Jan. 27, 1959 W. K. DONALDSON ET AL 2,870,628

CONTROL OF GASEOUS MEDIA IN MANUFACTURING PROCESSES

Filed Sept. 8, 1954 3 Sheets-Sheet 1

FIG. 1.

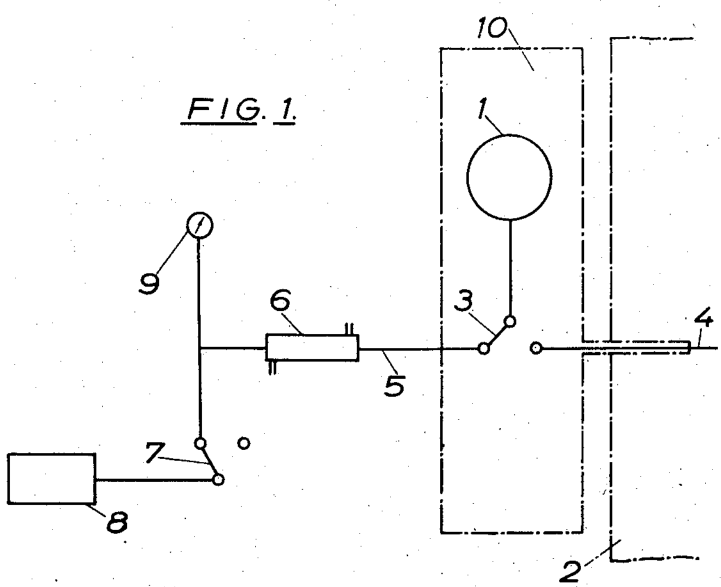


FIG. 4.

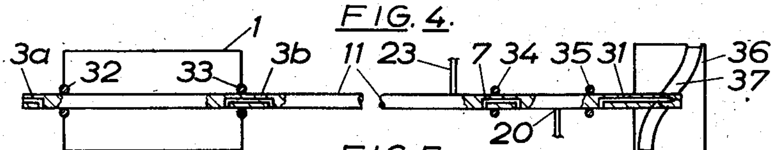


FIG. 5.

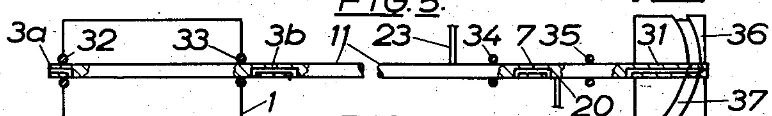


FIG. 6.

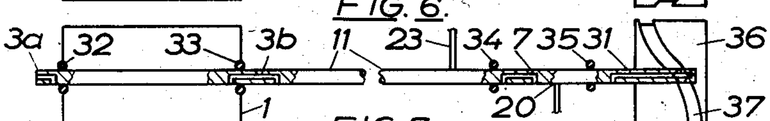
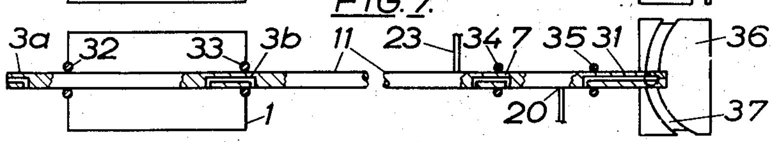


FIG. 7.



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CONTROL OF GASEOUS MEDIA IN MANUFACTURING PROCESSES

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FIG. 2.

