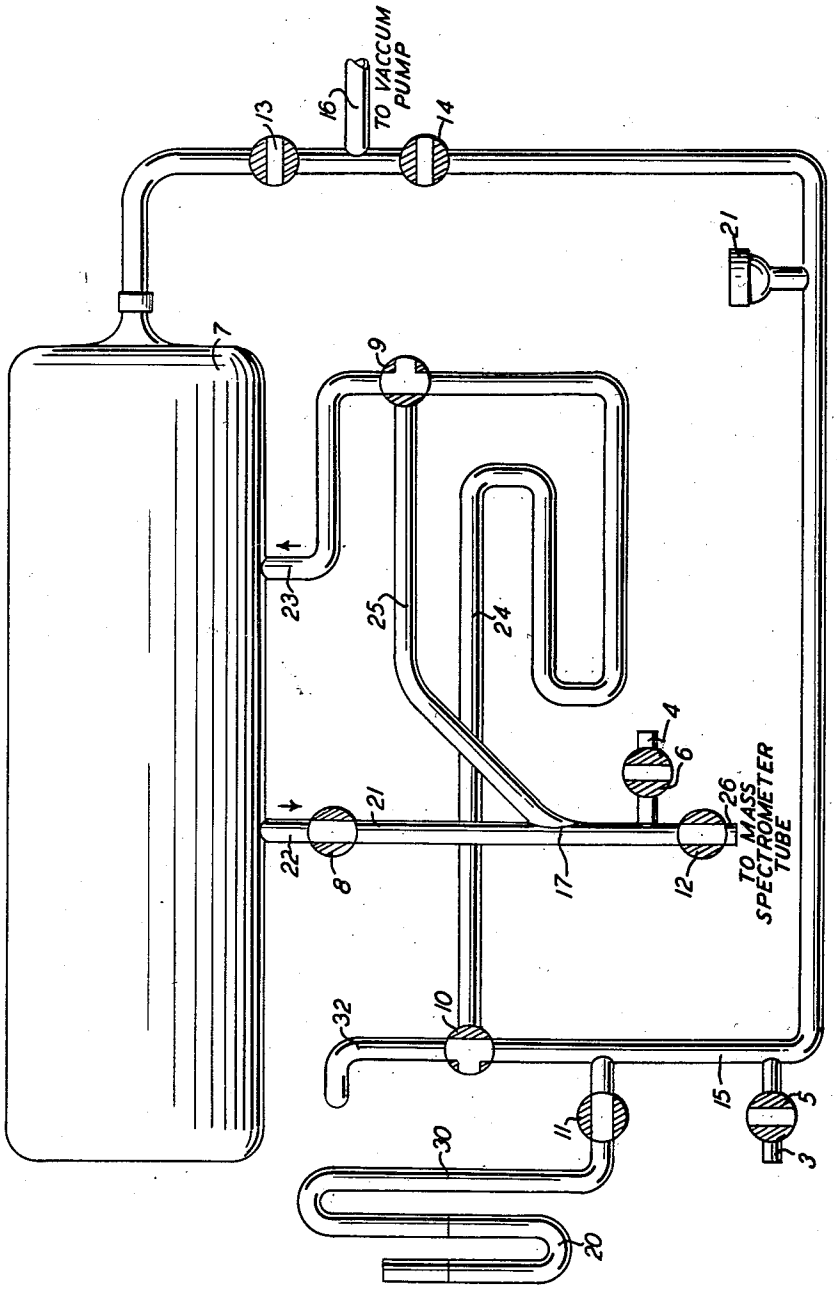
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SAMPLE SYSTEM FOR MASS SPECTROMETERS

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SAMPLE SYSTEM FOR MASS SPECTROMETERS

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This invention relates to mass spectrometry and particularly to an improved sample supply system for a mass spectrometer.

In the sample supply systems of most mass spectrometers, a fixed volume evacuated expansion tank is utilized for receiving gases to be analyzed, the sample gas being expanded to the full volume of the tank and then leaked out to the mass spectrometer tube by the pressure differential between the sample supply system and the spectrometer tube. These fixed sample supply systems function satisfactorily where large samples of the unknown gases are available, however, where only small samples are available as, for example, where an evacuated vacuum tube is to be analyzed for impurities, the test sample may become effectively lost by expansion in the fixed volume tank. In any event, the relatively large expanded volume of the gas substantially decreases the performance of the instrument.

