July 22, 1969 W. A. AYRES 3,456,488

APPARATUS AND METHOD FOR ELIMINATING GASES FROM A THERMOMETER BLANK

Filed Aug. 29, 1968

FIG. 1

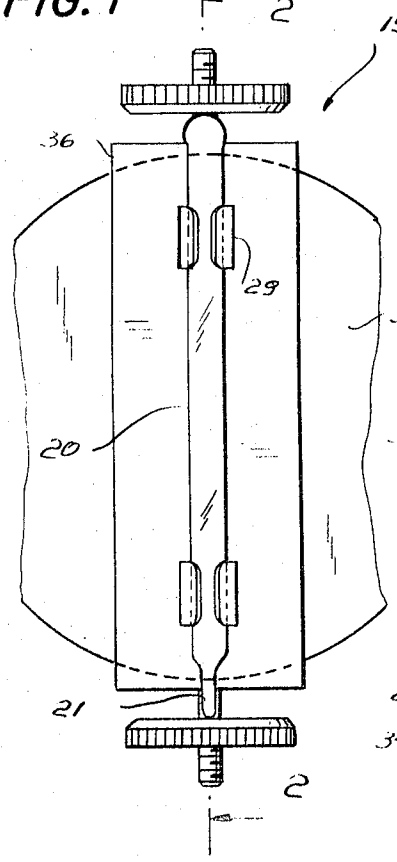


FIG. 3

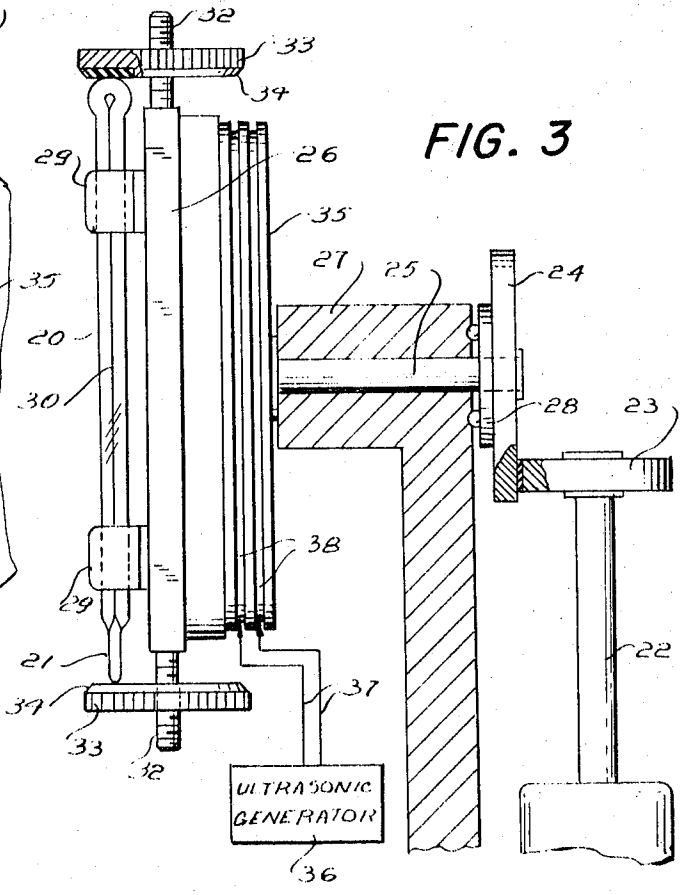
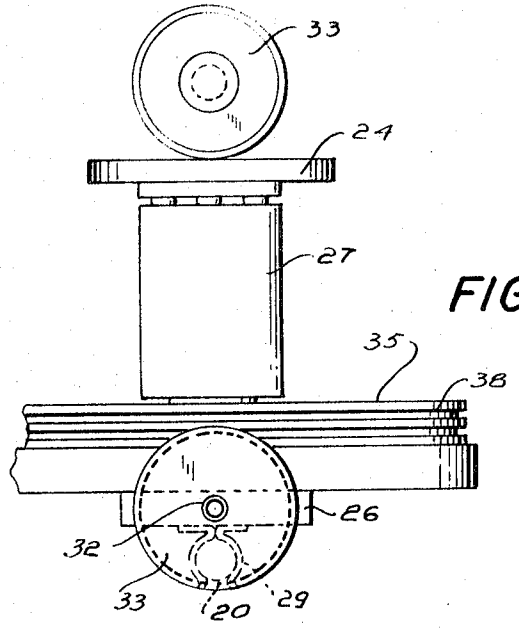


