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VACUUM GENERATION

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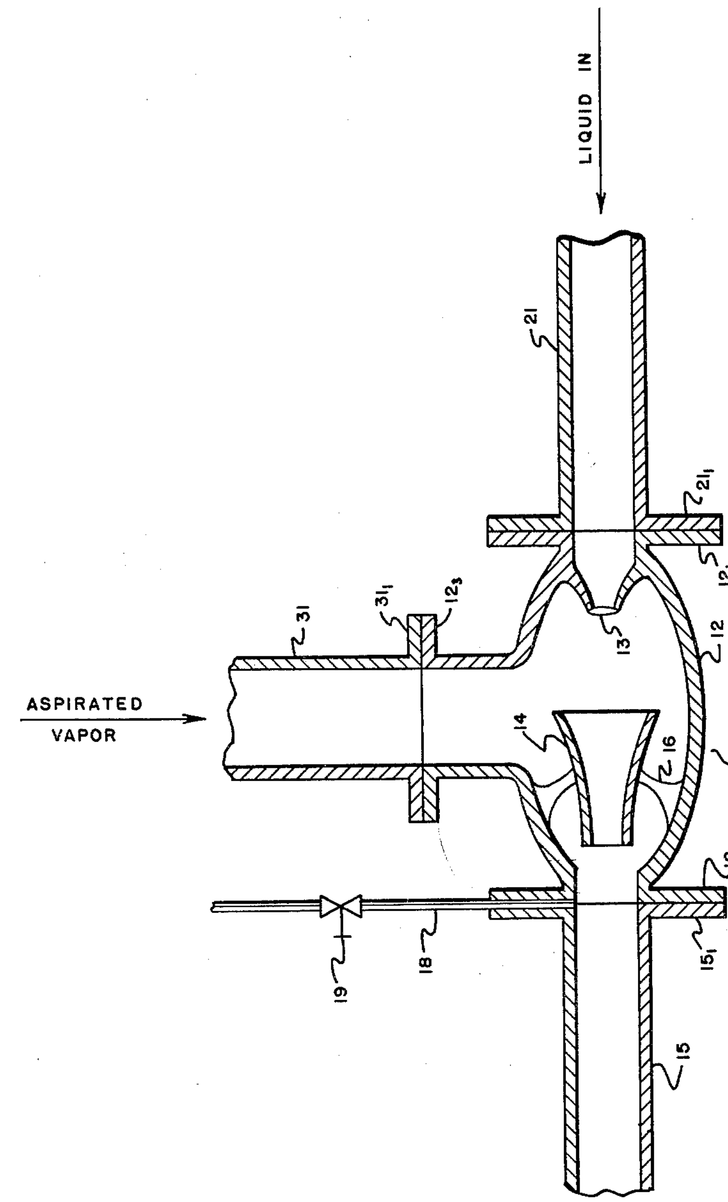

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VACUUM GENERATION

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Introduction

This invention relates to the generation of vacuum. More particularly, the invention relates to the generation of vacuum, for movement, usually, of liquid chemical products, wherein the vacuum generation is accomplished by the operation of an ejector, the vacuum being generated by the change in velocity principle, employing the customary application of the Bernoulli theorem. Even more particularly, the invention relates to an improvement in such an operation which formerly was plagued by noise generation, actually at the point or level which results in extreme auditory and physical discomfort to operators and other personnel.

Background and Problem

Vapor or gas ejectors (sometimes termed "eductors") have long been employed, in laboratory and in commercial scale processes, for the generation or establishment of vacuum. One particular type of installation employing such a device is employed for establishing vacuum to transport liquids of toxic or hazardous character, by creating a vacuum in a receiving tank, whereby a liquid of the character described can be passed or transported through appropriate lines under the influence of the pressure differential created by the vacuum, thus obviating the need for direct pressure application, by pumps or similar devices, on the liquid to be transported. Illustrative of such an operation is the movement of antiknock compounds containing organometallic liquids or compositions, wherein a high degree of caution is exercised to prevent undue application of supra-atmospheric pressure, whereby minuscule leaks might result in leakage of the material. The transport of such liquids by vacuum application obviously minimizes such difficulties or possibilities.

