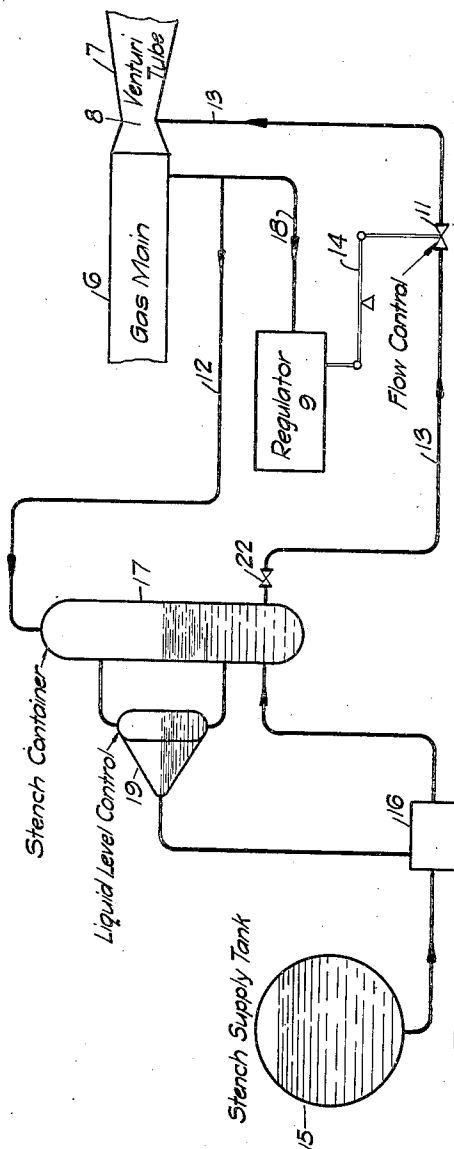
C. C. ASHLEY ET AL

1,930,848

APPARATUS FOR INJECTING LIQUID MATERIAL INTO GASES

Filed Jan. 20, 1931

3 Sheets-Sheet 1



William I. Steele
Chester C. Ashley
INVENTORS

BY THEIR ATTORNEY:

Byratama

Oct. 17, 1933.

