Dec. 8, 1942. R. A. FAIRBAIRN 2,304,731

METHOD OF DETERMINING THE DENSITY AND SHRINKAGE OF THE WOOL IN A BALE OF WOOL

Filed Feb. 6, 1940 2 Sheets-Sheet 1

Fig.1.

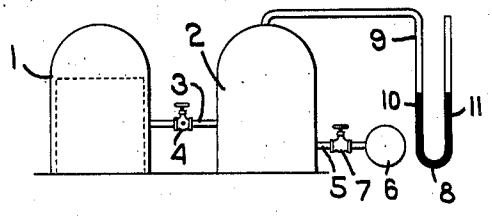


Fig.2.

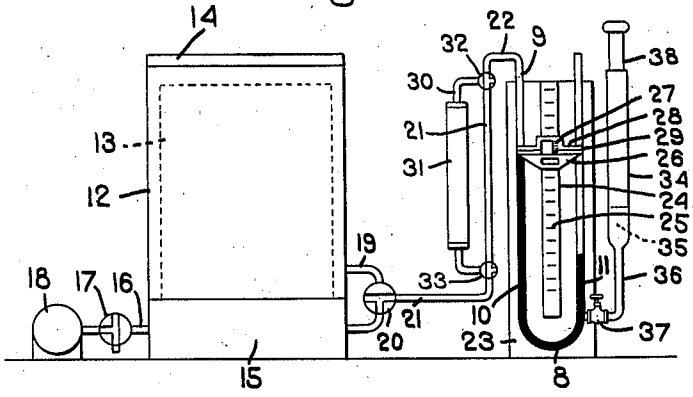
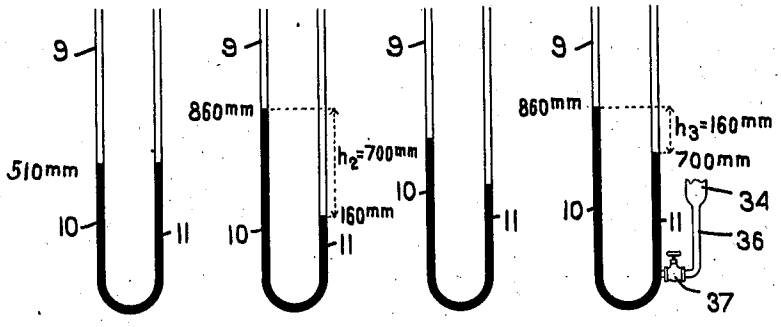


Fig.3. Fig.4. Fig.5. Fig.6.