In such a typical operation, or in comparable operations wherein the possibility of contact of the liquid, or vapors thereof, with an aqueous stream, is to be avoided, it is customary to employ a hydrocarbon liquid as the actuating stream to generate the vacuum. Such a technique has valuable aspects, in that minor amounts of vapor of the liquid being transported, when exposed to such a hydrocarbon stream, are absorbed at least in part therein, thus minimizing the possibility of release of portions of the liquid in vapor form. While the aforementioned technique is highly effective in generating vacuum for the purpose intended, it has been found that a supplemental problem is created with respect to the noise of operation. In particular, when the hydrocarbon liquid actuating liquid for the ejector has a relatively high vapor pressure, it has been discovered that an extreme noise level, at a high frequency, or shrill, level, is encountered. This causes severe physical and pyschological discomfort. This tendency has been particularly pronounced in recent years, in installations or operations employing gasoline range hydrocarbons as the actuating liquid, because of the general trend to relatively high volatility gasoline stocks. Not only has it been found that the above described noise represents a discomfort level factor, but in addition it is found that objectionable noise is frequently accompanied by significant erosion or corrosion of the piping of the systems.

Objects

The object of the present invention is to provide an improvement in the method of generating vacuums, for the

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movement of liquids or the like, which method generally has been plagued by high noise levels following previous techniques. A more explicit object is to provide an improvement or an improved and quieter vacuum generation operation, wherein the vacuum is generated by the velocity-change flow of a relatively volatile gasoline hydrocarbon stock, such as a gasoline or gasoline blending stock.

Statement of the Invention

The present invention comprises injecting, during the operation of an ejector employing a high volatility hydrocarbon actuating liquid, a small stream of non-condensible gas into the mixture of actuating liquid and aspirated gas (entrained by the operation of the ejector in establishing vacuum), at a downstream point usually at or near the point of re-initiation of normal velocity flow. The absolute quantity of gas introduced is not absolutely critical, but the proportion is highly important as will be illustrated more fully hereinafter. Generally, it is found that the gas, which can be air, nitrogen, carbon dioxide, or other non-condensible gas, including, for example, a substantially non-condensible hydrocarbon such as methane, is introduced in the proportions of from at least about 0.4 to 5 cubic feet per 10 gallons of flow of the actuating liquid. It is found that providing this supplemental feed of non-condensible gas results in an extremely profound reduction in loudness or noise of operation, particularly when the ejector is operating under conditions of maximum vacuum, or nearly maximum vacuum obtainable, and with very small flows of the aspirated gas which is being removed or transported in order to establish a negative pressure or partial vacuum.

The details of operation of the present improvement, and the mode of carrying out the invention under the best circumstances will be readily understood from the further description hereinafter, and from the accompanying FIGURE which illustrates, in schematic cross section, a typical ejector plus supplemental means to provide the noise reduction according to the present invention.

Description of Apparatus

Referring to the FIGURE, a typical ejector installation, with the supplemental apparatus employed according to the present invention, is shown. The ejector **11** includes a body portion **12** having three outlets thereto, provided with flanges 12_1, 12_2, 12_3 for connection to conduits as hereafter described. Connected to the ejector body is a liquid feed line **21** fastened to the intake flange 12_1 of the body, a discharge line **15**, fastened by means of flange 15_1 to the exit flange 12_2 of the body, and a vapor intake line **31**, fastened by the use of flange 31_1 to the third flange of the third opening 12_3 of the body. The ejector body is, generally, a circular cross section casting, a nozzle **13** being provided adjacent the intake end, so that liquid fed through line **21** has the velocity thereof appreciably increased by the nozzle **13**, above the velocity in the feed line **21**, immediately upon entrance of the actuating liquid into the body **12**.

A supplemental throat member **14**, having a circular cross section bore converging generally toward the lateral mid-section thereof, is centrally and integrally provided in the ejector body, and is positioned in permanent place therein by strut or support members **16**, the center of the supplemental throat member **14** being coincident with the center line of the high velocity feed nozzle **13** and the intake flange 12_1 and the exit flange opening 12_2.