C. C. ASHLEY ET AL

1,930,848

APPARATUS FOR INJECTING LIQUID MATERIAL INTO GASES

Filed Jan. 20, 1931

3 Sheets-Sheet 2

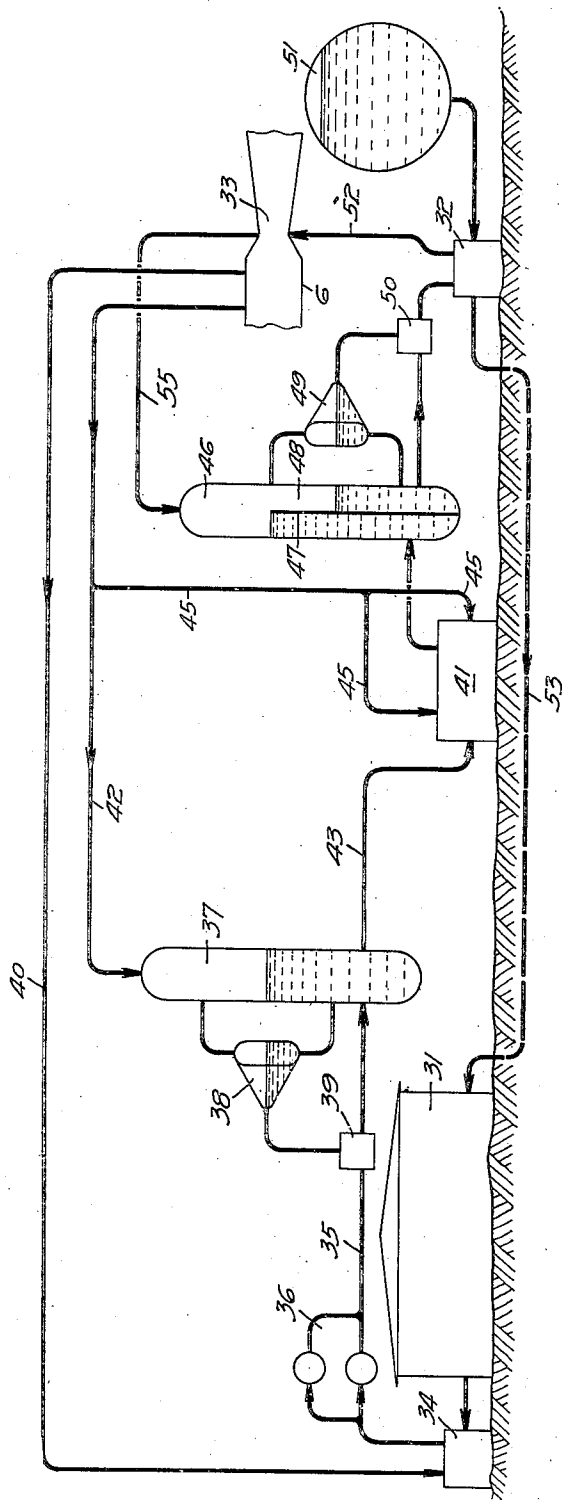


FIG. 2.

INVENTORS.
Chester C. Ashley
William I. Steele
BY *B. P. [Signature]*
ATTORNEY

Oct. 17, 1933.

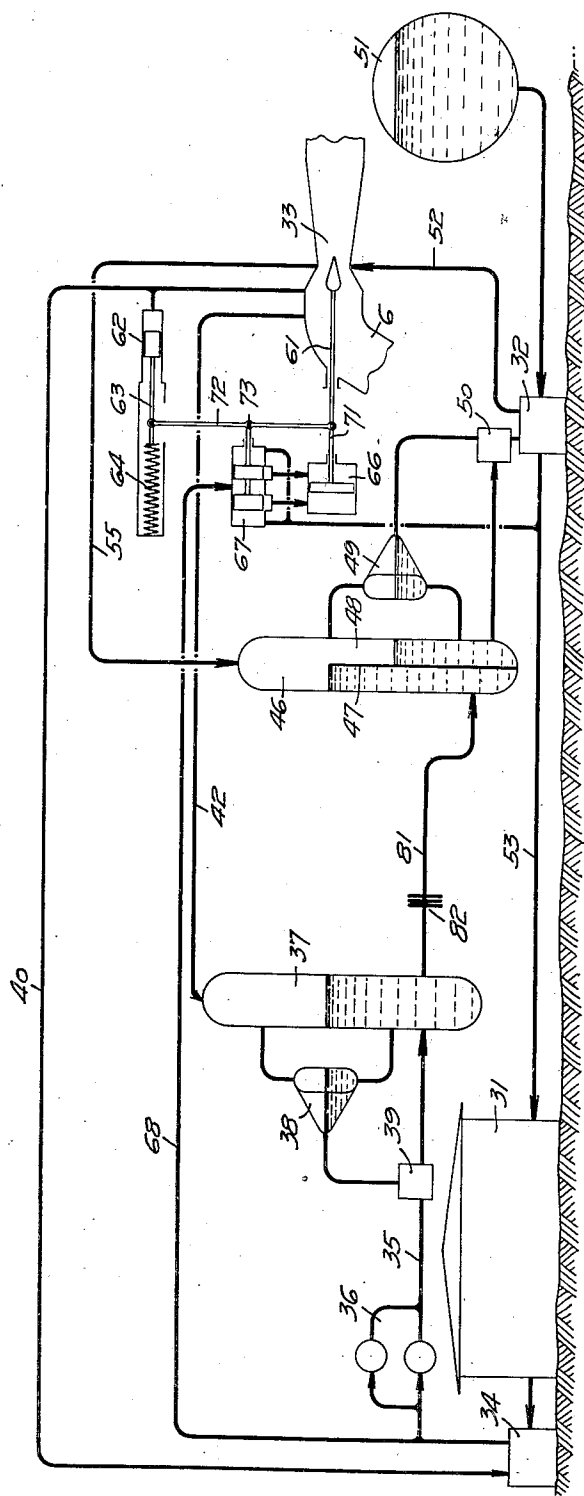
C. C. ASHLEY ET AL

1,930,848

APPARATUS FOR INJECTING LIQUID MATERIAL INTO GASES

Filed Jan. 20, 1931

3 Sheets-Sheet 3



四四四

INVENTORS
Chester C. Astley
William I. Steele
BY  ATTORNEY

UNITED STATES PATENT OFFICE

1,930,848

APPARATUS FOR INJECTING LIQUID
MATERIAL INTO GASES

Chester C. Ashley, Berkeley, and William I. Steele,
Redwood City, Calif., assignors, by mesne as-
signments, to Shell Development Company,
San Francisco, Calif., a corporation of Dela-
ware

Application January 20, 1931. Serial No. 509,964

10 Claims. (Cl. 261-76)

This invention relates to an apparatus for in-
jecting suitable volatile stench material into usu-
ally odorless gases, such as natural gas. How-
ever, the invention is useful in connection with
the intermingling or injection of a liquid and a
gas generally and is not limited in application
to natural gas or stenching liquids.