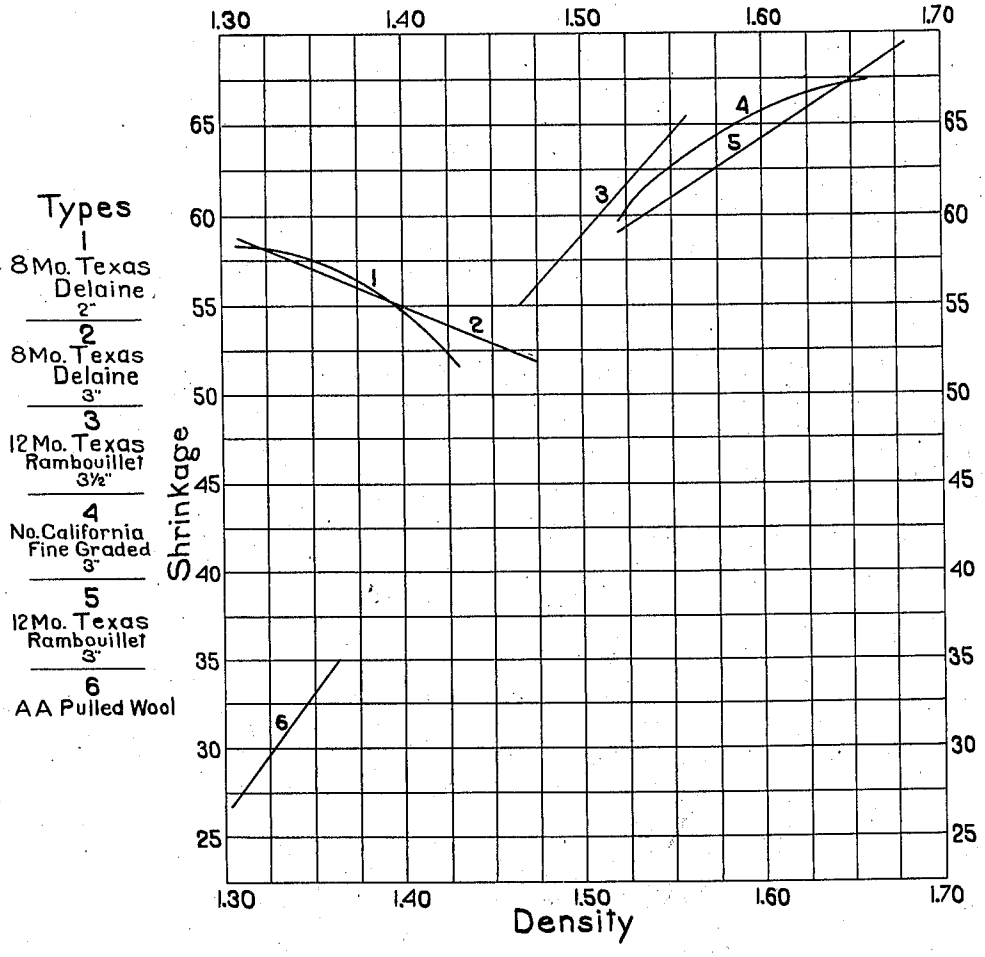
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METHOD OF DETERMINING THE DENSITY AND SHRINKAGE OF THE WOOL IN A BALE OF WOOL

Filed Feb. 6, 1940 2 Sheets-Sheet 2

Fig. 7.



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2,304,731

METHOD OF DETERMINING THE DENSITY AND SHRINKAGE OF THE WOOL IN A BALE OF WOOL

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Application February 6, 1940, Serial No. 317,475

5 Claims. (Cl. 73—51)

This invention relates to a method for investigating and accurately determining the shrinkage of the wool contained in a bale of raw or grease wool without disturbing the contents of the bale in order that the yield of the wool may be quickly and accurately estimated.

The term "shrinkage" as used in the wool trade refers, in per cent, to the amount of grease, suint, dirt and any other contamination present in a given lot of raw wool. The term "yield" refers, in terms of percentage, to the amount of clean wool left after the contamination has been removed from the raw wool. Obviously 100% less the per cent of shrinkage equals the yield.

It is the usual custom of buyers of wool in the United States to base the value of the wool upon its shrinkage rather than its yield and the present invention is described with reference to this practice although the yield of wool may be readily determined when the shrinkage is known.

It is usual for wool buyers who have had long experience in the business to estimate the value of wool submitted to them by carefully examining the wool and therefrom estimating the shrinkage and the actual cost of the clean wool after it has been scoured and otherwise treated to de-grease the wool and to remove dirt and other foreign matter therefrom. Inasmuch as different fleeces and even different parts of the same fleece vary in shrinkage, it is difficult thus to estimate the real value of the wool and the price which can be reasonably paid to the wool grower. For example, the grower is asking 30¢ per pound for raw wool in the grease. The buyer estimates the shrinkage at 62% and figures the clean cost of the wool at 78.9¢ per pound according to the formula that clean cost equals grease cost divided by the yield. If, however, the actual shrinkage is 64%, the clean cost will be approximately 83.4¢ or 5.7% more than 78.9¢. In other words, an error of 2% on this shrinkage makes a difference of 5.7% in the cost of clean wool which in many instances exceeds the expected net profit. Obviously a careful buyer will endeavour so to estimate the value of wool as to avoid possibility of such loss and the price offered to the grower will be less than the full value of his wool. It is the purpose of the present invention to provide a method by which the shrinkage of the wool may be accurately ascertained so that the price offered to and received by the grower will be fair and therefore advantageous to both.