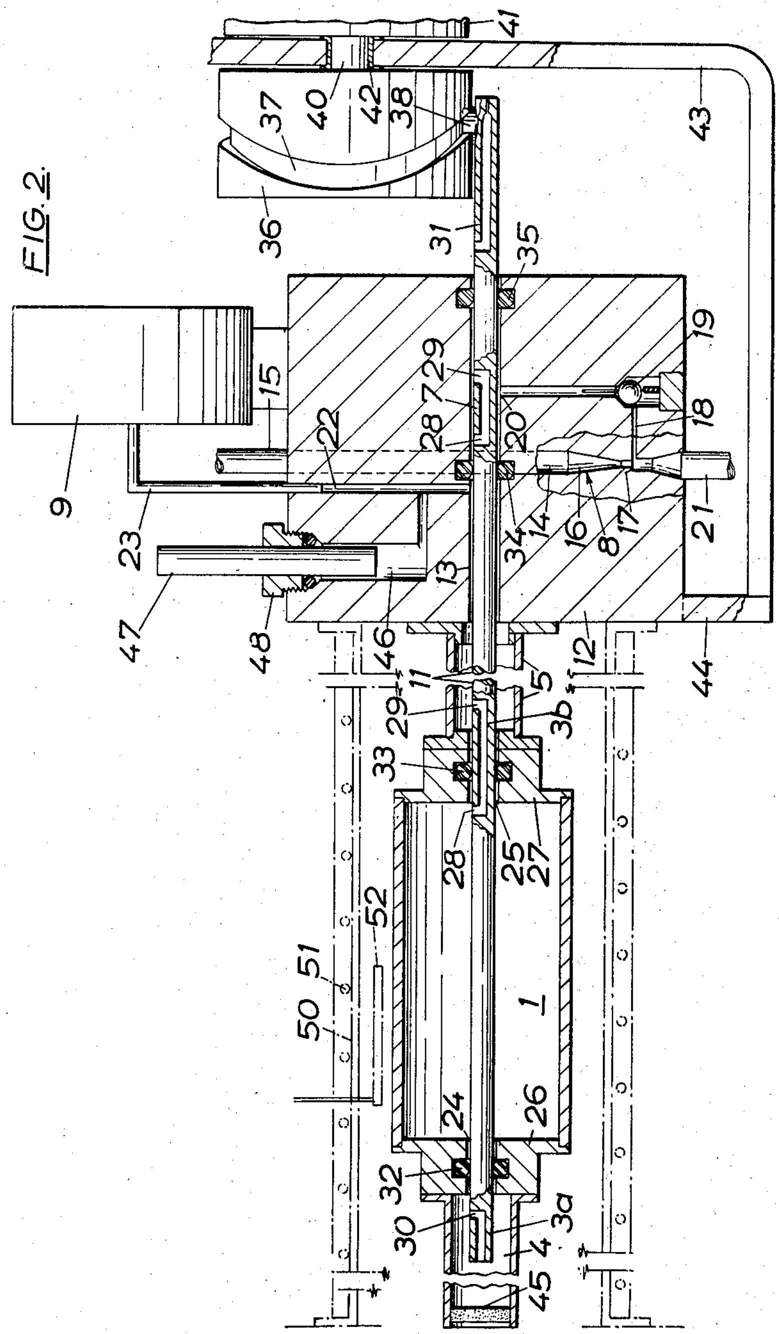

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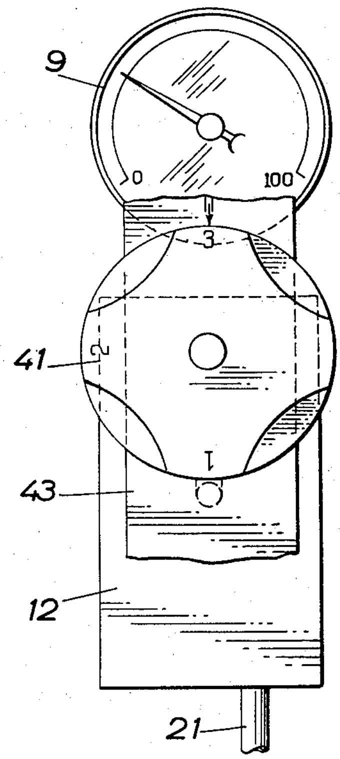
FIG. 3.



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CONTROL OF GASEOUS MEDIA IN MANUFACTURING PROCESSES

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1 Claim. (Cl. 73—29)

The present invention relates to the control of gaseous media in manufacturing processes and in particular to the measurement of the proportions of constituents of a gaseous mixture. The invention is especially applicable for example to the measurement of the proportions of the constituents of a mixture of air and steam or of air and water vapour or of air and conveniently condensable gases.

The expression "measurement" when used herein does not necessarily imply an actual quantitative measurement although this may be achieved fairly accurately by means of the present invention. This term may on the other hand imply a gauging of the proportions of the constituents rather than an actual quantitative measurement in the sense that the invention may be used to check whether a mixture is appropriate for carrying out a particular process without necessarily ascertaining the actual proportions of the constituents.

The term "constituent" when used herein means either a single substance or a mixture of substances all or none of which substances will condense within the range of temperature over which the measurement is carried out.

