

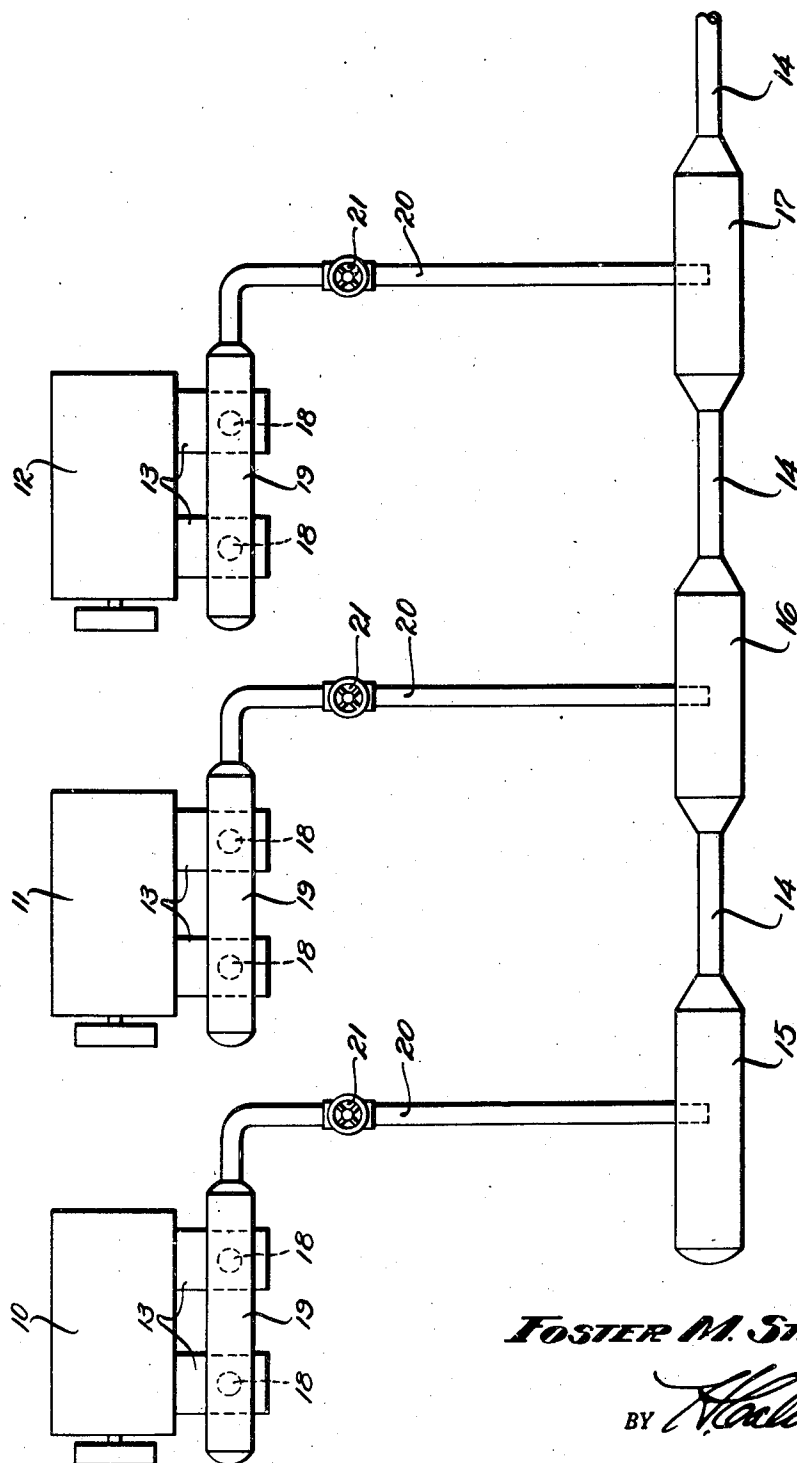
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GAS LINE PULSATION DAMPENING SYSTEM

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GAS LINE PULSATION DAMPENING SYSTEM

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This invention has to do with the dampening of pulsations in gas streams, and particularly with reference to situations where the pulsations are created at plural sources, as by a number of compressors, all discharging gas to or receiving the gas from a common line. As illustrative, the invention is applicable to particular advantage for the dampening of pulsations which otherwise recur in a natural gas pipe line connecting with either the suction or discharge sides of a series of compressors.