FIG. 2



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United States Patent Office

3,456,488

Patented July 22, 1969

3,456,488

APPARATUS AND METHOD FOR ELIMINATING GASES FROM A THERMOMETER BLANK

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Continuation-in-part of application Ser. No. 711,163, Mar. 4, 1968. This application Aug. 29, 1968. Ser. No. 756,187.

Int. Cl. G01k *15/00;* B01d *19/00*

U.S. Cl. 73—1 12 Claims

ABSTRACT OF THE DISCLOSURE

An apparatus and method for removing gas from a column of mercury in a thermometer blank having a top chamber at the upper end thereof and a bulb at the lower end thereof. A constriction is located between the ends of the thermometer. A slug of mercury is located at the upper end and the column of mercury is located at the lower end below the constriction. The blank is spun about an axis intermediate its ends and is substantially simultaneously vibrated to force the mercury to the extremities of the blank and displace the gas which collects between the mercury located at the top end and the mercury at the bottom end of the thermometer blank so that when the column of mercury is heated the gas will be forced into the top chamber by the rising column of mercury from the bulb end. The gas is subsequently removed from the thermometer blank. The blanks are mounted in a frame which is mounted on a shaft and both are driven by a drive means so that the frame and thermometer blank is spun about an axis which is located intermediate the ends of the blank. A vibrating means is also connected to the frame and thermometer blank combination so that the thermometer blank is vibrated while it is being spun about the predetermined axis.

Cross-reference to related applications

This application is a continuation-in-part of my earlier filed application, Ser. No. 711,163, filed Mar. 4, 1968, which in turn is a continuation-in-part of my earlier filed application, Ser. No. 548,224, now abandoned which was filed on May 6, 1966. The subject matter of these related applications is incorporated herein by reference.

Background of the invention

In the above mentioned related applications, considerable discussion is directed toward the necessity of removing gas bubbles which collect in a column of mercury within a thermometer blank during certain processing steps in the manufacture of a finished thermometer in order that an uninterrupted column of mercury remains thereby greatly minimizing the danger of inaccuracies in the finished thermometer and subsequent rejections. The apparatus and method as disclosed in my previously filed applications provides a considerable improvement in the art in reducing the number of these rejected thermometers by providing means to reduce the percentage of rejects. Even with this significant improvement in the art, there still exist a very small percentage of thermometer blanks in which spinning alone as employed in my previous applications will not remove all of the gases trapped within the column of mercury due principally to the following phenomenon which occasionally occurs. It is a reasonable assumption that occasionally the mercury forms a meniscus across the connecting capillary or elsewhere and plugs the capillary thereby preventing the gas from flowing around the mercury and into a region above the mercury during a spinning operation. Therefore it

would be extremely advantageous, in addition to the spinning operation, if other agitation means of some sort could also be employed to assist in freeing the gas so that it will pass by the mercury in these occasional difficult situations which sometimes occur even with the improved apparatus as disclosed in my previously filed applications.

One of the well known effects of ultrasonic or other types of vibration is to atomize liquids, that is, to break them into very tiny droplets, by the addition of this vibratory energy. It would therefore be beneficial to break up the mercury meniscus, bridging the capillary, into smaller separate droplets that gas can pass between. This would certainly serve to alleviate the above-mentioned occasional problem that occurs in some thermometer blanks. Also, the mercury sometimes may adhere to parts of the capillary and the ultrasonic vibration would aid in shaking the mercury loose so that it can flow in response to centrifugal forces toward the bulb. Therefore, by providing a vibratory means in addition to a spinning means, a very high percentage of formerly rejected thermometer blanks due to the presence of gas in the column of mercury in a thermometer would be alleviated. The apparatus and method as disclosed in my previous applications provides a significant reduction in the number of rejects in itself and with the additional improvement as suggested by this disclosure a still further percentage reduction in rejects would be possible.

