July 7, 1964 J. D. McCUNE 3,139,704

PIPELINE CLEANING APPARATUS

Original Filed Sept. 21, 1961 4 Sheets-Sheet 1

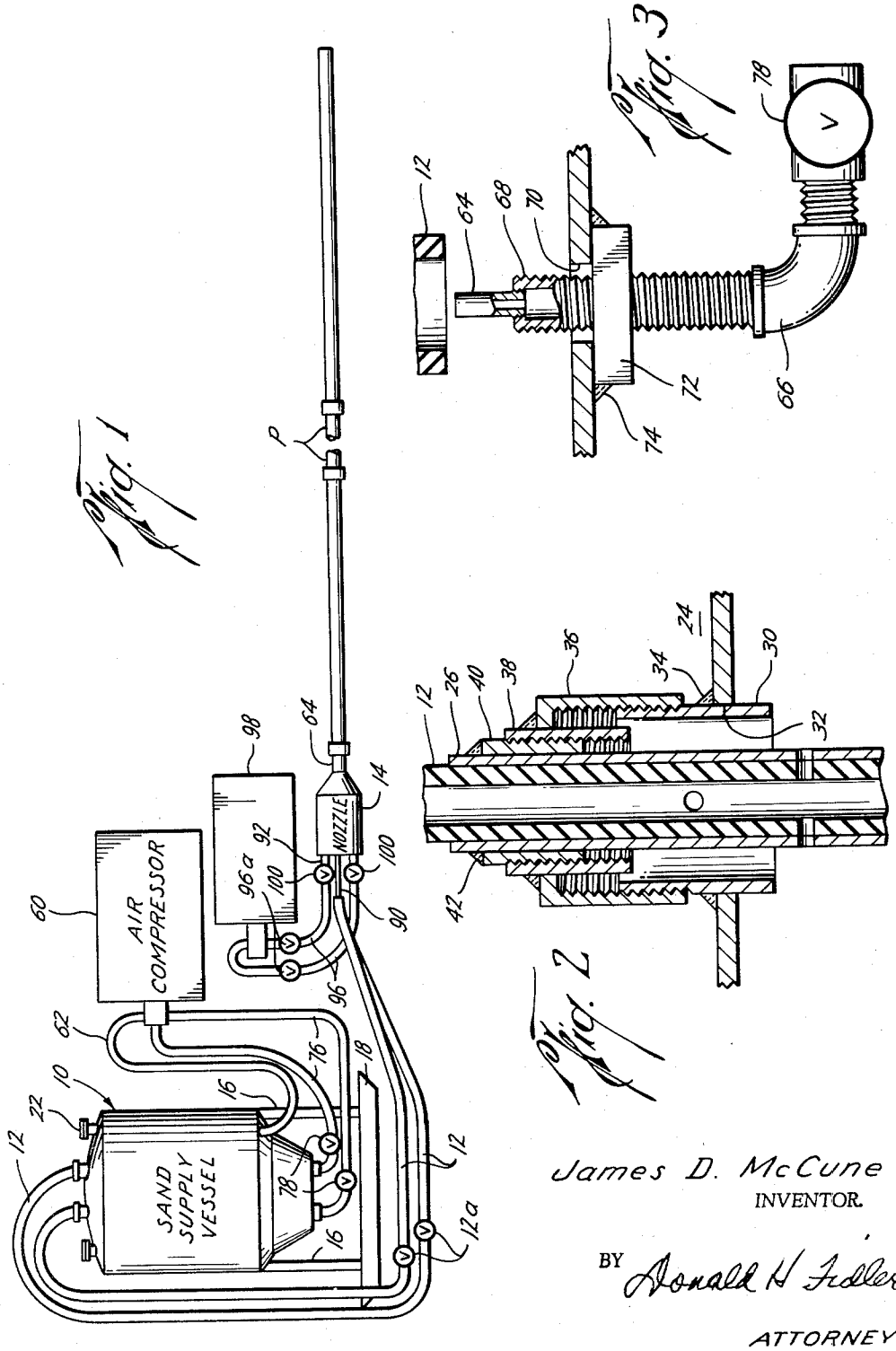


Fig. 1

Fig. 3

Fig. 2

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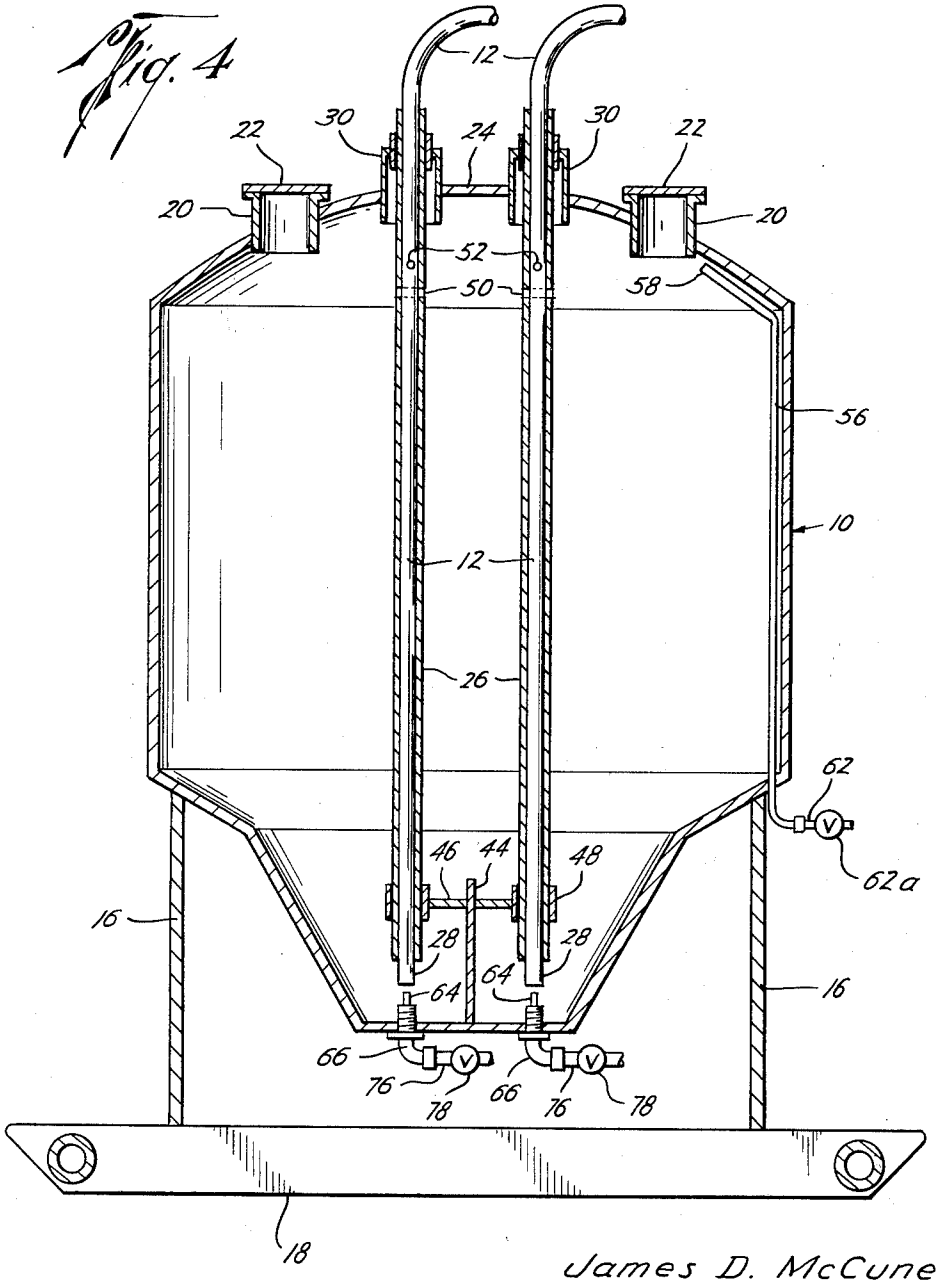
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PIPELINE CLEANING APPARATUS