In United States Patent No. 458,937 it is sug-
gested that inodorous gases of a poisonous and
toxic nature, such as natural gas, be injected
with vapors of strongly smelling liquid such as
mercaptans in order that the escape of the gas
may be readily detected. The injection of such
a strongly smelling liquid is particularly desir-
able today when natural gas is being so widely
utilized, since this gas, as is well known, is sub-
stantially odorless and its escape, therefore, can-
not ordinarily be detected.

It is the present practice to transport natural
gas by means of pipe lines, which extend for
long distances across the country and the gas is
handled therein under relatively extremely high
pressures. By virtue of the compressibility of
gases, the gas lines are ordinarily "packed" dur-
ing the night, the pressure being run up to a
relatively high pressure, in the neighborhood of
600 to 800 pounds. During the day time, this
pressure is allowed to fall as low as 150 pounds
so that the total quantity of gas in the pipe
lines varies. This packing is made use of instead
of providing large reservoir chambers, the pipe
line constituting one which is readily available
for reservoir purposes. It is, therefore, to be ap-
preciated that flow conditions vary widely in such
lines.

Since the pressure and velocity of the gas flow-
ing in the pipe line can vary between relatively
wide limits, the stenching of the gas presents a
relatively difficult problem, particularly since it
is very desirable that the odor provided in the
gas be substantially uniform. This is desirable,
not only from the standpoint of detection of the
gas if it escapes, but also from the standpoint
of expense of stenching material. The mercap-
tans and other materials utilized are relatively
expensive and when millions of cubic feet of gas
have to be stenching the stench cost item becomes
considerable. It is, therefore, believed to be ap-
parent that over-stenching is as undesirable from
an economic standpoint as under-stenching is
from a safety standpoint.

The present apparatus for injecting materials
into gas lines have not been suitable for pre-
serving uniform concentration of the injected
material in the flowing gas. In accordance with

the present invention an apparatus has been de-
vised which is responsive to variations in both
the pressure of the gas and its velocity so that
the injected material is injected in the proper
amount to give a uniform stench.

It is an object of the present invention to de-
vise an apparatus suitable for injecting stenching
material into gas so that substantially uniform
stenching of the gas is secured.

The stenching materials utilized such as mer-
captans are at times corrosive in nature or have
gum-forming tendencies so that the apparatus
handling them may become stopped up or other-
wise rendered inoperative. In accordance with
the present invention we advantageously utilize
a system in which the stench is controlled and
is injected into the gas by means of an accu-
rately controlled system in which system the
stench handling apparatus is but a minor part
so that the opportunity for the stenching mate-
rial to gum up or render the apparatus inopera-
tive is materially reduced.

A further object of the invention is to devise a
system for the injecting of the stench into the
gas so that problems in connection with handling
the stenching material are substantially over-
come.

The invention possesses other advantageous
features and objects, some of which, with the
foregoing, will be set forth at length in the fol-
lowing specification in which we have outlined a
preferred form of the stench injecting apparatus
of our invention. In the drawings attached hereto
and forming a part of the present specification,
we have indicated preferred forms of the appara-
tus of our invention but it is to be understood that
our invention may be embodied in other forms
and that the appended claims are to be accorded
a range of equivalents consistent with the state
of the prior art.

In the drawings, Figure 1 is a diagrammatic
view showing a relatively simple stench injecting
apparatus operating in accordance with the pres-
ent invention.

Figure 2 is a diagrammatic view showing a
stench injecting apparatus in which the stench is
injected by means of a relay system so that the
opportunity for the stench to clog up and gum
the apparatus, or otherwise impair its operative-
ness, is materially minimized.

Figure 3 is a diagrammatic view showing an-
other form of a stench injecting apparatus in
which the relay system is utilized and in which
the control of the injecting stench is secured by
novel means.