Summary of the invention

Therefore, the primary objective of this invention is to provide an improved apparatus and method which will accomplish the above desired results by providing an improved inexpensive centrifuging apparatus employed in conjunction with a vibratory apparatus to produce an apparatus and method with which to remove gas from a predetermined column of mercury below the constriction in a thermometer blank both quickly and efficiently without removing the mercury from the blank and without re-combining the mercury in the top chamber with the mercury below the constriction and in the bulb. It is also an objective of the invention to provide a further contribution to the art along with the contribution of my above-mentioned previously filed applications to alleviate problems in the thermometer manufacture art which are drawbacks to providing an uninterrupted column of mercury below the constriction of the thermometer so that accurate calibration of the thermometer blank during later steps of production is readily obtainable. Furthermore, the device of this invention along with my previous inventions provide improved methods of achieving the above-discussed results whereby an uninterrupted gas-free column of mercury is obtained below the constriction in a thermometer blank in an economical and efficiently produced manner, and primarily to reduce the number of rejects due to the presence of difficult to remove small amounts of entrapped gas in a predetermined amount of mercury below the constriction within a thermometer blank.

In summary, an apparatus and method is provided for removing the gas from a column of mercury in a thermometer blank having a top chamber at its upper end and a bulb at its lower end. A constriction is located between the ends of the thermometer and a slug of mercury is located at the upper end while the column of mercury is located at the lower end below the constriction. The blank is spun about an axis intermediate its ends and substantially simultaneously vibrated to force the mercury in opposite directions and into the extremities of the blank which thereby displaces the gases so that they become located in the region between the opposite bodies of mercury. When the column of mercury is thereafter heated, the rising column from the bulb end of the blank

will force the gas above it into the top chamber. During subsequent manufacturing processes the top chamber including the gases and mercury therein is removed. The blanks are mounted in a frame which is mounted on a shaft and both are driven by drive means so that the frame and thermometers are spun about an axis which is located intermediate the ends of the blank. The vibratory means is connected to the blank and frame combination so that as the thermometer blank is spun, it is also vibrated.

With the above and other objects in mind, reference is made to the attached drawings of the invention.

Brief description of the drawings

In the drawings:

FIG. 1 is a front elevational view of a spinning and vibrating apparatus of the invention in which individual thermometer blanks are handled, with portions thereof broken away and removed;

FIG. 2 is a top plan view thereof; and

FIG. 3 is a side elevation view thereof with portions thereof broken away and removed.

Description of the preferred embodiment

Although only one of the specific embodiments as shown in my previously filed application is shown in combination with the improvements of this invention, it is readily apparent that the improvements are also adaptable for use of all other embodiments shown or which may be interpreted from the above-mentioned previously filed applications.

In reference to the embodiment as depicted in FIGS. 1–3, the spinning and vibrating apparatus **19** is shown in condition for operation with a thermometer blank **20** suitably mounted for entrapped gas removal from a column of mercury located below the constriction and near the bulb **21**. As demonstrated in the drawings, a drive shaft **22** has suitably keyed thereto a rubber faced wheel **23** forming part of a friction type drive for the wheel **24**. Wheel **24** is connected to one end of shaft **25** which is connected to frame **26**. Shaft **25** is journaled in support **27**. Thrust bearing **28** is between the interface of wheel **24** and support **27** so that when the friction drive wheel **23** forces wheel **24** to rotate, it will rotate smoothly and easily in relation to support **27**.

Two clips **29** are located on the face of the frame **26** and are aligned so that together they will hold a thermometer blank **20** in a substantially fixed position with its center of mass **30** preferably coincidental with the center of rotation of the frame. However, proximity to the spin axis is not a necessity as long as the mercury below the constriction is thrust outwardly toward the bulb **21** and the mercury in or near the top chamber **31** is thrust in the opposite direction. Consequently, displacement of the blanks laterally or longitudinally along the blank axis relative to the spin axis are contemplated by this invention, but the two masses of mercury are maintained on opposite sides of the spin axis.

A pair of diametrically opposed threaded studs **32** extend from frame **26**. Knurled adjustable circular end stops **33** are threaded on studs **32**. End stops **33** cooperate in holding the thermometer blank **20** and prevent it from sliding free of clips **29** under the action of the spinning and vibrating movements. In order to minimize the danger of breakage of the thermometer **20**, the inner faces of end stops **33** are composed of a resilient material **34**.

