June 28, 1949. F. M. STEPHENS 2,474,553

ELIMINATION OF PULSATIONS IN GAS LINES

Filed March 19, 1946

Fig. 1.

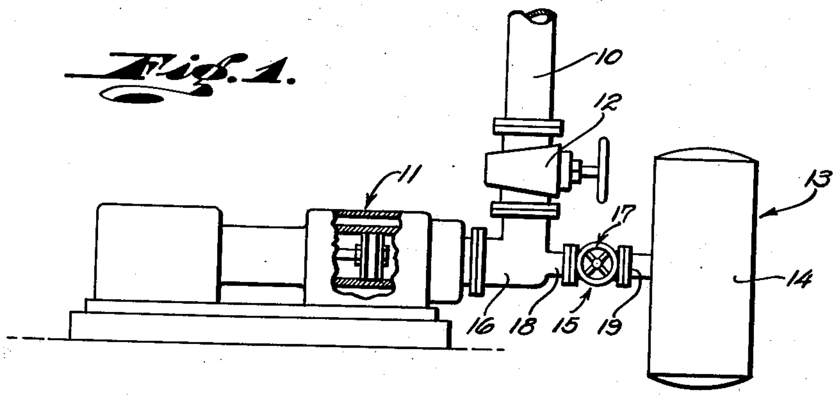
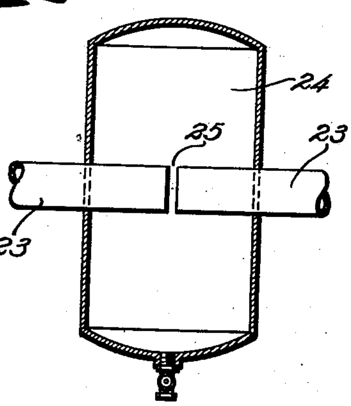
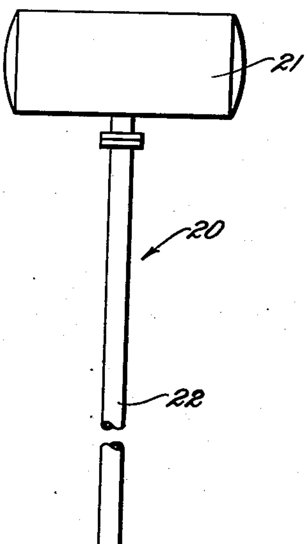


Fig. 3.





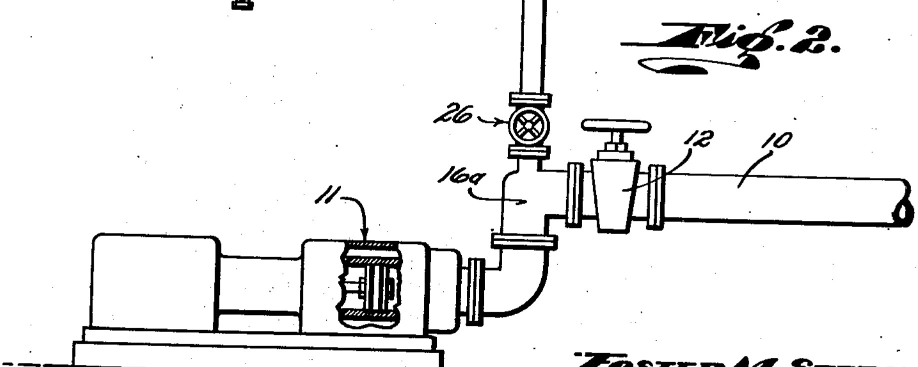


Fig. 2.

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ELIMINATION OF PULSATIONS IN GAS LINES

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5 Claims. (Cl. 230—236)

1

This invention has reference to the dampening or elimination of pulsations in gas streams, particularly for the correction of pulsating flow created in gas lines by a compressor or the like. Typically, the invention is applicable to the elimination of pulsations created by piston-type compressors in natural gas lines.

My general object is to provide a simple arrangement of equipment constituting a resonant type acoustical system having predetermined resonating characteristics rendering it responsive to the pulsating gas flow in a manner resulting in virtually complete elimination of the pulsations. Briefly, the purposes of the invention are served by the simple requirement of a single closed chamber having restricted communication with the gas line from which pulsations are to be eliminated, the sizes of the chamber and restricted communication being predetermined in the manner hereinafter explained.