We obtain the accurate control of the liquid stench injection, the object of our invention, by regulating the injection according to the square root of the product of the static pressure and the differential pressure in the gas flow, across an orifice or Venturi tube. The injection so regulated will correspond to variations both in velocity and in pressure in the main gas line and avoid as well understenching as overstenching.

It is relatively simple to vary the injection according to variations in the velocity of the gas flow, assuming that the static pressure in the gas line remains constant. It is only necessary to force the liquid stenching material into the gas line under a pressure proportional to the differential pressure across the orifice or Venturi tube; if the differential pressure varies, the liquid stench flow will be varied; the quantity of stench injected will always have the same relation to the gas velocity, namely, be proportionate to the square root of the differential pressure.

The difficulty of the problem comes in the question of varying the stench injection according to variations in the static pressure of the gas flow. Ordinarily in practice a variation in the static pressure will immediately cause a variation in the velocity and vice versa, but assuming for the moment that the linear velocity of the gas flow remains constant and only the static pressure varies, then, in order to insure that the same quantity of gas, say 1,000,000 cubic feet of standard gas, receives always the same quantity of stench notwithstanding the static pressure variations, the flow of liquid stenching material has to be varied in accordance with the variations in the square root of the static pressure in the main gas line or the variations in the static pressure have to be compensated for in some other manner, as by varying the gas flow at the point of injection as shown later. We do not know of any apparatus which fulfills this condition besides that of our invention, or of any publication pointing out that this is necessary to obtain accurate proportioning of the stench injection.

Figure 1 shows a simplified form of apparatus for our invention. A gas main line 6 is provided with a flow restriction such as Venturi tube 7 with throat 8. Gas line 12 connects the gas main with the top of stench container 17, the bottom of which is connected to the throat 8 by stench injection line 13 provided with shutoff valve 22. A side line of line 12, line 18, connects the gas main with regulator 9. This regulator is only schematically shown in the drawings as many different mechanical arrangements may be devised for its purpose, namely, to transmit variations in the gas pressure in line 18 to the liquid flow in line 13 in proportion to the square root of such variations instead of in a straight relation. For instance, it may contain a pressure responsive diaphragm, movement of which thru various levers and springs is converted into a mechanical movement of lever 14, proportionately to the square root of the movement of the diaphragm. This lever connects the regulator to flow control 11 which is also only schematically indicated, and which may contain for instance a valve mechanism, or variable orifice arrangement, operated by the movement of lever 14 and controlling the flow of liquid stench proportionally according to such movement. Of course it is also possible to have the conversion of movement in straight relation with the static pressure to movement according to the square root take place in

flow control 11 instead of in regulator 9, by a different mechanical arrangement.

Stench is drawn from a source 15 by a pump 16, which injects the stench into a container 17. This container is preferably positioned so that the liquid level within it is at the same elevation as the discharge end of line 13 so that an elevation head upon the stench or the conduit does not have to be considered. The liquid level in the container is suitably controlled by a liquid level control 19 which regulates the injection of stench by the pump 16.

It will be clear that the surface of the stench liquid in 17 is under the static pressure of the gas main thru line 12. The stench is injected thru line 13 against the lower pressure in the throat 8. The difference between the pressure in line 12, or that on the stench liquid and the pressure in 8 or against the liquid flow is the differential pressure in the gas main, the square root of which varies as the velocity if constant pressure is maintained in the gas main. Without the flow control 11, the liquid flow would therefore be regulated by the differential pressure, and the quantity of stench injected with constant static pressure would be varied only in proportion to variations of the square root of this differential pressure, and, therefore, in proportion to the gas velocity in the main 6.

By inserting in line 13 flow control 11, which is regulated according to the square root of the static pressure, we superimpose in the stench flow on the variations according to velocity the variations according to static pressure in the gas main and in this manner obtain accurate stench injection. The exact volume of stench desired per million cubic feet of gas can be regulated or changed by adjustment of regulator 9 or control 11.