The term "condensing" when used herein means changing the state of one constituent from vapour to liquid but does not include deliberate reduction in volume nor the use of chemical absorbent or physical adsorbent agents.

The invention is applicable to the improvement or control of manufacturing operations involving the use of mixtures of gases or vapours or involving the use of gases or vapours liable to contamination.

Thus, for example, the invention is applicable to the improvement or control of certain textile printing processes involving the use of steam or to processes for reducing the shrinkability of products containing wool by treatment with a mixture of chlorine and air. Again the invention is applicable to the improvement or control of a process for producing a crease-resisting fabric of improved resistance to abrasion in which the fabric bearing resin forming ingredients is passed through an atmosphere containing superheated steam and in which the best results are achieved when the atmosphere is 100% superheated steam or as near 100% superheated steam as is possible in practice.

One feature of the present invention is a method of measuring the proportions of the constituents of a gaseous mixture which comprises taking a sample of the mixture in a sampling space and condensing one constituent of the mixture so as to give rise to a pressure change in said space without allowing said space to fall in temperature to below that at which condensation occurs.

Another feature of the invention is a method which comprises admitting a sample of the mixture through a sampling connection to a sampling vessel and condensing one constituent thereof so as to give rise to a pressure change in the vessel but without allowing the temperature of the vessel and said connection to fall below that at which condensation occurs.

Another feature of the invention is a method which comprises admitting a sample of the mixture to a confined sampling space and condensing one constituent thereof so as to give rise to a pressure change in said sampling space by connecting said sampling space to a second confined space where the temperature is below the condensing temperature of said constituent and whilst maintaining said sampling space at a temperature not below the condensing temperature of said constituent. The said second confined space is preferably smaller than the sampling space.

A further feature of the invention is a method which comprises evacuating a confined space, admitting a sample of the mixture to the confined space and condensing one constituent thereof so as to give rise to a pressure change therein whilst preventing the temperature of said space from falling below that at which condensation occurs.

A further feature of the invention is a method which comprises evacuating a confined sampling space, admitting a sample of the mixture to the sampling space and condensing one constituent thereof so as to give rise to a pressure change in said space by connecting said space to a confined condensing space where the temperature is below the condensing temperature of said constituent and whilst maintaining said sampling space at a temperature not below the condensing temperature of said constituent.

A still further feature of the invention consists in a method which comprises maintaining a confined sampling space and a confined condensing space at different temperatures of which that of the sampling space is the higher, commonly evacuating said spaces to a standard pressure below atmospheric pressure and then isolating them from one another, admitting a sample of the mixture to the sampling space and then condensing one constituent thereof so as to give rise to a pressure change in the sampling space by connecting the sampling space to the condensing space, the temperature of the sampling space being maintained above and the temperature of the condensing space being maintained below the condensing temperature of said constituent.

Said condensing space is preferably smaller than the sampling space.

A further feature of the invention consists in that the said evacuation is effected by means of a water stream which by heat conduction is also used to effect the condensation of said constituent.

The invention includes the use of the methods herein set forth for controlling or maintaining the proportions of a gaseous mixture or for controlling a manufacturing operation which involves the presence of a gaseous mixture.

An apparatus for use in measuring the proportions of the constituents of a gaseous mixture according to the present invention comprises condensing means and a sampling vessel which is connectable and disconnectable to and from a source of a gaseous mixture and to and from said condensing means and a manometer connected or connectable to the sampling vessel to indicate changes of pressure therein. The apparatus preferably includes valve means adapted automatically to isolate the sampling vessel from the condenser when the sampling vessel is opened to the source of gaseous mixture and vice versa.

It will usually be advisable or necessary to evacuate the apparatus down to a relatively low pressure before admission of a sample of the gaseous mixture thereto and thus a further feature of the invention consists in the provision of an evacuating means, such as a vacuum pump, connectable with the sampling vessel.

The apparatus is preferably provided with a valve means controlling the connection of the sampling vessel with the condensing means and with the evacuating means and with the source of the gaseous mixture which is operable by a common control such that in a first position of the control the sampling vessel is connected to the condensing means and to the evacuating means and isolated from said source and in a second position the sampling vessel is connected to the source and isolated from the condensing means and evacuating means whilst in a third position the sampling vessel is connected to the condensing means but isolated from the evacuating means and from said source.

The manometer is preferably arranged so that it can be connected to the sampling vessel by a valve means which also connects the sampling vessel with the condensing means. Thus the manometer may be connected to the sampling vessel through the condensing means.