Generally speaking, the invention contemplates as the components of the resonator system, a closed chamber of predetermined volume, but otherwise shaped or proportioned as may be desired, and a restricted communication between the chamber and flow line, which may be one of different types. As a first example, the restriction may take essentially the form of an orifice of predetermined size, contained in a connection whose length is sufficiently short as to create no effect interfering with the acoustical functions of the orifice itself. The orifice may be of fixed size and capable of replacement by different sized orifices in accordance with changing operating conditions, or the orifice may be contained in a valve-type fitting and thereby rendered adjustable, i. e. variable in size.

Instead of using an orifice type restriction in the communication between the chamber and gas line, I may employ an extended restricted passage in the nature of an acoustical inductance, formed for example by an elongated pipe having a diameter substantially smaller than the gas line. As a further alternate form of the restricted communication, I may use a fixed size or adjustable orifice together with an extended inductance passage.

As indicated, in whatever form used, the restricted connection together with the communicating closed chamber, presents an acoustical resonating system "tuned" to the frequency of the pressure pulsations and responsive in such phase relationship therewith as to convert the gas stream from pulsating to steady flow.

Embodiments of the invention and methods for

2

predetermining the acoustical characteristics of the resonate systems, will be more fully understood from the following description wherein reference is made to the accompanying drawing, in which:

Fig. 1 is a view showing one form of resonator connected with a gas lie in which pulsating flow is created by a compressor;

Fig. 2 is a similar view illustrating a variational form of the invention; and

Fig. 3 is a fragmentary section showing a further variational form.

Referring first to Fig. 1, the gas line **10** may connect with either the intake or discharge side of the compressor **11**, since in either instance the compressor operation may, and is assumed to create by virtue of its piston displacement, pressure pulsations in the gas stream. When leading from the discharge side of the compressor, line **10** usually will contain a shut-off valve **12**. It will be appreciated that when serving as the gas line leading to or from the usual natural gas compressor (single-acting or double-acting), pipe **10** may be of relatively large size, e. g. 8 inch diameter or larger.

The resonator system, generally indicated at **13**, consists of the simple combination of a closed chamber or shell **14**, and a restricted connection **15** between the chamber and line **10**, desirably in such relation thereto that the path of communication through **15** is in the direction of the gas flow. Thus in Fig. 1, the gas is assumed to be discharged from the compressor into the T-fitting **16** from which passage **15** is formed by a short connection with the chamber. The connection contains a fitting **17** which, as previously indicated, may present a fixed size orifice, as for example in the conventional orifice plate, or a variable size orifice as provided by an adjustable or valve type fitting. For best results, it is preferred that the length of the connection between chamber **14** and the gas line **10** shall be sufficiently short that the restrictive effect in the connection **15** shall be substantially entirely the restriction presented by the orifice, although it is to be understood that the connecting passage otherwise may be considerably smaller than the cross-sectional area of the gas line. Thus the orifice may be present in say 4 inch diameter connections at **18** and **19** with the gas line and chamber.

The sizes of the chamber **14** and orifice at **15** may be predetermined to produce an acoustical system having proper resonant response to the gas pulsation frequency, substantially in accordance with the following formula:

$$F=K\sqrt{\frac{2R}{V}}$$

wherein

F=Gas pulsation frequency per second.

K=Velocity in centimeters per second of sound in the gas at its temperature and pressure.

R=Radius of orifice in centimeters.

V=Volume of the chamber 14 in cubic centimeters.

This general equation holds true when the connection at 15 is sufficiently short as not to affect the acoustical characteristics and functioning of the orifice as such.

In practical use of the formula, knowing the values for K (from tabulated data in the literature), and F from the cycle frequency of the compressor, an orifice of given size may be selected and the volume of the chamber calculated. Thus assuming air to be the gas (K value being 5475 cm. per second at 20° C. and substantially atmospheric pressure) in which pulsations are created at a resonant frequency of 100 cycles per second, a circular orifice of 2 cm. diameter may arbitrarily be selected. Applying the formula and solving for V:

$$V=\frac{2}{\left(\frac{100}{5475}\right)^2}=\text{substantially 6000 cu. cm.}$$

The variational form of the invention shown in Fig. 3 is functionally similar to the described embodiment, but differs in its structural relation to the gas flow line. Here the latter, corresponding to line 10 in Fig. 1, is indicated at 23 to extend through the closed chamber 24 and to communicate therewith through an orifice within the chamber. The orifice may be formed at 25 either as an opening in the wall of the pipe, or as in the case illustrated, by providing a gap between spaced sections of the pipe.