In Figure 2 we have shown a relay system by means of which the injection of the stench is controlled by another fluid so that harmful effects caused by the corrosive and gum forming properties of the stenching material can be confined to a suitably small portion of the system. In its broadest aspect, this phase of the invention is concerned with the metering of a fluid medium which is in turn utilized, when metered, to vary and regulate the injection of the stench. The variation, in accordance with the square root of the product of the static pressure and flow differential, is primarily effected in the separate fluid so that the quantity of apparatus with which the stenching material comes in contact is minimized, thus simplifying maintenance and operating problems. The medium, such as an oil, is withdrawn from a suitable storage tank 31 and is so metered and controlled in accordance with flow conditions that it can be utilized as for driving a stench injecting pump 32 so that the quantity of stench forced into the material is maintained in accordance with the actual quantity of material flowing in the line, irrespective of variations in the velocity of static pressure.

In this apparatus conduit 6 is also provided with a device such as Venturi 33 to which connections are made to control the flow of pilot oil and, thereby, the flow of stench. Pilot oil is withdrawn from the storage tank 31 by means of a pump 34, the pump injecting the oil to a line 35 through strainers 36 into a pressure container 37. The pressure container is provided with a liquid level control 38 which maintains a constant liquid level in the container 37 by means of valve 39.

The pump may be conveniently driven by gas drawn from the conduit 6 through a line 40.

Static pressure from the line 6 is placed upon the container 37 and upon a regulator mechanism 41 by means of line 42. The regulator 41 serves to control the quantity of pilot oil withdrawn from the container 37 through line 43 for injection into a second oil container 46 and preferably includes and controls a valve or orifice arrangement whereby the valve or orifice opening is varied in accordance with the square root of the static pressure placed on the device through lines 45 and 42, from the conduit 6. The oil container 46 is under the pressure of the throat of the venturi transmitted through pipe 55. This container is provided with a baffle plate 47 extending up within the container so that the liquid level is maintained at the same level as the liquid level in the pressure container 37 so that differences in elevation head do not have to be taken into account and the injection of stench can be directly controlled in accordance with the square root of the product of the static pressure and the differential pressure.

Excess oil delivered to the container 46 drops over the baffle into the compartment 48 and serves to actuate the liquid level controlled device 49 provided in communication with that compartment so that more or less pilot oil passes through liquid level controlled valve 50 to the pump 32. The withdrawal of stench from the source 51 for injection into the throat of the venturi through a line 52 is thus controlled. The pilot oil is returned back to the storage tank through line 53.

In Figure 3 we have shown another form of apparatus in which the system of utilizing a relay or pilot oil is employed, together with a form of pressure responsive device which serves to secure regulation of the injection of stench material quantity by compensating for the variations in the static pressure.

In this form of the invention a needle 61 is cooperatively positioned with respect to the venturi 33 in the conduit 6. A piston and cylinder mechanism, indicated generally at 62, is provided, the cylinder being connected to the line 40 which in this case admits gas under pressure to drive the pump 34. This pump 34, however, may be driven by some other means. Connection of the line 40 to the cylinder and piston mechanism 62 serves to make this mechanism responsive to static pressure variations in the conduit 6. The piston is provided with a rod 63 biased by means of a spring 64 to urge the piston into the cylinder.

The position of the needle 61 with respect to the Venturi throat is also varied in accordance with flow conditions by means of another cylinder and piston mechanism indicated at 66, which mechanism is actuated by means of pilot oil from pump 34. The admission of the pilot oil from the pump is controlled by a valve mechanism 67 connected by means of a pipe 68 to the pump.

The piston and cylinder mechanism 66 includes a rod 71 extending from the piston and joined to the needle so that reaction of the piston moves the needle directly. A link 72 is extended between the rod 63 and the rod 71 of the two cylinder and piston mechanisms and is connected to the valve mechanism as at 73 so that movement of the link is effective to move the valve mechanism to admit oil to one side of the piston and to drain it from the other side in the piston and cylinder mechanism 66.

The head of the needle 61 is specially designed so that the cross sectional area of the free ring

existing between it and the Venturi throat varies inversely in accordance with the square root of the absolute static pressure and a constant empirical upon the venturi and needle design utilized. The configuration of the needle can be empirically determined or it can be determined by calculation. Thus an equation can be set up as follows:

$$A = \frac{K}{\sqrt{P_1}}$$

wherein A is the area of the annular rings existing as free area between the needle and the Venturi throat, K is an empirical constant and P_1 is the absolute static pressure just ahead of the Venturi tube in the gas line in pounds per square inch. Assuming, by way of example, that the value of K is 490, P_1 is 400 lbs. per square inch absolute for one condition of the gas flow through the venturi, then area A as given by the above equation is 24.5 square inches, or 490 divided by the square root of 400 or 20. Upon a change in the flow conditions so that the absolute static pressure drops to 100 lbs. per square inch absolute, the area A should be automatically changed, within certain limits of area, to that given by the figures when placed in the above formula or 49 square inches. In practice it is desirable, of course, that maximum accuracy be attained, and in fact it is possible to work as close as three per cent we have found.