My general object is to provide a simple arrangement of chambers having by reason of their relationship in the gas line, the capacity for materially reducing the pulsations created in the gas stream flowing serially through the chambers, by the individual and combined effects of the compressors.

The invention further contemplates substantially complete elimination of pulsations from the gas stream by virtue of the combined effects and relationship between the line series chambers and other chambers interposed between compressors and the line chambers and communicable with the latter through pipe connections having the later described induction characteristics.

In accordance with the invention, the gas line may be considered to include a succession of series-connected chambers individually connected with a compressor inlet or outlet so that the line chambers function in combination to dissipate pulsations created by or transmitted from the compressors. This general arrangement permits utilization with respect to the individual compressors, of a pair of enlarged chambers in the nature of acoustical capacitances, interconnected by a pipe in the nature of an acoustical inductance, all as more particularly dealt with in Patent No. 2,405,100, issued July 30, 1946, on Pulsation elimination in gas lines. To this end, each individual compressor may communicate (through one or plural intake or discharge ports) with a capacitance chamber having an inductance pipe connection with a respective line chamber. As will appear, the stated combination of chambers with their induction pipe connection may have predetermined dimensions in accordance with various factors characteristic of the installation, to effect substantially complete elimination of pulsation. In addition to this chamber combination, the series connected line chambers have the further capacity for assuring regularization of the gas flow.

Economically, the invention is of particular advantage by reason of the ready feasibility and

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relatively low cost of employing the series-connected line chambers as acoustical capacitances, as for the purposes and in the manner stated.

The invention will be more fully understood from the following description of the accompanying drawing conventionally showing a typical arrangement of compressors and their connections with the pulsation dampening system.

Referring to the drawing, the system may include any number of individual compressors, three being shown as typical and diagrammatically indicated at 10, 11 and 12. It is to be understood that the pulsation dampening system may be connected to either the suction or discharge sides of the compressors, i. e. for elimination of pulsations in the low pressure gas fed to the compressors, or the high pressure gas being discharged therefrom. Each compressor may be assumed to be of a piston type, single or double acting, having a pair of cylinders 13 from which the compressed gas is discharged to a common line 14. The latter may be regarded as comprising a series of enlarged sections or chambers 15, 16 and 17 corresponding to the number of compressors and interconnected by the pipe 14 proper so that the gas has series flow through the chambers.

The cylinder ports of each compressor have discharge connections 18 with a common enlarged manifold type chamber 19 from which the gas is discharged through pipe 20 into one of the line chambers 15 to 17. At such time as a compressor may be shut down, or when for any reason it may be desired to disconnect the compressor from gas communication with line 14, the normally opened valve 21 in line 20 may be closed.

The effect of the series-connected chambers 15, 16 and 17 in line 14 is to create a relationship between the chambers and the interconnecting line sections, capable of effectively reducing gas stream pulsations transmitted from the compressor through the interconnecting pipes 20. Generally speaking, the functions of the chambers and interconnecting line sections are analogous respectively to capacitances and resistances or inductances in an electrical filtering system. Accordingly, the chambers and line sections serve to regularize or steady gas flow from the line through pipes 20 to the compressors, where the system is installed at the intake side, and to correspondingly stabilize the gas flow in the line 14 beyond the chambers where the installation is made at the discharge side of the compressors. And it may be mentioned that this characteristic

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effect of the line chamber series is present whether or not the enlarged chambers 19 be employed, or whether the compressor manifolds depart from the conventional designs. In the interest of effecting maximum removal of pulsations, however, it is preferred to maintain a capacitance-inductance relationship between each pair of chambers, e. g. 19 and 15 connected to compressor 10, and their interconnecting pipe 20, as and for the purposes described in the patent referred to above.