Affixed to one side of frame **26** in any common well known manner is a transducer **35** which is utilized to transform an electrical force into a mechanical vibrating force to vibrate the frame **26**, clips **29**, and blank **20**. The material utilized for transducer **35** may be barium titanate ($BaTiO_3$), nickel magnetostriction, or other well known suitable transducer means. Transducer **35** is fed by an electrical supply of the desired frequency such as ultrasonic generator **36** which is shown in diagramatic form in FIG. 3. An ultrasonic vibration source is merely one of many vibrating means which will serve the desired function. The object is to vibrate the thermometer while it is being spun and therefore the ultrasonic generator **36** must be connected to the vibrating transducer means **35** in a manner which will permit the vibrations to be transmitted during spinning to the thermometer. Therefore, as shown, the electrical connections **37** are made through sliprings **38** as an exemplary means for accomplishing this result. As previously discussed in detail, the difficulty we are confronted with is the presence of a meniscus of mercury formed across the connecting capillary which forms a plug in the capillary which prevents the gas from flowing around the mercury and into a region above the mercury during the spinning operation. The ultrasonic or other vibration means is present to atomize the mercury that is to break the globules into very tiny droplets, by the addition of this vibratory energy. In this manner, the mercury meniscus is broken up into smaller separate droplets and the gas can pass between these droplets. Also, the air bubbles sometimes will adhere to the sides of the capillary and the ultrasonic vibration will aid in shaking the bubbles loose so that the mercury can flow in response to the spinning action toward the bulb. This provides additional assistance in obtaining the desirable uninterrupted column of mercury in the more difficult thermometer blank reject situations.

In operation, shaft **22** is rotated by the drive means which rotates wheel **23** and consequently wheel **24**. Shaft **25** is, accordingly, rotated to spin frame **26** and all of its attached components, including the thermometer blank **20** being held by clips **29** and transducer **35**. Substantially simultaneously, ultrasonic generator **36** is activated to cause transducer **35** to vibrate, through the connected means of electrical connections **37** and sliprings **38**. Thermometer blank is then in a condition whereby it is being spun about an axis near its center of mass **30** and also is being simultaneously vibrated.

By reason of centrifugal force, the heavier mercury in the thermometer blank is forced radially outward toward bulb **21** and toward chamber **31**. In this connection, it is contemplated that all or a major portion of the column of mercury we are principally concerned with will be below the constriction of the thermometer blank being handled prior to placement within apparatus **19**. The gas we are concerned with is contained principally within this column of mercury below the constriction and is the gas which is difficult to remove and which thereby causes the percentage of rejections as previously discussed. Due to normal thermometer production techniques, there will also be a slug of previously removed mercury above the constriction and normally located in the blank at the point where the top chamber **31** meets the bore of the thermometer blank **20**. Also, at this point in the manufacturing process, normally the majority of the gas will have already been removed from the thermometer blank and will be located above the constriction primarily in the top chamber above the slug of mercury. This is the condition of the blank when it is normally placed within the apparatus of this invention.

In operation, the spinning of the blanks about a chosen axis and substantially simultaneous vibration forces the mercury below the constriction toward the bulb end of the thermometer blank and the mercury in the top chamber in the opposite direction. Therefore, the mercury below the constriction displaces the remaining gas trapped within the column and forces this gas radially inward in the capillary bore toward the center of spin. As previously discussed, the vibrating action alleviates the danger of a blockage in the capillary bore caused by a meniscus formation of a globule of mercury which prevents the passage of the gas and also assists in breaking the mercury down into smaller globules to facilitate the proper resultant positioning of the gas above an uninterrupted column of mercury.