An important feature of the invention consists in maintaining the sampling vessel and its connections to the source of gaseous mixture at a temperature above that at which condensation occurs. This may be achieved either by positioning the sampling vessel and its connections to the source of gaseous mixture actually within the source of the gaseous mixture, e. g. within an oven, conditioner or the like or it may be achieved by suitably heating the sampling vessel and its connections to the source of the gaseous mixture so as to keep them at a temperature above that at which condensation occurs. Thus the sampling vessel and its connections to the source of gaseous mixture may be suitably enclosed and/or lagged, for example by glass wool, and/or provided with a suitable heating means such as an electrical heating means.

If the manometer is permanently connected to the sampling vessel then similar arrangements must be made to maintain the temperature of the manometer and its connection to the sampling vessel above that at which condensation occurs. If however, the manometer can be isolated from the sampling vessel then this safeguard is not necessary.

A preferred form of evacuating means consists of a jet pump operated by water or other liquid and comprising a body having a passage therethrough which abruptly enlarges in cross sectional area or diameter and having a suction duct or opening leading into the enlarged passage adjacent to the place at which the cross-section or diameter is abruptly enlarged. In other words the jet pump consists of a body having a passage with a step at which the passage enlarged and with a suction duct or opening entering the enlarged passage close to the step. Thus the jet pump can be of simple and inexpensive construction and can consist of a single block of metal or other material suitably drilled.

The body of the jet pump may be cooled by the flow of liquid therethrough and may be formed so as to serve also as the condensing means. Thus the body of the jet pump may be formed of metal and may have an opening or passage therein which is connectable to the sampling vessel and adapted to serve as a condensing means.

A preferred form of valve arrangement for use in the apparatus of the present invention is one in which a valve element of substantially constant cross section over at least a portion of its length, and preferably of rod-like form, is longitudinally displaceable within a duct or passage and is surrounded by a resilient annular seal lying between the duct or passage and the valve element which latter has longitudinally spaced interconnected ports or openings therein at least one of which, by longitudinal displacement of the valve element relatively to the duct and seal, may lie on one or other side of the seal to close or open the valve.

In the preferred form of construction of the invention a single valve rod is formed with three such valve elements to control respectively the connection of the sampling vessel to the source of the gaseous mixture, the connection of the sampling vessel to the condensing means and the connection of the evacuating means to the condensing means. Said rod may be formed with a further valve element through which the apparatus can be connected to the atmosphere whilst remaining isolated from the source of the gaseous mixture.

The invention is further described with reference to the accompanying drawings in which:

Fig. 1 is a diagrammatic view of an apparatus according to the present invention in which the sampling vessel is not located within the source of the gaseous mixture.

Fig. 2 is a longitudinal sectional side view of a preferred form of apparatus according to the invention.

Fig. 3 is a front view corresponding to Fig. 2.

Figs. 4, 5, 6 and 7 are diagrammatic views illustrating the valve means of Fig. 2 in different positions.

In the arrangement diagrammatically shown in Fig. 1 a sampling vessel **1** can be connected through a two-way valve **3** either to a pipe **4** leading into a source **2** of gaseous mixture, e. g. an oven, or to a pipe **5** which passes through a condenser **6**. The pipe **5** continues through the condenser to a valve **7** which either seals the end of the pipe **5** or connects it to an evacuating means **8** such as an extraction pump. A manometer **9** is connected to the pipe **5** on that side of the condenser remote from the sampling vessel.

It is often desirable that the volume of the sampling vessel be very small compared with that of the source of the mixture so that sampling shall have little effect on the source. It is also desirable that the volume of the condensing system should be small compared with that of the sampling vessel. Likewise it is desirable to choose a manometer of low internal volume.

It is desirable that the sampling vessel and its connections to the source of the gaseous mixture should be maintained substantially at the temperature of the source of the gaseous mixture or at least not below the condensing temperature of the condensable constituent of the gaseous mixture. For this purpose the sampling vessel **1**, valve **3** and the pipe **4** might have been arranged within the source **2** of the gaseous mixture, but that is not always a convenient arrangement and thus in Fig. 1 the sampling vessel, the valve **3** and portion of the pipe **4** are enclosed by a housing or casing **10** which is suitably lagged and heated in order to keep the temperature of the sampling vessel **1**, valve **3** and pipe **4** substantially equal to that of the source of the gaseous mixture.