A given compressor will operate to produce pulsations in a connecting line at what may be referred to as the fundamental frequency of the compressor. In the case of a single-acting compressor, this fundamental frequency will correspond to the compressor R. P. M., and in the case of a double-acting compressor, the fundamental frequency will be twice the compressor R. P. M. Considering for example the relationship between the compressor 10, chambers 19 and 15, and their interconnecting pipe 20, best results are obtained by evaluating or predetermining the volumes of the chambers and pipe with relation to the particular conditions of the installation. The basis for these determinations is the following equation:

$$\frac{L}{R^2} \times V = \frac{C^3}{78.67 F^2}$$

wherein

L=The length in inches of the passage in pipe 20;

R=The radius in inches of that passage;

V=The volume in cubic inches of one of equal volume chambers 19 or 15, or the minimum common volume of two such chambers not necessarily of equal volume;

C=Velocity, as defined below, in feet per minute of sound in the gas;

F=Fundamental or selected frequency per second of the cumulative pulsations created in the gas streams by the compressor and at the compressor inlet or outlet as the case may be. At the risk of over sizing the equipment the frequency may be assumed, so long of course as it includes all frequencies, and higher harmonics, to be eliminated.

Relative to determination of the value of "C," if the apparatus is installed at the discharge side of the compressor, the theoretically correct value of "C" is the velocity of the gas at the connections 18 plus the velocity of sound in the gas. On the other hand, if the apparatus is installed at the suction or intake side of the compressor, the theoretically correct value of "C" becomes the velocity of the gas flow in that line. Accordingly, the expression "net velocity" is understood to mean the velocity of sound in the gas, plus or minus the velocity of the gas, depending upon whether the apparatus is installed respectively at the discharge or suction sides of the compressor. It may be observed that due to its small value in comparison with the velocity of sound, the velocity of the gas itself may be disregarded without serious sacrifice of satisfactory performance. However, where the formula is to be used in its strict theoretical correctness, the value for the velocity of the gas should be taken into account. Unless specifically qualified, the character "C" broadly denotes the net velocity or the velocity of sound in the gas with or without taking the gas velocity into consideration.

When a multiple cylinder reciprocating compressor is a source of pulsation, it is possible to

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determine the cumulative (taking into consideration the two cylinders) fundamental frequency (F) of the pulsations in accordance with the R. P. M. of the compressor. All harmonics of this frequency naturally will be at a higher frequency than this fundamental. For purposes of calculation and design, it is only necessary to select the cut-off frequency of the apparatus to be just less than the cumulative fundamental compressor frequency, and then the fundamental, as well as its harmonics, will not be transmitted downstream in the gas. Generally speaking, the value for "F," i. e. the selected cut-off frequency to be used in the equation, may be taken within the range of about 85% to 100% of the actual cumulative fundamental frequency, which is the total of the frequencies of the pulsations in the two gas streams discharged at 18. Where a compressor is operable at variable frequencies, or speeds, the value for "F" preferably is selected to be just less than the lowest frequency. Satisfactory results have been obtained at a value for "F" corresponding to about 90% of the actual fundamental frequency. As previously indicated, lower fundamental frequency may be assumed or selected but at the expense of over sizing the equipment.

Having determined the value "F" for a given compressor, it then remains necessary to evaluate the physical dimensions of the chambers 19 and 15 connected to that compressor, and of the interconnecting pipe 20. The left-hand side of the equation, i. e.

$$\frac{L}{R^2} \times V$$

defines the volume of each chamber and the length and inside radius of the connecting pipe 20. Accordingly, it is only necessary to determine the value for "C" in order to have an arithmetic value for the entire right-hand side of the equation. The value of the velocity of sound in the gas being compressed is first approximated from existing tables under standard conditions, and is then corrected for pressure and temperature considerations to meet those conditions actually existing at the location in the line where the pulsation is to be arrested.