Another problem encountered with mass spectrometers is that of maintaining the near perfect vacuum of the mass spectrometer tube and the sample system. Atmospheric leaks into the system, which might occur, for example, while replacing one expansion tank with another, will of course make the system inoperable for the period required to repump the system to remove the foreign ions and restore the very high vacuum condition.

The principal object of this invention is to provide a sample supply system having an adjustable expansion volume which may be quickly varied as required for the volume of the gas sample available without loss of vacuum to the system.

In the improved mass spectrometer sample supply system according to the invention, a gas sample is admitted to a pre-expansion chamber and is then expanded in an evacuated system of expansion chambers which includes interconnecting tubing and stopcocks for selectively connecting or by-passing the chambers as required for the particular volume of gas sample available for analysis.

According to a specific feature of the invention, a sample supply system may be adapted for analyzing extremely small volumes of gases by by-passing the pre-expansion chamber and leaking the sample directly into the mass spectrometer tube.

These and other features of the invention will be more fully understood from the following detailed description taken in conjunction with the single figure of the drawing showing a sample supply system constructed in accordance with the principles of the invention.

In the sample supply system shown in the drawing, gas may be admitted through tube 3 and stopcock 5 to a pre-expansion chamber comprising tubes 15, 30 and 32, a three way stopcock 10 between tubes 32 and 15 and expansion chamber 24 being provided for confining the sample thereto. A stopcock 11 in tubing 30 may be closed for disconnecting tube 30 to reduce the pre-expansion volume. A manometer 20 is connected to tube 30 and a thermocouple type low pressure vacuum gage 21 is connected directly to tube 15.

The expansion chamber 24 is connected to a second larger expansion chamber or tank 7 by a three way stopcock 9 connected to the tank inlet tubing 23 and also to a tubing 25. An outlet tubing 22 for the tank 7 is provided with a stopcock 8 and is connected to a tubing 21 which joins with tubing 25 to tubing 17 which in turn opens through stopcock 12 into a tubing 26 feeding the ionization chamber of the mass spectrometer tube. A second gas sample admitting tube 4 and a stopcock 6 therefor is connected to the tubing 17.

The tubing 15 of the pre-expansion chamber and the tank 7 are, by stopcocks 13 and 14 respectively, connected to a pipe 16 of a vacuum pump. Stopcocks 13 and 14 may be opened between gas analyses in order to maintain the near perfect vacuum required for the system.

For normal operation where a large volume of gas is available for analysis, stopcocks 8 through 14 are positioned as shown in the drawing, that, is, stopcock 8 between outlet tubing 22 of tank 7 and the tubing 21 is open, three way stopcock 9 is open between inlet tubing 23 of tank 7 and tubing 24 but closed to tubing 25, three way stopcock 10 is opened between the pre-expansion tubing 32 and tubing 15 but closed to chamber 24, manometer stopcock 11 is open, stopcock 12 is open to the ionization chamber of the mass spectrometer and the vacuum pump stopcocks 13 and 14 are closed.

The sample of gas is admitted in conventional manner to the tube 3, stopcock 5 being opened to admit only enough gas to produce a suitable pressure in the pre-expansion system as measured on the manometer. The sample is thereby confined to the tubing 15, 32 and 30. When stopcock 10 is turned 90° clockwise, this sample is permitted to expand by flowing through the tubing of chamber 24, the stopcock 9, tubing 23, into tank 7, out of the tank, through tubing 22, stopcock 8, tubing 21, tubing 17, stopcock 12 and out to the ionization chamber of the mass spectrometer tube through tubing 26.

For small volumes of gas, for example on the order of 0.01 cubic centimeters under standard conditions, the expansion volume must be reduced considerably to obtain optimum results with the mass spectrometer. In this case the expansion tank 7 is by-passed by closing stopcock 8 and turning stopcock 9 90° clockwise thereby cutting off the outlet and inlet tubes 22 and 23 for the tank and opening the passage between tubes 24 and 25. The other stopcocks are set the same as in the first case described above, the gas sample is again admitted to tube 3 and through stopcock 5 and the pressure of the sample, which is much lower than in the first case above, is measured on the low pressure thermocouple vacuum gage 21. The pre-expansion volume is the same as in the first case, the sample being similarly confined to the tubing 15, 32 and 30. When this gas is expanded, however, the expansion tank 7 and tubing 22 and 23 therefor are by-passed, substantially reducing the total expansion volume. The pre-expansion volume may be further reduced if desired by closing stopcock 11 for manometer 20. This also serves to reduce the mercury background when analyzing for mercury in the gas sample. If the gas sample pressure is sufficiently small, stopcock 10 may be turned 180° from the position shown and stopcock 5 may be left open to admit gas continuously to the mass spectrometer tube.