The apparatus illustrated in Figs. 2 and 3 includes a sampling vessel **1** which can be connected at its lefthand end to a source of the gaseous mixture through a tubular sampling connection **4** and it is connected at its right-hand end by a tubular connection **5** with a metal block **12** through which is formed a passage **13** coaxial with the tubular connection **5** and with openings or ducts **24**, **25** in the ends **26**, **27** of the sampling vessel **1**. The metal block is formed with passages therein constituting a jet pump generally indicated by the reference numeral **8** and comprising a passage **14** connected to a water supply through an external pipe connection **15** and which narrows downwardly at **16** and is then abruptly increased in diameter or cross-sectional area by means of a step **17**. A suction duct or opening **18** enters the passage **14** at or just below the step **17** where it increases in diameter. The suction duct **18** is connected through a non-return valve **19** to an evacuating opening **20** in the passage **13**. The jet pump **8** discharges through an external pipe connection **21**. The block **12** has a passage **22** therein which opens into the passage **13** and is connected through an external pipe connection **23** with a manometer **9**.

Since the block **12** is cooled by the water flowing through the jet pump **8** formed therein and since the passage **13** therein is connected by the tubular connection 5 with the sampling vessel 1, the block 12 serves as a condenser for the sampling vessel.

A valve rod 11 extends through the passage 13 of the block 12 and through the openings or ducts 24, 25 in the ends 26, 27 of the sampling vessel 1. The rod 11 embodies three valve elements which are referenced 3*a*, 3*b* and 7 of which the valve elements 3*a* and 3*b* perform the function of the valve 3 shown in Fig. 1 and the valve element 7 performs the function of the valve 7 shown in Fig. 1. The valve elements 3*b* and 7 have longitudinally spaced interconnected ports 28, 29 whilst the valve element 3*a* has a port 30 which is longitudinally connected to the lefthand end of the rod 11. A further valve element 31 is formed in the righthand end of the rod 11. The valve elements 3*a* and 3*b* are movable relatively to resilient annular seals 32, 33 housed in annular grooves formed in the ducts or openings 24, 25 in the end walls of the sampling vessel 1. The valve elements 7 and 31 are movable relatively to resilient annular seals 34, 35 housed in annular grooves formed in the passage 13 in the block 12 and located on opposite sides of the evacuating opening 20.

The valve rod 11 is longitudinally displaced by means of a cam 36 having a cam groove 37 formed therein which is engaged by a pin 38 at the righthand end of the valve rod 11. The cam 36 is connected through a stub shaft 40 with a control knob 41, the stub-shaft 40 being journalled in a bearing 42 formed in a bracket 43 extending from a supporting lug 44 on the metal block 12 and through which the metal block 12 and the cam 36 and knob 41 may be supported from any suitable structure.

The sampling connection 4 is provided at its lefthand with a filter element 45.

The metal block 12 has a bore 46 therein communicating with the passage 22 which is connected to the manometer 9. The bore 46 receives a plunger 47 which is sealed by a gland 48. By endwise displacement of the plunger 47 the total volume of the condenser and its connections to the manometer and to the sampling vessel can be adjusted in relation to the volume of the sampling vessel. Thus adjustment is useful in the calibration of the manometer 9.

In using the apparatus of Fig. 2 the first step is to isolate the sampling vessel from the tubular connection 4, i. e. from the source of the gaseous mixture, whilst at the same time connecting it with the jet pump 8 and with the condensing system of the metal block 12 and which may be regarded as the passage 22 and that part of the passage 13 lying to the left of the annular sealing ring 34. This can be achieved by rotating the knob 41 to bring the valve rod 11 into the position shown in Fig. 4 when the valve elements 3*b* and 7 are open and the valve element 3*a* is closed. With the valve rod 11 in the position shown in Fig. 4 the sampling vessel 1 and the condensing system will be evacuated.

The second step is to disconnect the sampling vessel 1 from the pump 8 and from the condensing system and to connect it with the source of the gaseous mixture through the tubular connection 4. This can be achieved by rotating the control knob 41 to bring the valve rod 11 into a position shown in Fig. 5 when the valve element 3*a* is open and the valve elements 3*b* and 7 are closed, since both of their longitudinally interconnected ports lie to one side of the resilient annular seals 33, 34. With the valve rod 11 in the position shown in Fig. 5 a sample of the gaseous mixture will be drawn into the sampling vessel 1.