The provision of the needle mechanism enables the regulator 41 utilized in accordance with that apparatus shown in Figure 2 to be dispensed with, the two pressure containers being connected by a line 81 in which an orifice plate 82 is placed while the other portions of the mechanism are substantially the same, the stench being confined to contact with only one side of the pump 32 and the necessary line for injecting it into the throat of the venturi through the pipe line 52.

The flow restriction conveniently provided by the orifice plate 82 in the line 81 enables the flow through the line 81 to be governed by the differential pressure created by the venturi 33. The needle is controlled by the needle control mechanism in response to static pressure changes. Liquid flow thru the orifice 82 is therefore in accordance with the square root of the product of the static pressure maintained in container 37 through line 42 and the differential pressure maintained in container 46 by line 55. Liquid passed by the orifice controls the pump 32 by the valve 50 controlled by liquid level device 49.

Having fully described three specific embodiments of our invention in order to bring out more clearly some of the generally possible combinations of various elements in carrying out our invention, we do not intend to limit ourselves either to said combinations or to the specific types of elements comprising described embodiments, as we fully realize that numerous equivalents are known in the art which can function similarly to the individual elements described in this specification; we also realize that a number of additional combinations of the elements is conceivable in practicing our invention, as well as certain modifications to meet various requirements of operation. What we declare as new and desire to secure by Letters Patent is the principle of combining various elements, so that the problem of continually and automatically injecting a liquid into a flowing gas at such a rate that a predetermined constant mass ratio of the two is maintained can be efficiently accomplished in a new and relatively simple manner.

We claim as our invention:

1. In a system for regulating the injection of liquid material into a gas stream, so that a substantially uniform concentration of said material in the gas is maintained, a combination of means for injecting the liquid material, comprising: a differential pressure-producing means in a gas stream, means for discharging a liquid stream into said gas stream, a differential pressure-responsive means in communication with the gas stream adapted to control the flow of the liquid in accordance with the velocity of the gas, and a static pressure-responsive means in communication with the gas stream adapted to maintain a predetermined mass ratio of the injected liquid to the gas.

2. In a system for regulating the injection of liquid material into a gas stream, so that a substantially uniform concentration of said material in the gas is maintained, a combination of means for injecting the liquid material, comprising: a differential pressure-producing means in a gas stream, means for discharging a liquid stream into said gas stream at a point of decreased static pressure, a differential pressure-responsive means in communication with the gas stream adapted to control the flow of the liquid in accordance with the velocity of the gas, and a static pressure-responsive means in communication with the gas stream adapted to maintain a predetermined mass ratio of the injected liquid to the gas.

3. In a system for regulating the injection of liquid material into a gas stream, so that a substantially uniform concentration of said material in the gas is maintained a combination of means for injecting the liquid material, comprising: a differential pressure-producing means in a gas stream, means for discharging a liquid stream into said gas stream, a flow controlling means within said liquid stream adapted to permit a rate of liquid flow in accordance with the gas velocity in the gas stream, a static pressure-responsive means in communication with the gas stream, whereby the rate of liquid discharge into gas stream is changed substantially in proportion to the square root of the static pressure in the gas stream.

4. In a system for regulating the injection of liquid material into a gas stream, so that a substantially uniform concentration of said material in the gas is maintained, a combination of means for injecting the liquid material, comprising: a differential pressure-producing means in a gas stream, means for discharging a liquid stream from a vessel in which a constant liquid level is maintained into said gas stream, a flow controlling means within said liquid stream adapted to permit a rate of liquid flow in accordance with the gas velocity in the gas stream, a static pressure-responsive means in communication with the gas stream, whereby the rate of liquid discharge into gas stream is changed substantially in proportion to the square root of the static pressure in the gas stream.