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Fig. 4



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PIPELINE CLEANING APPARATUS

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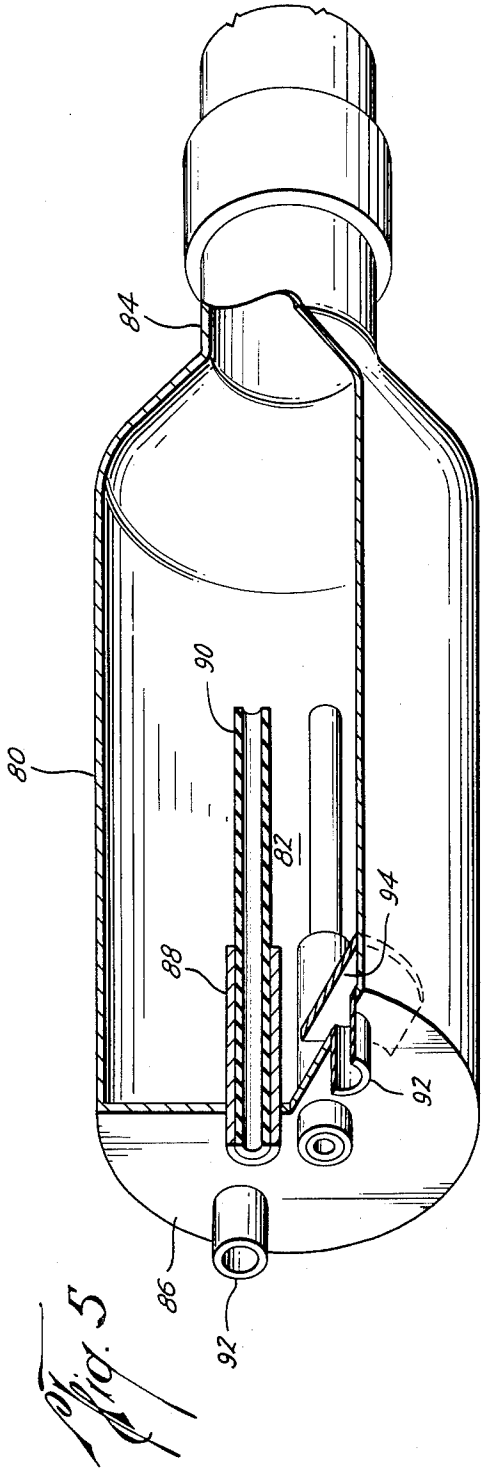


Fig. 5

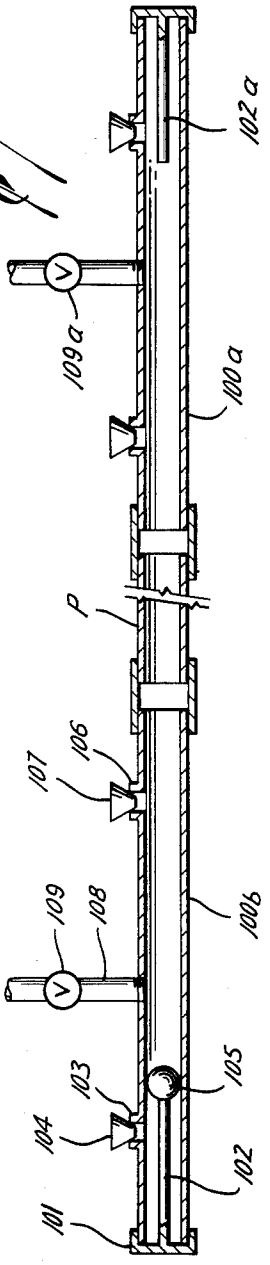


Fig. 6

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PIPELINE CLEANING APPARATUS

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Fig. 7

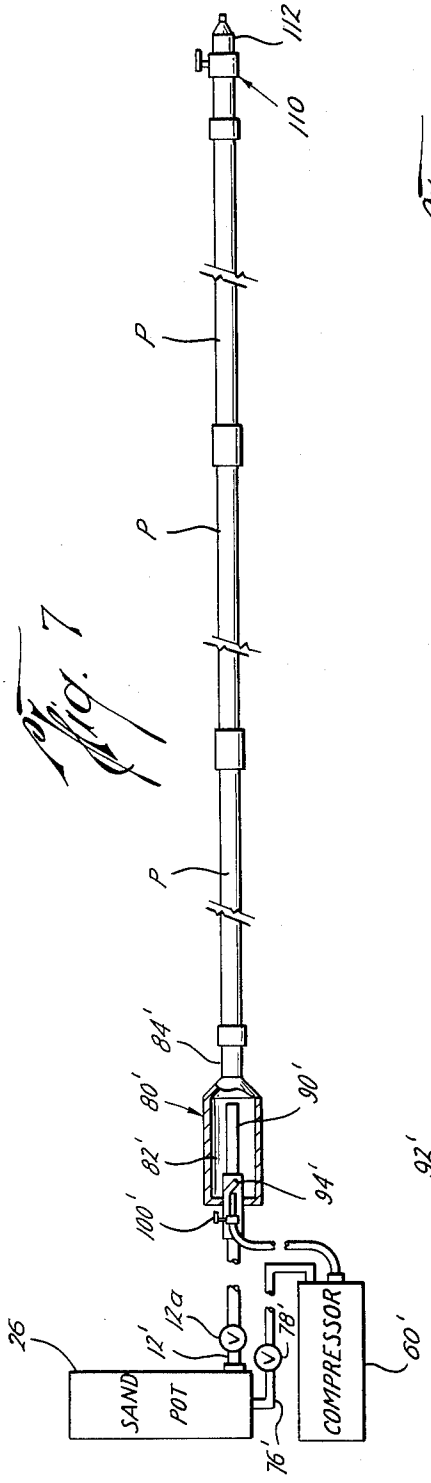
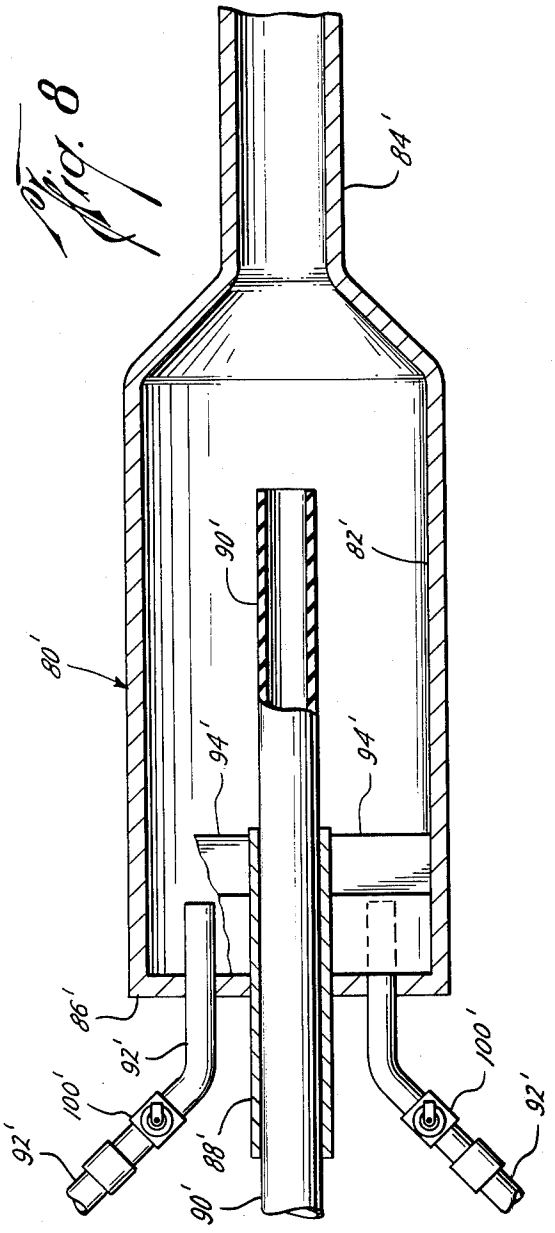