When the desired degree of gas separation and displacement has occurred, rotation and vibration is stopped. The

thermometer blank **20** may then be removed from the clips **29** and heated at the bulb end such that the column of mercury in bulb **21** and adjacent area below the constriction rises thereby pushing the displaced gas which has collected around the center of spin **30** ahead of the rising mercury column up into the top chamber portion **31** along with the slug of excess mercury. The heating is preferably done while the blanks are in an upright position with the bulbs at the bottom. Top chamber **31** is subsequently removed during the manufacturing process thereby removing the gas within the thermometer blank along with the excess mercury. Consequently, a gas-free column of mercury within the capillary bore of the thermometer blank is achieved. The thermometer blank may then be accurately calibrated and inaccurate reading due to the compressibility or expandability of the entrapped gas in the mercury column is, therefore, eliminated. Furthermore, the number of rejects due to the presence of gas entrapped in the column of mercury below the constriction is greatly reduced since this gas may now be removed by the use of centrifugal force and additionally by vibratory force whereby the thermometer is spun about an axis between its ends and vibrated so that the previously removed gas and excess mercury above the constriction is not re-combined with the column of mercury below the constriction.

Thus, an improved apparatus and method are provided for alleviating the problem of rejection of thermometer blanks during manufacture due to the presence of a significant amount of entrapped gas in the column of mercury below the constriction after the majority of gas and an excess amount of mercury have been removed therefrom and are located in the upper portion of the thermometer blank adjacent to or in the top chamber thereof. The improved apparatus and method of this invention involves low production cost, is efficient and capable of adaptation to mass production techniques.

Thus, the above-mentioned objects of the invention, among others, are achieved. The range and scope of the invention are defined in the appended claims.

I claim:

1. An apparatus for removing gas from a column of mercury in a thermometer blank having a top chamber at the upper end thereof and a bulb at the lower end thereof with a constriction therebetween and having a slug of mercury at the upper end and the column of mercury at the lower end below the constriction comprising:

a rotatable shaft coupled with a drive means;

a frame connected to said shaft so as to spin as the shaft rotates;

holding devices connected to the spinning frame;

said holding devices positioned so as to hold at least one thermometer blank so that the axis about which the thermometer blank spins is located intermediate its ends so that the mercury at one side of the axis is driven toward the top chamber and the mercury at the opposite side of the axis is driven toward the bulb under the influence of cetrifugal forces with gas in the blank collecting between the two bodies of mercury at the extremities;

vibrating means connected to said apparatus so as to vibrate said thermometer while spinning to facilitate driving the mercury on each side of the spin axis to the adjacent end and bulb respectively;

restraining means for cooperating in restraining the blank within the holding devices during the spinning and vibration thereof; and

means to remove the separated gas.

2. The invention in accordance with claim **1** wherein said vibrating means is connected to said frame so that said frame, holding devices and thermometer blank are vibrated during spinning.

3. The invention in accordance with claim **2** wherein said vibrating means includes an electrical vibration source, and a transducer means connected to said electrical vibrating source and said frame to transmit the vibrations to said frame during spinning.

4. The invention in accordance with claim **3** wherein said electrical vibration source is an ultrasonic generator.

5. The invention in accordance with claim **3** wherein the electrical connections between said electrical vibration source and said transducer is provided by at least one slipring connected to said transducer and said electrical vibration source.

6. The invention in accordance with claim **3** wherein said transducer is composed of barium titanate.

7. The invention in accordance with claim **3** wherein said transducer is a nickel magnetostriction transducer.

8. A method for removing the gas from a column of mercury in a thermometer blank having a top chamber at the upper end thereof and a bulb at the lower end thereof with a constriction therebetween and having a slug of mercury at the upper end and the column of mercury at the lower end below the constriction comprising:

spinning the blank about an axis located between the ends thereof and substantially simultaneously vibrating the blank to force the mercury below the spin axis toward the bulb and the mercury above the axis toward the top chamber under the influence of centrifugal force with the gas in the blank collecting between the mercury in the bulb and the mercury in the top chamber;

after spinning, heating the blank to cause the mercury column to rise and force the above gas into the top chamber; and

subsequently removing the top chamber to provide a column of mercury with no entrapped gas in the thermometer blank.

9. The invention in accordance with claim **8** wherein said vibrating is ultrasonic.

10. The invention in accordance with claim **8** wherein the thermometer blank is spun about an axis located between the constriction and the end of the blank at which the top chamber is located.

11. The invention in accordance with claim **8** wherein the thermometer blank is spun about an axis located approximately coincidental with its center of mass.

12. The invention in accordance with claim **8** wherein the thermometer containing the uninterrupted column of mercury is then calibrated and marked.

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U.S. Cl. X.R.

55—15, 52, 199, 277