5. In a system for regulating the injection of liquid material into a gas stream, so that a substantially uniform concentration of said material in the gas is maintained, a combination of means for injecting the liquid material, comprising: a differential pressure-producing means in a gas stream, means for discharging a liquid stream into said gas stream, a secondary stream of a different liquid in communication with the gas stream and the first liquid stream, a means

within the secondary stream adapted to change the rate of flow in said stream of liquid in accordance with changes in gas velocity in the gas stream, and other means within the secondary stream adapted to change the rate of flow in said stream of liquid substantially in proportion with the square root of the static pressure in the gas stream, and a means in communication with both the first liquid stream and the secondary stream adapted to control the discharge of the first liquid stream into the gas stream in proportion to the rate of liquid flow in the secondary stream.

6. In a system for regulating the injection of liquid material into a gas stream, so that a substantially uniform concentration of said material in the gas is maintained, a combination of means for injecting the liquid material, comprising: a differential pressure-producing means in a gas stream, means for discharging a liquid stream into said gas stream, a secondary stream of a different liquid in communication with the gas stream and the first liquid stream, a means within the secondary stream adapted to change the rate of flow in said stream of liquid in accordance with changes in gas velocity in the gas stream, a means in communication with both the first liquid stream and the secondary stream adapted to control the discharge of the first liquid stream into the gas stream in proportion to the rate of liquid flow in the secondary stream; a valve means positioned within the gas stream and adapted to change the cross-sectional area of the passage through the differential pressure-producing means inversely to the square root of the static pressure of the gas.

7. In a system for regulating the injection of liquid material into a gas stream, so that a substantially uniform concentration of said material in the gas is maintained, a combination of means for injecting the liquid material, comprising: a differential pressure-producing means in a gas stream, means for discharging a liquid stream into said gas stream, a secondary stream of a different liquid in communication with the gas stream and the first liquid stream, a means within the secondary stream adapted to change the rate of flow in said stream of liquid in accordance with changes in gas velocity in the gas stream, a means in communication with both the first liquid stream and the secondary stream adapted to control the discharge of the first liquid stream into the gas stream in proportion to the rate of liquid flow in the secondary stream; a valve means positioned within the gas stream, controlled by the static pressure of the gas, actuated by a suitable means, and adapted to change the cross-sectional area of the passage through the differential pressure-producing means inversely to the square root of the static pressure of the gas.

8. In a system for regulating the injection of liquid material into a gas stream, so that a substantially uniform concentration of said material in the gas is maintained, a combination of means for injecting the liquid material, comprising a differential pressure-producing means in a gas stream, means for discharging a liquid stream into said gas stream, a secondary stream of a different liquid in communication with the gas stream and the first liquid stream, a means within the secondary stream adapted to change the rate of flow in said stream of liquid in accordance with the gas velocity in the gas stream, a means in communication with both the first

- liquid stream and the secondary stream adapted to control the discharge of the first liquid stream into the gas stream in proportion to the rate of liquid flow in the secondary stream; a valve means positioned within the gas stream, controlled by the static pressure of the gas actuated by a pilot valve and a piston and cylinder means positioned within the secondary liquid stream, said valve means being adapted to change the cross-sectional area of the passage through the differential pressure-producing means inversely to the square root of the static pressure of the gas.
9. In a system for regulating the injection of liquid material into a gas stream, so that a substantially uniform concentration of said material in the gas is maintained, a combination of means for injecting the liquid material, comprising: a differential pressure-producing means in a gas stream, means for discharging a liquid stream into said gas stream, a flow controlling means within said liquid stream adapted to permit a rate of liquid flow in accordance with the gas velocity in the gas stream; a valve means positioned within the gas stream, and adapted to change the cross-sectional area of the passage through the differential pressure-producing means inversely to the square root of the static pressure of the gas.
10. In a system for regulating the injection of liquid material into a gas stream, so that a substantially uniform concentration of said material in the gas is maintained, a combination of means for injecting the liquid material, comprising: a differential pressure-producing means in a gas stream, means for discharging a liquid stream into said gas stream, a flow controlling means within said liquid stream adapted to permit a rate of liquid flow in accordance with the gas velocity in the gas stream; a secondary stream of a different liquid to actuate a pilot valve and a piston and cylinder means operating a valve means positioned within the gas stream and adapted to change the cross-sectional area of the passage through the differential pressure-reducing means inversely to the square root of the static pressure of the gas.
- CHESTER C. ASHLEY.
WILLIAM I. STEELE.

30	105
35	110
40	115
45	120
50	125
55	130
60	135
65	140
70	145
75	150