Fig. 8



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United States Patent Office

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3,139,704

PIPELINE CLEANING APPARATUS

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Original application Sept. 21, 1961, Ser. No. 139,787. Divided and this application Aug. 28, 1962, Ser. No. 219,995

14 Claims. (Cl. 51—8)

This invention relates to the cleaning of relatively long lengths of pipelines, conduits, or the like, and more particularly to apparatus for cleaning the internal surface of pipelines to remove rust, corrosion or other deposits therefrom and to provide a desired surface finish on the interiors of such pipelines.

This application is a divisional application of my patent application Serial No. 139,787 filed September 21, 1961 now abandoned which is a continuation-in-part of both of my patent applications, Serial No. 813,253 filed May 14, 1959 now abandoned and Serial No. 22,885 filed April 18, 1960 now abandoned.

The present invention is capable of broad application in connection with the maintenance of pipelines and conduits of all kinds and finds particular utility in the removal of deposits which are of relatively hard character, such as rust or scale or substances which cannot be readily removed by washing or flushing operations, and also finds utility in the development of a desired surface finish on the interior of the string of pipe.

In the operation of pipelines or piping systems deposits of various kinds are often built up in the pipe, such as rust, hydrocarbon deposits, paraffin or scale forming materials, which may be insoluble or cannot otherwise be readily removed by washing or flushing with solvents. Also, the internal surface of the pipe may become coated with rust or corroded prior to installation. Rusting and corrosion also occur subsequent to installation due to substances present in the fluid which is being transported. These internal defects in the wall surface of the pipe are not easily removed once the pipe is in the ground. This is because the removal of such deposits by disassembling the line and separately cleaning each section of pipe is obviously a procedure which can only be accomplished at a great expenditure of time and labor. The commonly used apparatus for cleaning a line i.e., a pipeline "pig" has been found to be considerably less effective than the apparatus of the present invention.

An object of the invention is the provision of apparatus for cleaning the interior of a pipeline by abrasive action on the same including means for providing a mixture of abrasive material and air or gas under pressure and for introducing the same into a pipeline in an agitated condition to cause the mixture to flow through the pipeline without settling of the abrasive material.

Another object of the invention is the provision in sand blasting apparatus for cleaning a pipeline, of means for providing a mixture of sand and air or gas under pressure comprising a container for sand, an outlet pipe extending into the top of the container and downwardly therein and whose lower end opens into the container at a location above the bottom of the container and below a normal level of a full load of sand in the container, the outlet pipe having an opening located in the container above the lower end of the pipe and the normal level of a full load of sand in the container, means for introducing air or gas under pressure into the container above normal level of a full load of sand so that an outflow of air or gas may flow through said opening, and means for discharging air or gas under pressure into the lower end of the outlet pipe to cause a flow of mixed sand and air or gas in the pipeline.

A further object of the invention is to provide sand blasting equipment for use in the cleaning of pipelines, which equipment is of simple design and rugged construction, having parts which are easily replaceable and which is designed to be easily transported from one location to another.

A further object of the invention is to provide apparatus for cleaning the interior of pipelines by subjecting the same to a sand blasting operation.

Another object of the invention is the provision of apparatus for cleaning a pipeline which includes means adapted to be connected to one end of a section of a pipeline and operable to open and close the end of the pipeline, and means adapted to be connected to the other end of the pipeline for introducing into the pipeline a mixture of abrasive particles, such as sand and gas or air under pressure to develop a continuous flow of the mixture through the pipeline which scours the internal surface of the pipeline.

A further object of the invention is to provide apparatus for sand blasting the interior of a pipeline embodying a housing having an internal mixing chamber and provided with an outlet from said chamber adapted to be connected to the end of a section of the pipeline to be cleaned for introducing sand and gas or air under pressure into said chamber, and means for causing the sand and gas or air to be agitated in the chamber to provide a mixture of air or gas and sand to be introduced into the pipeline through said housing outlet.

In accordance with the present invention, in the cleaning of the interior of a long length of pipeline which typically includes a number of coupled pipe sections buried in the ground, the line is preliminarily cleared by the application of a gas or air under pressure to blow out loose debris and the use of a pipeline pig to mechanically scrape or clear loosely attached matter from the interior of the pipe as well as remove any remaining debris or fluid which may be present in the line. Next, the line is sand blasted to scour the interior of the pipe. Thereafter, the powder deposited on the interior surface as an after result of the sand blasting operation is removed by gas or air pressure, washing with a treating fluid or a brush type pig. Following this last cleaning step, the interior of the line may be coated with a protective coating film if desired.

The sand blasting step in general comprises the introduction of a mixture of air or gas and sand in an agitated or turbulent condition into the inlet end of the line at a pressure and volumetric flow rate sufficient to provide a minimum inlet velocity of not less than 2000 feet per minute to clean pipelines ranging in diameter from two to eight inches. For pipelines with diameters ranging from eight to twenty inches, an inlet velocity generally not less than 3000 feet per minute is suitable while with pipelines with diameters ranging from twenty to thirty-six inches an inlet velocity generally not less than 5000 to 6000 feet per minute is suitable.

The apparatus of the present invention includes means for suspending abrasive particles in a gas flow and more particularly a supply container arranged to provide a mixture of air or gas and sand to a delivery nozzle. The delivery nozzle is adapted for coupling to the end of a pipeline and a gas drive is supplied to the nozzle to propel the mixture of air or gas and sand through a pipeline.