Numerous attempts have been made to provide methods and means for determining more accurately the shrinkage of wool but in all such cases, so far as I am aware, such methods have been applied only to small samples, such, for example, as ten pounds or less of raw wool. Very few types of wool lend themselves to a reliable sampling procedure in view of the variation of shrinkage of different fleeces or different parts of the same fleece. Furthermore, assuming that an accurate sample could be obtained, the scouring of such sample, as for example ten pounds of wool, under controlled conditions, without the loss of small pieces, and then determining the average moisture content, necessitates such accuracy and consumes so much time as practically to preclude its use under competitive buying conditions.

One of the objects of the present invention is to provide a method by which the actual volume of a large quantity of material, such as a bale of wool, may be quickly determined and by which from the known weight of the bale the density thereof can be accurately determined while the wool is still in the bale and without modification from its original state and condition.

A further object of the invention is to provide a method for determining accurately the shrinkage of the wool by comparison of the density of the particular type of wool with a standard table or graph giving the density and shrinkage of wool of substantially the same type.

The method of determining the volume of a bale of raw wool, comprises broadly placing the wool or other material in the main of two hermetically sealable communicable chambers, each of known volume, initially maintained at the same gaseous fluid pressure, either atmospheric or such other pressure as may be desired, and at a uniform temperature, measuring the atmospheric or initial pressure, partially evacuating the fluid from the supplementary chamber only, then measuring the fluid pressure of such chamber, thereafter transferring a sufficient amount of the fluid from the main chamber to the supplementary chamber to establish a balanced pressure in said chambers, measuring said balanced pressure, and computing by Boyle's law from the ratio of pressures the volume of fluid in the main, wool-containing, chamber, then by deducting this volume from the known volume of the main chamber obtaining the actual volume of the mass of wool or other material therein.

By the further step of dividing the known weight of the bale of wool or other mass of material by the volume thus computed the density

of the wool or other material may be readily determined.

When the density of a given type of wool has thus been determined the shrinkage thereof can readily be estimated by comparison with the data of a standard table or graph upon which the densities and shrinkages for different types of wool or other material are given and the value of the particular wool fairly estimated.

Suitable illustrative apparatus for performing the method is shown in the accompanying drawings, in which,

Fig. 1 is a diagrammatic illustration of the manner in which the formula of the method which is based on Boyle's law may be determined;

Fig. 2 is a view of an illustrative form of commercial apparatus adapted to be used in the warehouse or in the field in accordance with my invention, and comprises an hermetically sealed main chamber superimposed upon an hermetically sealed supplementary chamber, with means for exhausting gaseous fluid from the supplementary chamber, a conduit connecting the main and supplementary chambers provided with a valve operable to establish communication between said chambers or with the supplementary chamber alone, and a manometer which, for purpose of clearness, is greatly exaggerated, communicating with said conduit;

Figs. 3, 4, 5 and 6, are detail views illustrative of the mercury columns of the manometer at levels illustrative of the different fluid pressures hereinafter described; and,

Fig. 7 illustrates a graph having the density of the wool as abscissae and shrinkage of the wool as ordinates with lines plotted thereon from standard tables or tests of wools of different types from which the shrinkage of wool of any type having a determined density may be accurately and speedily read.

Referring first to the diagrammatic illustration in Fig. 1, the apparatus comprises a main chamber 1, such as a bell jar, to receive a mass of the material, and which otherwise is filled with the gaseous fluid such as air, a supplementary chamber 2, which likewise may be a bell jar of equal or different size, which is filled only with gaseous fluid, a conduit 3 provided with a suitable valve 4 adapted when in one position to establish communication between the containers or when in another position to establish communication between the atmosphere and said containers, a conduit 5 leading to a suitable pump 6 and having in advance of said pump a valve 7 and means, such as a mercury manometer 8 one of the tubes 9 of which communicates with the supplementary chamber.