At a downstream position, in this embodiment precisely at the flanged connection between the discharge line **15** and the discharge flange opening 12_2 of the ejector body, a conduit or line **18** is provided for feeding a non-condensible gas into the downstream channel established by the ejector and the downstream discharge line 15. Usually a control valve 19 is provided in said line.

In operation, a stream of actuating liquid is pumped into the line 21, by pump means not shown, and thence enters the body through the nozzle 13, necessarily at an appreciably greater velocity than the velocity in the feed line 21. Being propelled normally under considerable force and with reasonably high velocity, the stream of liquid passes into the opening of the throat member 14, and is discharged therefrom directly through the discharge flange opening 12_2 to the discharge line 15. As a result of the velocity changes and entrainment action created by the above described liquid flow, vapors are aspirated or induced to flow into the ejector body 12, from the vapor intake line 31, which is connected to the space in which a sub-atmospheric pressure or partial vacuum is to be established. The gases introduced in this manner are aspirated or entrained with the actuating liquid introduced through the feed line 21, thus forming a mixture of liquid and gas which is discharged through the outlet line 15 as mentioned.

The principal feature necessary for successful operation of the present invention is, as already indicated, provision of means to provide a supplemental and minor flow of non-condensible gas to the materials discharged from the ejector. In this embodiment, the conduit 18 is positioned between the flanges 12_2, 15_1, which form the connection between the body 12 and the downstream pipe 15. The conduit 18 is normally of relatively small diameter, relative to the thickness of the said mating flanges 12_2, 15_1, and is readily positioned as indicated by machining of small apertures at the joint thereof to accommodate the tube or conduit 18.

The highly beneficial effect of the improvement of the present invention is illustrated more fully by the detailed description and working examples given below.

The ejector proper of the above described apparatus is generally of well known design, typical units in variable sizes being obtainable from known suppliers such at the Schuette and Koerting Company or the Builders Iron Foundry. Further, the ejector may be made of any of a variety of appropriate metallic materials such as cast iron, cast steel, bronzes or brasses, etc.

Examples

In this operation, the results being tabulated below, a commercial ejector was employed, the ejector having an intake of on inch diameter and an exit diameter of about 2 respectively, and a vacuum connection opening corresponding to 2 inch series 40 iron pipe size. A non-condensible gas connection was provided between the flanges connecting the discharge opening of the ejector to the discharge line, the non-condensible gas feed line being a one-fourth inch diameter copper tube, fitted with an appropriate needle valve adjustment and measuring means on the upstream side of the valve.

A series of operations were carried out involving the generation of a partial vacuum in a sealed drum or tank, which was connected by a line to the vacuum connection of the ejector. The motivating liquid in this series of operations was a blended gasoline mixture of approximately 6.0 p.s.i. Reid vapor pressure, as determined at 100° F. Temperatures were varied during the test series between 90° F. and 110° F. in order to simulate ejector operation at other vapor pressures. The gasoline density was approximately 45 pounds per cubic foot.

The above described gasoline stock was circulated at a rate of approximately 89–90 gallons per minute, and, at a temperature of about 100° F. Vacuum was built up or developed, in a tank to which the suction connection of the ejector was attached, until a maximum vacuum was attained of 17.6 inches mercury. Under such operating conditions, very little gas is aspirated by the ejector. It will be noted this degree of vacuum corresponds to an absolute pressure of about 6 pounds per square inch, or approximately the Reid vapor pressure of the gasoline motivating liquid. Hence, there is a strong tendency for the gasoline to partly vaporize during operation.

It was observed that the noise of the operation increased relatively uniformly until the maximum vacuum development was reached, at which time the noise was extremely shrill and objectionable. The operation was then modified by introducing a stream of air, at a controlled, uniform rate, into the outlet stream from the ejector, the air being introduced in the manner already described by passing through a line positioned between the flanges of the connection with the downstream pipe. In all cases, an immediate decrease in the noise intensity was encountered, and no perceptible change in the vacuum developed was observed, upon introduction of the air.