The above and other important objects and advantages of the invention may best be understood from the following detailed description constituting a specification of the same when considered in conjunction with the annexed drawings, wherein:

FIG. 1 is a side elevational view, on a reduced scale illustrating an arrangement of apparatus embodying the

invention and showing an arrangement of the apparatus as may be used to clean a pipeline;

FIG. 2 is a fragmentary, vertical, central, cross-sectional view, showing details of structure of one of the discharge pipes of the sand supplying apparatus of the invention and the structure by which the pipe is removably connected to the sand supplying apparatus;

FIG. 3 is a side elevational view, partly in cross-section, showing details of construction of one of the air or gas inlet nozzles of the sand supplying apparatus and the means by which the same is connected to the sand supplying apparatus and adjusted therein relative to a sand discharging pipe;

FIG. 4 is a vertical, central, cross-sectional view of the structural details and arrangement of parts of a sand supplying apparatus;

FIG. 5 is a view partly in cross-section showing structural details of a sand delivering and agitating nozzle;

FIG. 6 is a side elevational view on a reduced scale illustrating an arrangement of apparatus embodying another feature of the invention and showing an arrangement of the apparatus as may be used to clean a pipeline;

FIG. 7 is a fragmentary, side elevational view, partly broken away and partly diagrammatic, illustrating another embodiment of the invention and showing the manner in which the same is used in the cleaning of pipes; and

FIG. 8 is a view partly in cross-section showing another embodiment of a sand delivering and agitating nozzle.

The present invention is concerned with the cleaning of long lengths of pipelines on the order of eight hundred feet to ten miles or more in length and which may range in diameter from two inches to thirty inches or more. Generally, apparatus is particularly useful in cleaning pipelines horizontally buried in the earth which over years of use have developed interior coatings or surface irregularities with a corresponding reduction of efficiency in the transmission of fluids therethrough. For example, by use of the present invention on natural gas lines, such pipelines have been rejuvenated to raise the transmission efficiency to a like-new condition. Moreover, in the case of new pipelines, transmission efficiency has been raised on the order of ten percent or more so that the pipelines are, figuratively speaking, better than new.

As shown in FIG. 1, the apparatus of the invention includes sand dispensing and supply vessel or container **10**, from which a mixture of sand and air or gas is supplied or delivered through one or more suitable supply hoses **12** to a delivery and agitating nozzle or injector head **14**. Air or gas under pressure is coupled to the head **14** to provide an impelling and agitating force to the delivered mixture of sand and air to introduce the mixture at proper velocities into the pipeline.

The sand supply vessel or container **10** may take the form of a metal tank, such as that shown in detail in FIG. 4. The container **10** has a generally cylindrical or other convenient shape and is suitably supported, as by means of uprights **16** attached at their lower ends to skids, such as that shown at **18** which permit the sand supply container to be readily moved as a unit from place to place. The sand supply container **10** is provided with suitable inlet openings **20** at the top, which are closed by removable closures **22** and through which the supply of sand may be loaded into the container. Sand supply pipes **26** extend through the top **24** of the container and terminate in the container somewhat above the bottom of the container. Hoses **12** may be passed through the pipes **26** so that their lower ends **28** are at locations well below the upper level of a full load of sand in the container. The confining and supporting pipes **26** extend upwardly through the top of the container through a tubular element **30**. Element **30** extends through an opening **32** in top **24** and is welded thereto as indicated by the numeral **34** (FIG. 2). The outer end of the element **30** is externally threaded for the threadable connection thereto of an internally threaded cap **36**, which carries an inner internally threaded tubular part **38** into which a tubular nut **40** is threaded, the pipe **26** extending through the nut and being welded thereto, as shown at **42** in FIG. 2. By this arrangement, the cap **36** may be removed to permit the removal of the pipe **26** from the container.

The pipes **26** may be held at their lower ends in spaced apart relation within the container, as by means of a bracket **44** having opposite arms **46**, each of which carries a collar **48** through which one of the pipes is extended. Air or gas under pressure is introduced into the lower ends of the pipes **26** and hoses **12** through suitable jets **64** arranged in the lower section of the container to be in axial alignment proximate to the open end of pipes **26**. The jets **64** are adjustable vertically to selectively position the discharge ends of the jets **64** relative to the pipes **26** and hoses **12**. Air or gas under pressure admitted via inlet pipes **66** to the jets **64** thus entrain the sand in the lower section of the container and carries the sand upwardly through the hoses **12** and pipes **26**. To adjust the vertical position of the jets **64**, each of the jets **64** is attached to the upper end of an externally threaded pipe **68** which passes through an opening **70** and a nut **72** located externally of the container under the opening **70**. Nut **72** is suitably attached to the container as by welding, as shown at **74** in FIG. 3. Air or gas under pressure can be supplied to the pipe **66** as by means of hoses **76**. A valve **78** may be provided for each of the pipes **66** to control the pressure of the air or gas introduced to the pipes **26** via the jets **64**.

Each of the pipes **26** is also provided with openings **50** and **52** respectively, which extend through the hoses **12** and are positioned in the pipes to be normally above the level of a full supply of sand in the container. An air or gas inlet pipe **56** to the container is arranged so that its outlet end **58** is located to discharge air or gas under pressure into the container above the normal level of a full load of sand therein to develop a pressure in the container and cause an outflow of air or gas through openings **50** and **52** into the hose **12**. Air or gas under pressure is supplied to the pipe **56** from any suitable source via a supply pipe **62** and valve **62***a* which can be used to control the pressure to the container. The mixture of air or gas and sand delivered is carried upwardly in the pipes **26** by action of the jets **64** at the bottom of the container is further reinforced by the air or gas under pressure entering hoses **12** via openings **50** and **52**. The mixture, under the influence of the pressure of air or gas provided to the container, is conveyed via the connecting hoses **12** to the injector head or nozzle **14**.

The apparatus as described thus provides a mixture of gas and sand in proper proportions to the nozzle **14**. The proportions of the mixture are, of course, based upon the size of the pipeline to be cleaned. For example, as the diameter of the line increases, the supply or amount of sand and gas should also increase. However, too much sand per unit volume of gas would cause ineffective cleaning while too little sand per unit volume of gas would likewise produce inefficient cleaning. The proper proportions are relatively difficult to determine with precision; however, I have found a mixture on the order of 30% of sand to air by weight to be suitable.

As shown in FIG. 5, the sand delivering and agitating nozzle **14** includes a hollow casing **80** which may conveniently take the form of a cylindrical casting having an internal chamber **82** and provided with an outlet connection **84** adapted to be connected to the inlet end of the pipeline and through which the mixture of air or gas and sand may be introduced into the pipeline. At the end of the chamber **82**, opposite the outlet connection **84**, the casing is provided with an end wall **86** through which a pair of inlet pipes **88** extend into the chamber **82**. Flexible hoses **90** may be extended into the chamber through pipes **88** and have inner ends open into the chamber near the outlet end of the chamber **82**. The hoses **90** can be provided with valves **12***a* (FIG. 1) connected at

their outer ends to the respective sand supply hoses **12** in any suitable manner. A hose **90** is secured to the interior of the pipe **88** in any suitable manner to provide a fluid-tight seal between the internal wall of the pipe **88** and the external surface of the hose.