In accordance with the laws of Boyle and Gay-Lussac $PV=nRT$ in which P represents the pressure in millimeters of mercury, V the volume, n the number of moles or units, R constant depending upon the character of the gaseous fluid, and T the temperature. Using subscript numerals to represent the respective containers: V_1 equals the volume of fluid in the chamber of the container 1 which is not displaced by the mass of material therein; V_2 equals the volume of fluid in the chamber of the container 2; and P_1, P_2 represent the initial pressures in millimeters of mercury in the respective chambers.

$$n_1=\frac{P_1V_1}{RT};\quad n_2=\frac{P_2V_2}{RT}$$

When the valve 4 is opened to establish communication between the chambers 1 and 2, the resultant pressure which may be designated P_3 provides the following formula:

$$P_3(V_1+V_2)=\frac{P_1V_1+P_2V_2}{RT}\times RT$$

Reducing this formula

$$V_1=\frac{P_1V_1+P_2V_2}{P_3}-V_2$$

or

$$P_3V_1=P_1V_1+P_2V_2-P_3V_2$$

Consequently,

$$(P_3-P_1)V_1=P_2V_2-P_3V_2$$

or

$$V_1=\frac{P_2-P_3}{P_3-P_1}V_2$$

Assuming that P_1 represents atmospheric pressure in millimeters of mercury and that h equals the height of the mercury column of a manometer measuring the degree of vacuum then when the valve 4 in the conduit, connecting the containers 1 and 2 has been closed, the pump actuated to produce a desired degree of vacuum and the valve 7 between the container 2 and the pump 6 closed, the pressure P_2 in the container $2=P_1-h_2$ in millimeters of mercury. When this reading has been taken and the valve 4 opened to establish communication between the containers 1 and 2 the mercury will drop so that $P_3=P_1-h_3$. Substituting these values of P_2 and P_3 in the last equation

$$V_1=\frac{P_1-h_2-P_1+h_3}{P_1-h_3-P_1}V_2$$

Cancelling the common factors of this equation

$$V_1=\frac{h_2-h_3}{h_3}V_2$$

By this equation the volume V_1 is measured in terms of V_2 by a ratio of pressures. It is therefore not necessary to correct for outside changes in temperature and atmospheric pressure so long as they remain constant during the test which in practice will last not more than ten or fifteen minutes.

Referring to Figs. 3, 4, and 5, as an illustrative example, the mercury is introduced into the open end of the column 11 of the manometer until the column of mercury therein is balanced, so that the meniscus of the mercury in each column is at the same level at 510 mm. as illustrated in Fig. 3.

If then the chamber 2 is evacuated until the left hand column 10 of mercury rises 350 mm. to 860 mm., as illustrated in Fig. 4, the right hand column 11 of mercury will descend 350 mm. to a height of 160 mm. In such case h_2 will equal 700 mm.

When the valve 4 is opened air will flow from the chamber of the container 1 to that of the container 2 and the mercury in the left hand column 10 will drop and the mercury in the right hand column 11 will correspondingly rise as illustrated in Fig. 5. If then a sufficient amount of mercury is added to the manometer to raise the column of mercury in the left hand column 10 to the level of 860 mm. to guard against error induced by a change in the volume of the system brought about by the drop of the mercury column, as shown in Fig. 5, the right hand column 11 of mercury will stand at a level, for example of 700 mm. so that h_3 will equal 160 mm.

Consequently $h_2-h_3=700-160$ or 540. Substituting these values in the last equation

$$V_1=\frac{540}{160}\times V_2$$

Inasmuch therefore as V_2 is a known volume, the volume of air V_1 in the main chamber may be readily computed when this volume thus computed is subtracted from the known total volume of the container 1 the actual volume of the bale of wool, or other material, is ascertained.

Inasmuch as the weight and volume of the bands and burlap on the bale of wool can be computed with accuracy, since they vary little from bale to bale, one measurement for each type of wool or other material is all that is necessary and by subtracting the weight of the bands and burlap from the total weight of the bale and subtracting the volume of the bands and burlap from the total volume of the bound bale the actual weight and volume of the wool itself may be accurately determined.

By dividing the weight thus ascertained by the volume, the weight per unit volume or density of the wool may be quickly and readily established.

When the density of a given type and condition of wool is thus determined by the process aforesaid, comparison may be made with the table or graph prepared from standard tabulated data of the densities and shrinkages of different types and conditions of wool previously determined by accurate tests.