The following table gives the data on a series of different operations of this character, the sound or noise being measured by a sound Survey Meter (General Radio Company), Type 1555–A. Measurement was made with the reactor positioned four inches from the ejector body. The values measured by this instrument were in decibels, a logarithmic expression of a sound intensity without differentiation according to frequency. In the accompanying table, the noise intensity is expressed on the relative units derived from the decibel notations. During the portion of a run in which air was introducted, by contrast with the noise intensity prior to such introduction, a direct determination of the decrease in noise intensity was obtainable. It will be noted that at air rates of about 0.4 cubic feet per 10 gallons of gasoline flow, a recrease in noise intensity approaching 90 percent was obtained. At only slightly higher air levels, of from 1, or more cubic feet of air per 10 gallons of gasoline, the decrease in noise intensity was well over 95 percent in all cases. By introducting the air as described and reducing the nozzle's intensity 90 percent or more, the operation became entirely tolerable to the observer immediately adjacent the equipment.

Run	No Air Added—	Air Added		
	Noise Intensity [1]	Rate (cu. ft./10 gal. gasoline)	Noise Intensity	Decrease in Noise Intensity [1] (Percent)
1	10^9	1.0	3.3×10^7	96.7
2	9.75×10^8	0.38	1.05×10^8	89.2
3	1.05×10^9	1.0	3.3×10^7	96.8
4	1.05×10^9	1.6	1.42×10^7	98.6
5	1.05×10^9	2.3	1.26×10^7	98.8
6	1.05×10^9	3.0	1.0×10^7	99
7	1.05×10^9	3.9	8×10^6	99+
8	1.05×10^9	4.8	8×10^6	99+

[1] Expressed on basis of 10 decibels=10 units of sound intensity.

Variables—Equivalents

Similar operations were conducted under conditions in which appreciable volumes of vapor were being removed from the aforementioned vessel or tank, in approaching the maximum vacuum attainable by the ejector using the motivating gasoline described. The introduction of air during such periods of operation was similarly effective in reducing the noise intensity level, although the magnitude of the discomfort, during such periods of operation, were not as great as in the period of operation at maximum obtainable vacuum. There was no significant adverse effect on vacuum generating capacity of the operation by the introduction of the air which was shown to be so effective in reducing the discomfort associated with the noise frequency and intensity.

While it is not intended to be bound by any theory of explanation, and although the precise explanation of the effectiveness of the improvement of the present invention is not fully understood, it is believed that the ejector operation as such results in the volatilization of small components of the gasoline used as a motivating liquid, at the conditions of ejection, thereby generating a vapor which in turn is discharged from the ejector on the downstream side. Owing to the fact that the downstream conditions involve a re-establishment of relatively high pressure, it is believed that the aforesaid vapor collapses due to the pressure and the absorption or re-absorption of the components back into the gasoline liquid phase, at such a rapid level that sound waves are generated by the collapse of the vapor bubble. The provision of a non-condensible gas according to the present improvement prevents the full conversion of the mixture discharged from the ejector back into a liquid phase, i.e., prevents complete collapse of the bubbles of vapor or gas in the outlet stream, thus prevents the shock impulses resulting in the noise customarily generated.

Although air is a customarily highly desirable non-condensible gas to be employed, in some certain cases it may be undesirable to introduce an oxygen containing gas into the process stream. In such instances, many other non-condensible gases if readily available can be employed. Thus, when the above described operations are repeated, using instead of air, nitrogen, helium, argon, carbon dioxide or methane, similar and comparable benefits are achieved.

Corresponding operations were carried out with gasoline having an effective vapor pressure of 5.5 and 5.9 pounds per square inch, and similar results were obtained.

What is claimed is:

In the method of generation of vacuum, for inducing transport of liquids or the like, by an ejector operation, said method employing a motivating liquid comprising a volatile hydrocarbon capable of partially vaporizing at the vacuum generated in the ejector body, the improvement comprising injecting a non-condensible gas into the fluid stream discharged from the ejector, in proportions of from about 0.4 to 5 cubic feet per 10 gallons of the motivating liquid, thereby substantially decreasing the noise generally accompanying said vacuum generation.

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