Two pressure supply pipes **92** extend through the wall **86** of the housing **80** into the chamber **82**, and have discharge ends positioned near the wall **86** at a location remote from the discharge ends of the hoses **90**. The housing **82** is provided with internal baffles **94** for each of the inlets, the baffles being inclined and disposed in front of the open ends of the pressure supply pipes, so that air or gas under pressure discharged from the pressure pipes will be given a swirling motion in the chamber **82** as the air or gas passes through the chamber. The pressure pipes **92** may be suitably secured to the wall **86**, as by means of welding or otherwise, and each of these pipes is connected to a hose line **96** (FIG. 1), leading to a suitable source of air or gas under pressure, each pressure pipe being also provided with a suitable valve **100** (FIG. 1), by which the inflow of air or gas under pressure into the chamber **82** may be regulated. The outlet end of discharge connection **84** of the nozzle may be externally threaded or otherwise provided with suitable means, whereby this connection may be removably connected to the inlet end of the pipeline.

Under some conditions, it may be desirable to provide additional pressure supply pipes connected into additional pressure supply lines when the sand delivery nozzle is to be used on pipelines of large diameter. It will be appreciated that all of the various pressure supply lines may be provided with separate valves, whereby the flow of fluid or pressure in such lines may be controlled as desired. Air compressors **60** and **98** may be used to provide air under pressure. For larger diameter pipelines carrying natural gas, the gas under pressure in the pipeline may be used as a motivating force. In general, the number of sand and gas inlet openings depends upon the volumetric quantity of mixture necessary to clean a given diameter of pipe line. Obviously, the larger the diameter of the pipeline, the greater the volumetric quantity of mixture necessary.

In making use of the above-described apparatus, the container **10** is loaded with sand through the openings **20**, until the level of the sand reaches a point a little below the outlet openings **50** and **52**, and the delivery nozzle **14** is connected to the inlet end of the pipeline P; air or gas under pressure is then supplied to the inlet pipes **92** through the supply lines **96** to cause a swirling action of the mixture air or gas supplied to chamber **82**, so that the mixture of sand and air or gas entering the pipeline will be thoroughly agitated to uniformly distribute the sand in the air or gas. The pressure of air or gas drive to the delivery nozzle **14** is regulated to provide an inlet velocity of the sand entering the pipeline adequate to provide turbulence and prevent settling of the sand in the line and to cause cleaning of the pipeline. The presence of turbulence can, of course, be determined by calculating the Reynolds' number for the flow of gas necessary to provide the minimum inlet velocity. Normally about a 12 pound pressure differential between the pressure in the container **10** and pressure in the nozzle **14** is adequate to feed the mixture into the nozzle although higher pressure differentials may be used. Thus, by properly adjusting the differential pressure of air or gas entering the container **10** through pipe **56** and through jets **64** and the pressure of air or gas entering pipes **92**, a suitable mixture may be supplied to the nozzle. The quantity of gas and the velocity of the gas entering the pipeline may be controlled by valves in pipes **92**, so that the expansion of the air or gas along the pipeline increases the velocity of the gas and sand to prevent settling of the sand and in this manner provide an effective sand blasting of the internal surface of the pipe.

To better understand the nature of the present invention, it should be appreciated that a suitable inlet velocity of the mixture to clean the line will depend mainly on the diameter of the line as discussed previously. The dependency of inlet velocity to pipe diameter is believed to be based on the reasoning that as the diameter of a pipeline increases, more abrasive particles are necessary for a cleaning of a larger surface area with a corresponding increase in flow rates necessary to suspend the increased amount of sand and hence, the higher inlet velocities for pipes of larger diameter. Likewise the density of the gas involved affects the flow rate. For example, in a given size of pipe, a quantity of natural gas with a specific gravity of 0.6 will support less sand than a like quantity of air with a specific gravity of 1. It has also been established that outlet velocities ranging from 9000 feet per minute to 16,000 feet per minute or more may be successfully employed to efficiently clean up the interiors of pipe ranging in diameter from 2 to 30 inches.

An approximation of the relationship of the variables involved can be obtained by the use of the Weymouth equation in which the relationship for air takes the form:

$$Q=0.462d^{2.67}\sqrt{\frac{P_1^2-P_2^2}{L_m}} \tag{1}$$

and for gas with a specific gravity of 0.6 takes the form:

$$Q=0.6d^{2.67}\sqrt{\frac{P_1^2-P_2^2}{L_m}} \tag{2}$$

where

Q=cubic feet of flow per minute.
d=inside diameter of pipe in inches.
P_1=initial pressure in pounds per square inch absolute.
P_2=outlet pressure in p.s.i.a.
L_m=length of line in miles.

The above relationship assumes the temperature T of the gas to be constant at 70° F.; that the gas quantity Q is constant; and the effect of sand on the gas flow is neglected. The inlet and outlet velocities, as related to the above formulas, are obtained from the following relationships:

$$Q=\frac{V_2AP_2}{P_s} \tag{3}$$

$$Q=\frac{V_1AP_1}{P_s} \tag{4}$$

where V_2 equals outlet velocity in feet per minute; V_1 equals inlet velocity in feet per minute; A equals pipe area in square feet; and P_s equals standard atmospheric pressure in p.s.i.a. While the various minimum values of the parameters can be calculated from a selected value for the minimum inlet velocity, the efficiency of the process may be improved by increasing the quantity of flow well above the quantity necessary to provide a minimum inlet velocity. This has little effect towards a further substantial increase in the inlet velocity but does, however, significantly increase the outlet velocities. In general, the outlet velocity provides an indicium for the cleaning in that higher outlet velocities seem to scour the pipe interior more efficiently than the lower velocities will; thus, if considerable cleaning is necessary, the quantity of flow can be increased to provide a higher outlet velocity. It will be appreciated that the parameters may be determined by first selecting an outlet velocity and then calculating the value of the inlet velocity to check whether the inlet velocity exceeds the minimum inlet velocity necessary for cleaning.

It will also be appreciated that the precise conditions to be maintained as to the grade of sand employed and the pressure and volumetric flow rate at which the mixture is introduced into the inlet end depend somewhat upon the length of the pipe, its diameter, and the material which is to be removed.

For example, from Equations 2 and 4 the following relationship may be expressed

$$V_1=\frac{0.6d^{2.67}P_s\sqrt{P_1^2-P_2^2}}{AP_1\sqrt{L_m}} \quad (5)$$

From Equation 5 it will be seen that as the value of P_1 approaches infinity, the value of the term $P_1^2-P_2^2$ approaches the value of P_1 since the value of P_2^2 becomes insignificant as compared with the value of $P_1^2=\alpha$. With this consideration, the length of pipeline L_m is limited in accordance with the diameter d of the pipeline and the inlet velocity V_1 obtained. Hence, the pressure and flow rate of the mixture entering the pipe should be maintained sufficient to provide an inlet velocity which provides turbulent cleaning action for the sand particles and also prevents the particles from settling out of suspension.