The third step is to disconnect the sampling vessel 1 from the source of the gaseous mixture and to connect it to the condensing system of the metal block 12 whereby to condense the sample whilst isolating the condensing system from the jet pump 8. This is achieved by rotating the control knob 41 to bring the valve rod 11 into the position shown in Fig. 6 in which the valve elements 3*a* and 7 are closed and the valve element 3*b* is open with its longitudinally interconnected ports 28, 29 lying on opposite sides of the resilient annular seal 33.

The proportions of the gaseous mixture will then be indicated by the manometer 9.

At the end of a series of tests the internal pressure within the apparatus can be brought up to atmosphere pressure by moving the valve rod 11 to the position shown in Fig. 7 in which the atmospheric valve element 31 and the valve elements 3*b* and 7 are open and the valve element 3*a* closed.

The cam groove 37 in the cam 36 is formed so that the valve rod 11 can be moved successively into the positions shown in Figs. 4, 5, 6 and 7 by unidirectional movement of the control knob 41.

The advantage of keeping the sampling vessel and its connections at a temperature not below the condensation temperature enables samples of the gaseous mixture to be tested as frequently as may be desirable and without any time interval which would otherwise be required for reheating the sampling vessel after condensation has taken place.

The apparatus of Figs. 2 and 3 as so far described is suitable for use when the sampling vessel and its tubular connection 4 are to be inserted into the source of the gaseous mixture. If, however, the sampling vessel 1 and the connection 4 are not to be inserted into the source of the gaseous mixture then they will be provided with an enclosure and/or lagging diagrammatically indicated by the broken lines 50 and with an electrical heating means such as a spiral element diagrammatically indicated at 51 wound around the enclosure 50, lagged and controlled in part by a thermostatic element 52.

Preferably the manometer 9 is not one which measures pressures on the absolute scale but is of the type which indicates differences from atmospheric pressure i. e. an open manometer. If it is a Bourden gauge the usual unsealed case is suitable.

It is preferable to evacuate the sampling vessel 1 by means of the jet pump 8 to a convenient standard vacuum figure e. g. 27 inches of mercury below atmospheric pressure.

The use of a standard vacuum figure of the order of 27 inches yields the advantage of rendering the calibration of the manometer or vacuum gauge virtually independent of variations of atmospheric pressure.

The manometer is preferably calibrated, for steam/air or other mixtures, on the assumptions of virtually constant volumes of sampling and condensing systems, virtually constant sampling temperature and condensing temperature and the presence in the condensing system of a free liquid surface of the condensable constituent.

For example when measuring the proportions of the constituents of a mixture of steam and air, using a standard vacuum figure and knowing the volumes of the sampling system (i. e. of the sampling vessel 1 up to the valve element 3*b*) and of the condensing system lying between the valve elements 3*b* and 7 and including the manometer 9 and knowing the temperature of the sampling system and of the condensing system it is possible to calculate the reading of the gauge after a sample of air containing no steam has been admitted to the sampling vessel and the sampling vessel has been connected to the condensing system. When a sample containing 100% of steam is so condensed after admission to the sampling vessel, then if, as is preferred, the temperatures of both sampling and condensing systems remain constant then the pressure will remain constant at the standard vacuum figure, e. g. 27 inches.

Having calculated as indicated above the gauge reading which corresponds to 0% steam, the graduation of the scale between the readings corresponding to 0% and 100% steam can be made since the scale between these points is linear.

The manometer may be associated with any suitable recording device for providing a permanent record or may be adapted to perform a controlling operation in dependence upon its own readings.

In carrying out this invention, known equivalents may be used for the particular pumps, manometers etc. herein described by way of example.

We claim:

An apparatus for use in measuring the proportions of the constituents of a mixture of steam and air including a sampling vessel, a manometer for indicating changes of pressure in the sampling vessel, means for maintaining the sampling vessel at a temperature above the condensation temperature of the steam, a jet pump comprising a body defining a passage therethrough, which passage abruptly enlarges in cross-sectional area or diameter, a suction duct communicating with the enlarged passage adjacent to the position at which the enlargement occurs,

said body defining a further passage enabling it to serve as condensing means, and valve means for connecting the sampling vessel to the source of said mixture and to said condensing means, and further valve means for connecting said jet pump to said sampling vessel and said condensing means.

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