For extremely small gas volumes, such as 0.0001 cubic millimeter under standard conditions (for example, the gas in a gaseous vacuum tube) the stopcock 8 is again closed and stopcock 9 is set as shown in the drawing to close tube 25. The gas sample is admitted in this case to tube 4 and passes through stopcock 6 to the tubings 17, 21 and 25 and passes directly to the mass spectrometer tube through the stopcock 12 and tubing 26. To protect the mass spectrometer tube from exposure to air

during this operation stopcock **12** should be closed while admitting the sample through tube **4**.

A system constructed in accordance with this description capable of handling a wide range of volumes of gas samples has a two liter expansion tank **7** and the chambers **24** and associated tubing are proportioned to provide expansion volumes of 2154 cubic centimeters, 50.2 cubic centimeters and 20 cubic centimeters for the 3 cases discussed and expansion ratios of 720 to 1 and 16 to 1 for the first 2 cases. It would of course be possible to provide more and different volume expansion chambers in a similar fashion.

It is to be understood that the above described arrangements are simply illustrative of the application of the principles of the invention. Numerous other arrangements may be readily devised by those skilled in the art which will embody the principles of the invention and fall within the spirit and scope thereof.

What is claimed is:

1. In an evacuated mass spectrometer sample supply system, a pre-expansion chamber, gas sample admitting means for the pre-expansion chamber, a first expansion chamber having inlet and outlet tubing, a second expansion chamber, means including stopcocks for connecting the second chamber between the pre-expansion chamber and the inlet tubing for the first chamber and means for feeding gas from the outlet tubing to a mass spectrometer tube.

2. In an evacuated mass spectrometer sample supply system having tubing for feeding gas therefrom to a mass spectrometer tube, a pre-expansion chamber, gas sample admitting means for the pre-expansion chamber, a first expansion chamber having inlet and outlet tubing, a second expansion chamber, means including three way stopcocks for connecting the second chamber between the pre-expansion chamber and the inlet tubing for the first chamber, tubing interconnecting the three way stopcock between the second chamber and the inlet tubing with the outlet tubing and the tubing for the mass spectrometer tube and a stopcock for the junction between the outlet tubing and the interconnecting tubing.

3. In an evacuated mass spectrometer sample supply system having tubing for feeding gas therefrom to a mass spectrometer tube, a first gas sample admitting means for the tubing, a pre-expansion chamber, a second gas sample admitting means for the pre-expansion chamber, a first expansion chamber having inlet and outlet tubing, a second expansion chamber, means including three way stopcocks for connecting the second chamber between the pre-expansion chamber and the inlet tubing for the first chamber, tubing interconnecting the three way stopcock between the second chamber and the inlet tubing with the outlet tubing and the tubing for the mass spectrometer tube and a stopcock for the junction between the outlet tubing and the interconnecting tubing.

4. In an evacuated mass spectrometer sample supply system having tubing for feeding gas therefrom to a mass spectrometer tube, a pre-expansion chamber, a manometer for the pre-expansion chamber and a stopcock for selectively connecting the manometer thereto, gas sample admitting means for the pre-expansion chamber, a first expansion chamber having inlet and outlet tubing, a second expansion chamber, means including three way stopcocks for connecting the second chamber between the pre-expansion chamber and the inlet tubing for the first chamber, tubing interconnecting the three way stopcock between the second chamber and the inlet tubing with the outlet tubing and the tubing for the mass spectrometer tube and a stopcock for the junction between the outlet tubing and the interconnecting tubing.

5. In an evacuated mass spectrometer sample supply system having tubing for feeding gas therefrom to a mass spectrometer tube, a first gas sample admitting means for the tubing, a pre-expansion chamber, a manometer for the pre-expansion chamber and a stopcock for selectively connecting the manometer thereto, a second gas sample admitting means for the pre-expansion chamber, a first expansion chamber having inlet and outlet tubing, a second expansion chamber, means including three way stopcocks for connecting the second chamber between the pre-expansion chamber and the inlet tubing for the first chamber, tubing interconnecting the three way stopcock between the second chamber and the inlet tubing with the outlet tubing and the tubing for the mass spectrometer tube and a stopcock for the junction between the outlet tubing and the interconnecting tubing.

No references cited.