It should also be appreciated that with this operation, the initial inlet velocities are very high while the initial inlet pressure is relatively low and the length of pipelines contemplated for cleaning are such that an interval of time elapses before the inlet pressure and inlet velocity arrive at a steady state value even though the outlet is full open to the atmosphere. In an actual operation, several minutes elapse before the inlet pressure builds up to a steady value and during this interval the inlet velocity, of course, decreases to its steady state minimum value.

A mixture of air or gas and sand is introduced into the inlet end of the pipeline while the outlet of the pipeline is at substantially atmospheric pressure with a gas drive at a controlled pressure and volumetric flow rate sufficient to provide an inlet velocity of the sand in excess of that which is required to prevent settling and which is adequate to clean the line, the air or gas expanding during the flow of the mixture through the pipe to cause an increase in the velocity of the sand and gas mixture. In the performance of the sand blasting step, the container may run out of sand before the line is clean. In this case, the container is refilled and the sand blasting continued. The cleaning action may be judged from the condition of the particles exiting from the outlet. During the first stage of cleaning, the outflow is cloudy and dirty colored while in the final stages of cleaning, the outflow of sand is similar in color to its color at the input end of the line. A final gas drive or flow is then supplied to the pipeline to purge remnant materials from the pipeline.

By way of example, a pipeline having an overall length of three miles and having a diameter of 6″ was effectively cleaned in the following manner: The pipeline was purged with a continuous blast of air under pressure for a period of twenty minutes. Next, the line was preliminarily cleared by use of a conventional pipeline pig. Following this, into the inlet end, a mixture of air and sand blasting sand of the grade designated #4, were introduced at an inlet pressure controlled to about 68 lbs. per square inch absolute, with a resulting inlet velocity of about 2300 feet per minute, the outlet end of the line being fully open to the atmosphere. The pressure in the line at distance of 10 feet from the outlet end of the line during the cleaning of the line was found to be about 15.2 pounds per square inch absolute, while the velocity of the mixture discharged at the outlet end was approximately 12,600 feet per minute. The volume of air introduced through the pipeline to produce these conditions was about 2600 cubic feet per minute. The container was refilled twice to perform the entire cleaning of the line. After the sand blasting step, the powder deposit on the interior of the pipe was removed by a purge of gas and the use of an undersized squeegee ball blown through the pipeline.

The above operations may, for example, be analyzed as follows: The length of pipeline L_m, the pressure P_2 at the outlet end are known. Starting then with Formula 1 and substituting the known values:

$$Q=.462(119.5)\sqrt{\frac{P_1^2-231}{3}}=31.8\sqrt{P_1^2-231} \quad (6)$$

and from Formula 3

$$Q=\frac{V_2(.197)(15.2)}{14.7}=.209V_2 \quad (7)$$

and from Formula 4

$$Q=\frac{V_1(.197)P_1}{14.7}=.0134V_1P_1 \quad (8)$$

Equations 6, 7 and 8 can be rewritten as

$$31.8\sqrt{P_1^2-231}=.209V_2=.0134V_1P_1 \quad (9)$$

From the Equation 9 it will be appreciated that a minimum value for V_1 can be assigned and the corresponding value of P_1 can be calculated. For example, with a selected V_1 of 2300 feet per minute; P_1 is equal to 60.5 p.s.i.a.; and V_2 would be equal to 8900 feet per minute; and the flow rate Q would equal 1860 cubic feet per minute. To increase the efficiency of the cleaning V_2 can then be selected as 12,600 feet per minute which increases the inlet pressure P_1 to a value of 82.7 p.s.i.a.; and the flow rate Q to a value of 2630 cubic feet per minute; while the inlet velocity is only 2380 feet per minute. These sample calculations illustrate that the inlet velocity varies only slightly with changes in inlet pressure but the outlet velocities and flow rate change considerably. Since the higher velocities at the outlet end of a line clean better than the lower velocities at the inlet end of the line, the sand blasting step may be performed from each end of the line to insure a relatively uniform sand blasting action along the length of pipe.

Another pipeline, comprised of coupled lengths of pipe, approximately three miles in length and of 8″ diameter, was cleaned in the following manner: The pipeline was purged with a continuous blast of five minutes. Next, the line was cleared by a conventional pipeline pig. Following this, a mixture of sand and air was introduced into the inlet end of the line at a pressure of approximately 34 pounds per square inch absolute at an initial velocity of about 2170 feet per minute, the pressure at the outlet end of the pipe being about 15.2 pounds per square inch absolute and the velocity V_1 at the inlet being approximately 9800 feet per minute. The volume of air introduced through the line to produce the conditions of this example was about 2600 cubic feet per minute. The container was refilled twice. After the sand blasting step, the powder deposit on the interior of the pipe was removed by the use of a gas purge and an undersized squeegee ball blown through the pipeline. It should also be noted that in larger diameter lines, natural gas is preferable to air since it is readily available in large quantities and relatively dry to eliminate any wetting of the sand in the process.

In these examples, sand blasting sand of the grade known as #4 was employed, the particle size of the sand being such that all of the sand passes through a sieve of 40 meshes per inch, and 80% of the sand passes through a sieve of 80 meshes per inch. Another class of sand may, of course, be employed, such as #3 grade, all of whose particles will pass through a sieve having 30 meshes per inch and 80% of which will pass through a sieve having 60 meshes per inch, or a #2 grade sand all of whose particles will pass through a sieve having 16 meshes per inch and 80% of which will pass a sieve having 30 meshes per inch. The conditions to be maintained, regardless of the particular grade or size of particles of the abrasive employed, are that the mixture must be thoroughly agitated to cause the particles to be suspended in the air or gas and the mixture is introduced into the inlet end of the line at a sufficient pressure and volumetric flow rate to provide an inlet velocity at which the particles will remain

suspended and clean the inlet end of the pipe. The outlet end of the line is opened to the atmosphere so that the gas or air may expand in the line which causes an increase in the velocity at the outlet end of the line and an efficient sand blasting or abrading effect is obtained. It has been determined by actual operation of the invention that coarser grades of sand provide an abraded surface which is of relatively rough character, to which coatings will adhere readily, while finer grades of sand may be used to provide a highly polished surface, when such a surface is desired. Sands of #2 and #3 grade have been found desirable for use where the pipe is heavily corroded or for the removal of coatings, scale deposits, or the like. It will also be apparent that by the use of the invention, the density or amount of sand per unit weight of air or gas is readily regulated by adjusting the pressure of air or gas entering the container **10** through pipe **56** and jets **64** and by adjusting the positions of the jets relative to the inlet ends of the hoses **12**.

It will thus be seen that the invention provides apparatus for cleaning pipes which is simple in operation, possesses great flexibility of adjustment, and by which relatively long lengths of pipeline may be easily and quickly cleaned without disassembling the same.

Referring now to FIG. 6, a line with a relatively small diameter may be cleaned in the following manner:

(1) The pipeline is first blown out by a blast of air or gas.

(2) Next, the line is pigged one or more times as necessary to clean or clear the line of debris and obstruction, fluid or the like which may be in the line.