A suitable illustrative apparatus for performing the process above described upon a large scale, and which may be used in the warehouse or in the field, is illustrated in Fig. 2 of the drawings. This apparatus comprises a main container 12 having a chamber of suitable size to receive a bag or a bale of wool provided with a removable hermetically sealable cover 14. The main container 12 desirably is superimposed upon a relatively smaller hermetically sealed second container 15 having a chamber from which the conduit 16 leads through a three-way valve 17 to a suitable air pump 18, or other means of sufficient capacity properly to evacuate the container 15. A conduit 19, which leads from the main container 12 to the chamber of the second container 15, is provided with a three-way valve 20 adapted selectively to establish communication between the chamber of the main container 12 and that of the second container 15. This valve is also adapted to establish communication between the chamber of the container 15 and a pipe 21 leading through a loop 22 to the vertical left hand branch 9 of the U-shaped tube of the manometer.

Desirably the U-shaped mercury containing tube of the manometer is mounted upon a suitable vertical stand 23 having secured to it a vertical guideway 24, preferably of Invar steel which has an extremely low and negligible coefficient of expansion, and which is provided with a scale 25 having suitable horizontal graduations in millimeters.

A slide 26, which is mounted upon the guideway 24 and extends across the tubes containing the mercury columns 10 and 11, desirably is provided with a vernier 27 graduated in tenths of millimeters which in conjunction with the scale will enable the height of the mercury columns to be accurately read.

The slide 26 also desirably has secured to it a narrow glass plate 28 extending above and below the horizontal edge of the slide and provided with a hair line 29 so that by sighting along the straight upper edge of the slide and the hair line an index is provided whereby the height of the column of mercury at the top of its meniscus may be accurately observed, thereby avoiding any error which might be due to parallax in the observance of the height of the mercury column.

In order further to insure accuracy in the operation of the manometer a pipe 21 is provided with a by-pass 30 having a tubular chamber 31 containing a suitable dehydrating agent, suitable valves 32 and 33 being provided to control the passage of the fluid either directly through the tube 21 to the tube 9 of the manometer or through the by-pass and dehydrator. In normal operation the valves 32 and 33 are so set that when the container 15 or the containers 12 and 15 are evacuated air will be caused to flow from the manometer downwardly through the tube 21 and the manometer read. When thereafter air is to be admitted to the chambers, the valves 32 and 33 will be adjusted to permit air to flow through the by-pass 30 and dehydrator 31 so that as the column of mercury 10 drops any moisture in the air passing into the pipe 9 which contains the mercury column 10 will be extracted, thereby avoiding any error which might otherwise occur in the accurate reading of the manometer in the next test.

Suitable means may be provided for supplying adidtional mercury to the manometer. As illustrated herein a vertical tube 34 forming a reservoir containing a body of mercury 35 communicates at its lower end through a pipe 36 and valve 37 preferably with the lower right hand column 11 of mercury. Suitable means, such as a piston 38 reciprocably mounted in the tube 34 is adapted to be depressed to force the mercury from the reservoir into the columns 10 and 11, thereby to raise the left hand column 10 of mercury to the height of the column produced when the chamber of the casing 15 is evacuated, thereby further to compensate against any error produced by change in the volume of the system brought about by the drop in the mercury column 10 when the chamber 15 is in communication with the chamber 12 to determine the balanced pressures in the containers 12 and 15.

In the preferred operation of the device shown in Fig. 2, assuming that the test is to be made with the fluid in both containers 14 and 15 initially at atmospheric pressure, the cover 14 is removed, the bale of wool 13, after having been weighed, is placed in the main container, and the cover closed and hermetically sealed. The slide 26 of the manometer is then adjusted to insure that both columns of mercury are at an equal height, it being understood that the valves 17 and 20 are so adjusted as to permit air to flow into the second container 15 and through the conduit 19 into the main container 12 and through the pipe 21 into the pipe 9 of the manometer, the chambers of both containers being at atmospheric pressures as indicated by the manometer.

The valve 17 is then adjusted to establish communication between the vacuum pump 18 and the second container 15 and the valve 20 so set as to establish communication between the container 15 and the manometer.