In accordance with the variational form of the invention shown in Fig. 2, the resonant system 20 is formed by closed chamber 21 having an extended inductance-type connection 22 with the gas line 10. Here the communication 22 may be in the form of an elongated pipe of substantially smaller diameter than the gas line 10, the latter typically having 8 inches or larger diameter and pipe 22 a diameter of 4 inches or smaller. Here the sizes of the chamber and length of pipe 22 (beyond a normally full open and non-restrictive valve 26 that may be placed adjacent the fitting 16a) are predeterminable by the following formula:

$$F=KR\sqrt{\frac{1}{V(.318L\times.5R)}}$$

wherein

F=Gas pulsation frequency per second.

K=Velocity in centimeters per second of sound in the gas at its temperature and pressure.

R=Radius (inside) of pipe 22 in centimeters.

L=Length of pipe 22 in centimeters.

V=Volume of chamber 21 in cubic inches.

As a practical example of calculation, again assuming the gas to be air at 20° C. and substantially atmospheric pressure, pulsating at a frequency of 100 cycles per second, pipe 22 arbitrarily may be assigned a given length and diameter, for example a length of 100 cm. and inside radius of 10 cm. Solving for the volume of chamber 21:

$$V=\frac{1}{(.318\times100\times.5\times10)\left(\frac{100}{5475\times10}\right)^2}$$

$$V=1{,}886.4\text{ cu. cm.}$$

I claim:

1. In combination with a gas compressor, apparatus for the removal of pulsations in a gas stream having pulsating flow created by the compressor, comprising a line pipe connected with the compressor and conducting the pulsating gas stream, and means comprising a closed chamber and a restricted orifice through which said chamber is in communication with the pipe the sizes of said orifice and chamber being predetermined in substantial accordance with the formula:

$$F=K\sqrt{\frac{2R}{V}}$$

wherein

F=Gas pulsation frequency per second;

K=Velocity in centimeters per second of sound in the gas stream at its temperature and pressure;

R=Radius of the orifice in centimeters;

V=Volume of the chamber in cubic centimeters.

2. In combination with a gas compressor, apparatus for the removal of pulsations in a gas stream having pulsating flow created by the compressor, comprising a line pipe connected with the compressor and conducting the pulsating gas stream, and means comprising a closed chamber and an elongated smaller diameter pipe forming an acoustical inductance passage connecting said line pipe with the chamber, the sizes of said smaller pipe and chamber being predetermined in substantial accordance with the formula:

$$F=KR\sqrt{\frac{1}{V(0.318L\times0.5R)}}$$

wherein

F=Gas pulsation frequency per second;

K=Velocity in centimeters per second of sound in the gas stream at its temperature and pressure;

R=Radius of smaller pipe in centimeters;

L=Length of smaller pipe in centimeters;

V=Volume of the chamber in cubic centimeters.

3. In combination with a gas compressor, apparatus for the removal of pulsations in a gas stream having pulsating flow created by the compressor, comprising a line pipe connected with the compressor and conducting the pulsating gas stream, and a closed chamber having a restricted communication with said stream and forming with said communication an acoustical filter having a resonant frequency corresponding to the frequency of the dominating pulsations in said gas stream.

4. In combination with a gas compressor, apparatus for the removal of pulsations in a gas stream having pulsating flow created by the compressor, comprising a line pipe connected with the compressor and conducting the pulsating gas stream, a closed chamber, and means forming a restricted passage of smaller size than the pipe and chamber connecting said chamber with the pipe, said chamber and passage forming an acoustical filter having a resonant frequency corresponding to the frequency of the dominating pulsations in said gas stream.

5. In combination with a gas compressor, apparatus for the removal of pulsations in a gas stream

having pulsating flow created by the compressor, comprising a line pipe connected with the compressor and conducting the pulsating gas stream, a closed chamber and an elongated smaller diameter pipe forming an acoustical inductance passage connecting said line pipe with the chamber, said chamber and passage forming an acoustical filter having a resonant frequency corresponding to the frequency of the dominating pulsations in said gas stream.

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