(3) Next, the line is sand blasted by introducing the mixture of sand and air at the preselected quantity and pressure to provide an inlet velocity to agitate the mixture and prevent substantial settling out of the sand.

(4) Identical adapters **100***b* and **100***a* are then coupled to each end of the pipeline P. An adapter **100***b* typically is a hollow tube which has its open end arranged to receive an end cap **101** which has a spacer element **102** extending inwardly into the adapter **100***b*. An access opening **103** is provided in adapter **100***b* intermediate of the end of the spacer and the cap **101** on the adapter which can be closed by a removable plug **104**. Thus, a squeegee ball **105** or a pig can be positioned within the adapter **100***b* by spacer **102** so that air or gas under pressure admitted via the access opening **103** can be used to drive the squeegee ball **105** through the line to clear the line after the sand blasting step.

(5) Near the end of adapter **100***b*, which is coupled to the pipeline P, another access opening **106** and plug **107** are provided to facilitate the introduction of fluids to the pipeline while the ball **105** is at the end of the adapter. Intermediate of the access openings **103** and **106** is an opening **108** with a valve **109** to provide a valve controlled access opening. A cleaning and drying fluid such as methyl ethyl ketone is introduced via the access opening **106** to the line. Then opening **106** is plugged and valve **109** closed. At the other end of the line valve **109***a* is opened. Air or gas is then supplied via opening **103** to drive the ball **105** and fluid to the other end of the line. When the fluid reaches valve **109***a* it may be caught in a suitable container and the ball **105** is driven into contact with spacer **102***a*. Thereafter, the fluid may be returned to the point or origin in a similar manner. The fluid serves to wash the interior of the line after the sand blasting step.

(6) Following this, a coating fluid such as a paint or plastic can be introduced into the line in a manner similar to the introduction of the washing fluid to coat the interior of the line.

Referring now to FIGS. 7 and 8, in this embodiment of the invention, wherein like parts to apparatus previously described are identified with superscripts, a suitable discharge or bleeder valve **110** is adapted to be connected to the outlet end of the pipeline. Valve **110** is preferably of a quick opening type and may be formed with a reduced discharge outlet **112**, by which the rate of discharge of fluid from the pipeline may be predetermined for a predetermined diameter of pipe and for the particular pressure or range of pressure at which the apparatus is to be operated.

In making use of the pipe cleaning apparatus of the invention, the inlet end of the discharge valve **110** is connected to the outlet end of the pipeline, and the discharge connection **84′** of the housing **80′** is connected to the inlet end of the pipeline, as shown in FIG. 6. The discharge valve **110** is then closed and the gas supply valves **100′** are opened to introduce gas under pressure into the pipeline to build up the line to a predetermined pressure. When this predetermined pressure is reached, the valves **100′** are closed and the discharge or bleeder valve **110** and the valve **12***a* in the sand supply line **12′** are quickly opened, whereupon the outflow of air or gas through the discharge valve **110** causes a sudden reduction in the pressure in the pipeline which results in an inflow of sand and gas through the hose **90′** into the pipeline. After the valves **110** and **12***a* have been opened for a short time, depending upon the diameter and length of the pipeline, the valves **100′** in the pressure lines **92′** are opened to admit air or gas under pressure into the chamber **82′** to cause a swirling action of the air or gas as the same flows through the chamber **82′** into the pipeline, to produce a substantially uniform mixture of the air and sand which is introduced into the pipeline to cause a continuous flow of such mixture through the line to clean the line. Because of the flexible nature of the hose **90′** extending into the chamber **82′**, the portion of the hose extending inwardly beyond the pipe **88′** in the chamber may gyrate freely about in the chamber to aid in the mixing of the sand and air to form a more uniformly dispersed mixture, which will be effective to sand blast and abrade the interior of the pipe to clean the same.

By way of example, a pipeline having an inside diameter of 2 inches and 1300 or more feet in length, may be readily cleaned by the method of the invention, by the use of air under a pressure of approximately 100 pounds per square inch flowing at a rate of approximately 350 cubic feet per minute. Under these conditions, it has been found that a delay of about 10 seconds between the time that the discharge valve **110** and sand supply valve **12***a* are opened to admit air under pressure into the chamber **82′**, is sufficient to provide for the initial introduction of sand into the pipeline to cause a continuous flow of the mixture of air and sand through the line. It will, of course, be appreciated that the pressure and volume of flow and the time interval allowed may be adjusted to suit the particular conditions under which the apparatus is operated, such as the length of the pipeline and its diameter.

The above operation includes the pressurizing of the line, providing an inflow of sand and gas into the inlet end of the line and gas under pressure being supplied to the inlet end of the line to cause a substantially continuous flow of a mixture of gas and sand through the line.

It will thus be seen that the invention constructed and operated in the manner described above provides pipe cleaning apparatus which is of economical manufacture and which is easily applied and operated in connection with pipelines of various sizes and of relatively long lengths to quickly and effectively clean the interior of such lines.

The invention is disclosed herein in connection with embodiments of the same, but it will be understood that these are intended to be illustrative only and that various changes may be made in the construction and arrangement of the various parts, as well as the steps of the method, within the spirit of the invention and the scope of the appended claims.

What is claimed is:

1. Apparatus for cleaning the internal surface of pipe

comprising supply means for pre-mixing abrasive particles and gas thereby forming a mixture, injection means nozzle coupled to said supply means including means for agitating the mixture and for introducing into the mixture additional gas at a pressure and volume to form another mixture in which the abrasive particles are in a substantially uniform state of suspension and to prevent settling of the particles during the flow of the mixture at said pressure, and means coupling said injection nozzle to a pipe for introducing the last-mentioned mixture into one end of a pipe, while the other end of the pipe is open to the atmosphere to allow the last-mentioned mixture to flow freely through the pipe without settling of the particles.

2. Apparatus for cleaning the internal surface of pipe comprising means for mixing abrasive particles and gas at a pressure to form a mixture in which the abrasive particles are in a substantially uniform state of suspension and to prevent settling of the particles during the flow of the mixture at said pressure, and means for introducing the mixture into one end of a pipe while the other end of the pipe is open to the atmosphere to allow the mixture to flow freely through the pipe to allow the gas to expand during such free flow to increase the velocity of the mixture, said mixing means including means for introducing a pressured gas into said mixture tangentially to the normal flow of said mixture into said pipe to cause a swirling of said mixture in said pipe.

3. Apparatus for cleaning the internal surface of pipe comprising means for mixing abrasive particles and gas at a pressure to prevent settling of the particles during flow of the mixture at said pressure, means for introducing into the mixture additional gas to vary the amount of abrasive in the mixture per unit volume of the mixture to maintain the abrasive particles in a substantially uniform state of suspension, and means for introducing the mixture into one end of a pipe while the other end of the pipe is open to the atmosphere to allow the mixture to flow freely through the pipe.

4. Apparatus for cleaning the internal surface of pipe comprising means for forming a mixture of abrasive particles and gas at a pressure to prevent settling of the particles during flow of the mixture at said pressure and including means for varying the amount of abrasive in the mixture per unit volume of the mixture to maintain the abrasive particles in a substantially uniform state of suspension and means for introducing the mixture into one end of a pipe while the other end of the pipe is open to the atmosphere to allow the mixture to flow freely through the pipe said mixture means also including additional gas introduction means for swirling said mixture flowing into said pipe.