The pump is then actuated to evacuate the container 15 to a desired degree and the valve 17 closed. The slide 26 is then raised so that the

hair line index 29 is exactly at the top of the meniscus of the mercury column 10. The height of the mercury in said column is then read and noted and the slide moved downwardly similarly to measure the height of the mercury in the column 11. The number of millimeters corresponding to the difference in the height of the two columns 10 and 11 represents the degree of vacuum or pressure in the container 15.

The valve 20 is then rotated to establish communication with the conduit 19 between the containers 12 and 15 and with the pipe 21 leading to the manometer.

By reason of the drop in pressure caused by the transfer of air from the container 12 to the container 15, the column of mercury 10 will drop and the column of mercury 11 will rise, as illustrated in Fig. 5. In order to guard against error induced by change in the volume of the system brought about by the drop in the mercury column under such conditions the piston 38 is forced downwardly in the tube 34, thus forcing mercury into the manometer until the level of mercury in the column 10 is level with the index 29 set at the same level as the top of the mercury column was when the air was previously exhausted from the container 15 only and the difference in the height of the columns 10 and 11 then read as before thereby determining h_3 in millimeters.

From the known volume of the second container 15, and the values of h_2 and h_3 the portion of the volume of the wool containing chamber 15 not occupied by the wool may be accurately determined by Boyle's law as above described and by subtracting such volume from the known volume of the container 12 the actual volume of wool in the container 12 may be computed.

Since the weight of the bale of wool has been previously determined the density of the wool may be computed as above described by dividing the weight of the wool by its volume. Thus the average density of the wool of an entire bale can be accurately determined and such density may be compared with a suitable standard table or graph prepared from tabulated data of the densities and shrinkages of different types of wool previously determined by accurate tests as aforesaid. Thus the shrinkage of the particular type of wool having the determined density may be speedily and accurately ascertained.

An illustrative graph suitable for the purpose is shown in Fig. 7. In this graph the abscissae represents the densities of wool and the ordinates the percentage of shrinkage and the lines upon the graph designated by the numerals 1, 2, 3, 4, 5, and 6, are plotted from accurate tests carefully made to show the relative densities and percentage of shrinkage of wool of each particular type and condition. When therefore the density of a given bale of wool is determined the intersection of a vertical line from the abscissae, representing such density, and the line upon the graph for that particular type of wool will be horizontally opposite the percentage of shrinkage of the given type of wool. When therefore the density of the particular type of wool has been determined its shrinkage can be immediately read from the graph without the necessity of laborious computation.

It is therefore obvious that by the present invention the shrinkage of wool of any usual type may be much more rapidly and accurately determined than by any of the methods now known or employed as the densities of the wool thus determined relate to the entire bale and avoids such errors as might occur by estimates made by the wool buyer or by sampling and testing a relatively small amount of wool taken from the bale or bag and determining the shrinkage thereof by laborious and complicated laboratory tests such as at present are employed.

For simplicity in the practice of my method it has been described with respect to tests made of a bale or mass of wool or other material when the initial pressure in the main and second containers is atmospheric pressure. It will be understood, however, that other initial pressures may be employed in either or both of the containers and the same result obtained by more complicated computation from Boyle's law. It is therefore to be understood that the particular description of the method is not restrictive of the scope of the following claims.

Having thus described the invention, what is claimed as new, and desired to be secured by Letters Patent, is:

1. The method of determining the density of the wool contained in a bale of raw wool without disturbing the contents of the bale which comprises weighing said bale, placing the same in one of two hermetically sealed communicable chambers maintained at the same temperature, each of known volume and initially at atmospheric pressure, partially evacuating the second chamber only and measuring the fluid pressure therein, transferring said fluid from the wool-containing chamber to the second chamber in amount sufficient to establish a balanced pressure in said chambers, measuring said balanced pressure, computing by Boyle's law from the known volume of the second chamber, and the atmospheric and measured pressures the portion of the volume of the wool-containing chamber not occupied by the wool, deducting said portion from the known volume of the wool-containing chamber, thereby determining the volume of the mass of raw wool, and dividing the weight of said wool by its volume thereby determining the average density of all the raw wool of the bale.