The value for

$$\frac{L}{R^2}$$

is arbitrarily taken to be as large as can be tolerated with regard to pressure loss in the pipe 20. In other words, knowing the gas pressure at chamber 19 and the rate of gas flow to occur through pipe 20, the latter may arbitrarily (based upon experience or actual calculation) be given length and radial dimensions permitting passage of the gas through the line within a suitable or limiting range of pressure drop. Having thus determined the values for "C" and

$$\frac{L}{R^2}$$

the value of each chamber volume, or "V," becomes directly determinable. It should be understood that the determined value for "V" is substantially a minimum value, and that the chamber volume may be increased beyond that value without impairing performance, although in practice it is ordinarily desirable to make the chamber of a size close to its calculated volume in order to economize on materials and avoid unnecessarily large equipment.

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In the equation given above, the value 78.67 represents essentially a conversion factor predicated upon values for L, R, V and C according to the English system, as distinguished from the metric system. If these factors be evaluated in terms of the metric system (expressing L and R as centimeters, V as cubic centimeters, and C as centimeters per second) then the value of pi, or 3.14, is to be used instead of 78.67. It will be understood, and the claims are to be so construed, that the stated equations express the theoretically correct relationship and values, and that in practice it may not be necessary to adhere precisely thereto, so long as the calculations or relative proportions of the apparatus conform fundamentally and substantially to the equations.

I claim:

1. In combination with a plurality of gas compressors, a gas manifold line consisting of a succession of enlarged chambers, adjacent chambers being interconnected by a smaller cross-sectional area passage, and pipes connecting each chamber with one each of the compressors so that the gas is caused by the compressor displacements to flow through said manifold line from one into a next of said chambers and the gas flow is regularized by virtue of the chamber and interconnecting passage series.

2. In combination with a plurality of gas compressors, a gas manifold line consisting of a succession of enlarged chambers, an elongated relatively small cross-sectional area tube interconnecting adjacent chambers, and pipes connecting each chamber with one each of the compressors so that the gas is caused by the compressor displacements to flow through said manifold line from one into a next of said chambers and the gas flow is regularized by virtue of its flow through the chamber and interconnecting tube series.

3. In combination with a plurality of gas compressors, enlarged first gas chambers individually connected with the cylinder ports of one each of the compressors, a gas manifold line consisting of a succession of enlarged second chambers, the adjacent second chambers being interconnected by a smaller cross-sectional area passage, and pipes connecting each of said second chambers with one each of the first chambers that the gas is caused by the compressor displacements to

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flow through said manifold line from one to the next of said second chambers and the gas flow is regularized by virtue of the second chamber and interconnecting passage series.

4. The combination as claimed in claim 3, in which said smaller cross-sectional area passage interconnecting the second chambers is formed by an elongated tube.

5. In combination with a pair of gas compressors, a plurality of enlarged first gas chambers individually connected with the cylinder ports of one each of the compressors, a gas manifold line consisting of a succession of enlarged second chambers, an elongated relatively small cross-sectional area tube interconnecting adjacent second chambers, and pipes connecting each of said second chambers with one each of the first chambers so that the gas is caused by the compressor displacements to flow through said manifold line from one to the next of said second chambers and the gas flow is regularized by virtue of the second chamber and interconnecting tube series, the volumes of the pair of the first and second chambers connected to each compressor and the dimensions of the gas passage in the pipe interconnecting the last-mentioned pair of chambers having predetermined values substantially in accordance with the following equation:

$$\frac{L}{R^2} \times V = \frac{C^2}{78.67F^2}$$

wherein L=length of said passage in inches, R=radius of said passage in inches, V=minimum volume of each chamber in cubic inches, C=the velocity in feet per minute of sound in the gas, and F=a selected value for the fundamental frequency per second of pulsations created by the compressor in the gas stream flowing through the pair of chambers.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
261,605	Hill	July 25, 1882
2,405,100	Stephens	July 30, 1946