5. Apparatus for cleaning the internal surface of pipe comprising means for forming a mixture of abrasive particles and gas at a pressure to prevent settling of the particles during flow of the mixture at said pressure and including means for varying the amount of abrasive per unit volume of the mixture, means for agitating the mixture while introducing additional pressured gas into the mixture to maintain the abrasive particles in a substantially uniform state of suspension and means for introducing the mixture in an agitated condition into one end of a pipe.

6. Cleaning apparatus for the internal scouring of lengths of coupled pipes comprising: means for injecting abrasive particles into the inlet of a pipe; supply tank means for providing a continuous flow of premixed suspended abrasive particles and gas to said injecting means; means coupled to said injecting means for supplying gas in quantities sufficient to inject said flow of suspended abrasive particles and gas into the inlet of the pipe and at the pressure adequate to maintain said abrasive particles in suspension in the pipe; means coupling said supply tank means to said injecting means including flow control means for discontinuing the flow of premixed suspended abrasive particles and gas to the injecting means independently of said means for supplying said gas.

7. The apparatus of claim 6 wherein said injecting means comprises: a hollow injection nozzle with a tubular rearward end section having a larger diameter than the diameter of the pipeline to be cleaned, a forward tubular end section with a diameter substantially equal to the diameter of the pipeline to be cleaned, and an intermediate frusto-conical section connecting the forward and rearward sections to one another, a first, open-ended feed pipe centrally mounted in said rearward wall, said first feed pipe terminating within the rearward section short of said intermediate section end coupled to said flow control means, a second, open-ended feed pipe mounted in said rearward wall near the outer periphery of said rearward wall coupled to said means for supplying gas.

8. The apparatus of claim 6 wherein said supply tank means comprises: a hollow tank member having means for admitting a supply of abrasive particles into the tank members; a first open-ended pipe coupled to said flow control means for supplying a flow suspended abrasive particles thereto, said first pipe being mounted in said tank member and extending from the upper end of the tank member to a point just above the bottom of the tank member, a second open-ended pipe mounted in said tank member below said first pipe and opening into said first pipe, said second pipe serving to conduct a flow of gas to said first pipe and entrain abrasive particles therewith, said second pipe having a smaller diameter than said first pipe and being centrally aligned with said first pipe, the open ends of said first and second pipe means in said tank member terminating short of one another, a third pipe in said tank member having an open end in the upper portion of said tank member disposed at a location above the level designated for a full load of abrasive particles in the tank member for conveying gas to the interior of the tank member, said first pipe having openings therein disposed at a location near the upper end of the tank member above the level designated for a full load of abrasive particles for the introduction of gas in the tank member to the interior of said first pipe.

9. The apparatus of claim 6 wherein said injecting means comprises: a hollow injection nozzle with a tubular rearward end section having a larger diameter than the diameter of the pipeline to be cleaned, a forward tubular end section with a diameter substantially equal to the diameter of the pipeline to be cleaned, and an intermediate frusto-conical section connecting the forward and rearward sections to one another, a first, open-ended feed pipe centrally mounted in said rearward wall, said first feed pipe terminating within the rearward section short of said intermediate section end coupled to said flow control means, a second, open-ended feed pipe mounted in said rearward wall near the outer periphery of said rearward wall coupled to said means for supplying gas and wherein said supply tank means comprises: a hollow tank member having means for admitting a supply of abrasive particles into the tank member, a first open-ended pipe coupled to said flow control means for supplying a flow suspended abrasive particles thereto, said first pipe being mounted in said tank member and extending from the upper end of the tank member to a point just above the bottom of the tank member, a second open-ended pipe mounted in said tank member below said first pipe and opening into said first pipe, said second pipe serving to conduct a flow of gas to said first pipe and entrain abrasive particles therewith, said second pipe having a smaller diameter than said first pipe and being centrally aligned with said first pipe, the open ends of said first and second pipe means in said tank member terminating short of one another, a third pipe in said tank member having an open end in the upper portion of said tank member disposed at a location above the level designated for a full load of abrasive particles in the tank member for conveying gas to the interior of the tank

member, said first pipe having openings therein disposed at a location near the upper end of the tank member above the level designated for a full load of abrasive particles for the introduction of gas in the tank member to the interior of said first pipe.

10. The apparatus of claim 6 wherein said injecting means includes baffle means for causing a swirling movement of said gas in said injecting means.

11. The apparatus of claim 6 wherein said injecting means includes a pipe member positioned midway along the length of said injection means for introducing said suspended abrasive particles to said injecting means.

12. The apparatus of claim 11 wherein said pipe member includes a terminal flexible portion of elastomer material.

13. As a subcombination for use in cleaning the internal surface of lengths of coupled pipes, injecting means comprising: a hollow injection nozzle having a tubular rearward end section with a uniform diameter and rearward wall, the diameter of said end section being larger than the diameter of the pipeline to be cleaned, a forward tubular end section with a uniform diameter which is substantially equal to the diameter of the pipeline to be cleaned, and an intermediate frusto-conical section connecting the forward and rearward sections to one another, a first, open-ended feed pipe centrally mounted in said rearward wall and extending into said hollow injection nozzle, said first feed pipe terminating short of said intermediate section, said first feed pipe being adapted for coupling to a supply of gas and suspended abrasive particles, a second, open-ended feed pipe mounted in said rearward wall near the outer periphery of said rearward wall, said second feed pipe being adapted for coupling to gas supply means, and baffle means disposed relative to said second feed pipe so as to cause a swirling movement of gas supplied through said feed pipe, said baffle means being disposed intermediate of said rearward wall and the open end of said first feed pipe.

14. As a subcombination for use in cleaning the internal surface of lengths of coupled pipes, supply tank means comprising: a hollow tank member having means for admitting a supply of abrasive particles into the tank member; a first open-ended pipe coupled to said flow control means for supplying a flow suspended abrasive particles thereto, said first pipe being mounted in said tank member and extending from the upper end of the tank member to a point just above the bottom of the tank member, a second open-ended pipe mounted in said tank member below said first pipe and opening into said first pipe, said second pipe serving to conduct a flow of gas to said first pipe and entrain abrasive particles therewith, said second pipe having a smaller diameter than said first pipe and being centrally aligned with said first pipe, the open ends of said first and second pipe means in said tank member terminating short of one another, a third pipe in said tank member having an open end in the upper portion of said tank member disposed at a location above the level designated for a full load of abrasive particles in the tank member for conveying gas to the interior of the tank member, said first pipe having openings therein disposed at a location near the upper end of the tank member above the level designated for a full load of abrasive particles for the introduction of gas in the tank member to the interior of said first pipe.

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

July 7, 1964

Patent No. 3,139,704

James D. McCune

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 11, line 2, before "means" insert -- nozzle --; line 3, strike out "nozzle"; column 11, line 70, before "suspended" insert -- premixed --.

Signed and sealed this 9th day of February 1965.

(SEAL)
Attest:

ERNEST W. SWIDER
Attesting Officer

EDWARD J. BRENNER
Commissioner of Patents