2. The method of determining the percentage of shrinkage of raw wool of a particular type while in a bale, without disturbing the contents of the bale which comprises weighing said bale, placing the same in one of two hermetically sealed communicable chambers maintained at the same temperature, each of known volume and at the same initial atmospheric pressure, partially evacuating the second chamber only and measuring the fluid pressure therein, transferring air from the wool-containing chamber to the second chamber in amount sufficient to establish a balanced pressure in said chambers, accurately measuring said balanced pressure, computing by Boyle's law from the known volume of the second chamber and the initial atmospheric and measured pressures, the portion of the volume of the wool containing chamber not occupied by the wool, deducting said portion from the known volume of the wool-containing chamber, thereby determining the volume of the mass of wool and dividing the weight of said raw wool by its volume to determine the average density of all the wool of the bale and then comparing said average density with standard data of density and shrinkage which has been previously determined for raw wool of the same type.

3. The method of quickly and accurately determining the percentage of shrinkage of raw wool of a particular type while in a bale, without disturbing the contents of the

bale which comprises weighing said bale, placing the same in one of two hermetically sealed communicable chambers maintained at the same temperature, each of known volume and at the same initial atmospheric pressure, partially evacuating the second chamber only and measuring the fluid pressure therein, transferring said fluid from the wool-containing chamber to the second chamber in amount sufficient to establish a balanced pressure in said chambers, accurately measuring said balanced pressure, computing by Boyle's law from the known volume of the second chamber and the initial atmospheric and measured pressures, the portion of the volume of the wool containing chamber not occupied by the wool, deducting said portion from the known volume of the wool-containing chamber, thereby determining the volume of the mass of wool and by dividing the weight of said raw wool by its volume determining the average density of all the wool of the bale, comparing the density with standard data of density and shrinkage which has been previously accurately determined for raw wool of the same type, and obtaining the shrinkage from a graph having abscissae and ordinates respectively of densities and shrinkage and lines plotted thereon representing standard densities and shrinkages of raw wool of the same type.

4. The method of determining the shrinkage of raw wool of a particular type while in the bale, without disturbing the contents of the bale, which comprises weighing the bale, placing the bale in a main hermetically sealable chamber of known volume communicable with a supplementary chamber of known volume both of which are subject to the same temperature and the same initial gaseous fluid pressure, measuring said fluid pressure, varying the pressure in the supplemental chamber and measuring said varied pressure, transferring gaseous fluid from the main chamber to the supplemental chamber in amount sufficient to establish equal pressure in both chambers, measuring such equalized pressure, computing by Boyle's law from said known temperature and the respective measured pressures the portion of the volume of the main chamber not occupied by the raw wool of the bale, deducting said portion from the known volume of the main chamber thereby determining accurately the volume of raw wool of the bale, dividing the weight of said raw wool by its volume to determine the average density of all of the wool of the bale, and then comparing said average density with standard data of density and shrinkage which has been previously determined from raw wool of the same type.

5. The method of determining the shrinkage of raw wool of a particular type while in the bale, without disturbing the contents of the bale, which comprises weighing the bale, placing the bale in a main hermetically sealable chamber of known volume communicable with a supplementary chamber of known volume both of which are subject to the same temperature and the same initial gaseous fluid pressure, measuring said fluid pressure, varying the pressure in the supplemental chamber and measuring said varied pressure, transferring gaseous fluid from the main chamber to the supplemental chamber in amount sufficient to establish equal pressure in both chambers, measuring such equalized pressure, computing by Boyle's law from said known temperature and the respective measured pressures the portion of the volume of the main chamber not occupied by the raw wool of the bale, deducting said portion from the known volume of the main chamber thereby determining accurately the volume of raw wool of the bale, dividing the weight of said raw wool by its volume to determine the average density of all of the wool of the bale, and then comparing the average density thus determined with a graph having abscissae and ordinates respectively of densities and shrinkages and a line plotted thereon representing standard densities and shrinkages of wool of the same type which has been previously accurately determined.

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