Feb. 21, 1956 V. MORRILL, JR 2,735,230

PROCESS OF FABRICATING GLASS ARTICLES

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FIG. 1.

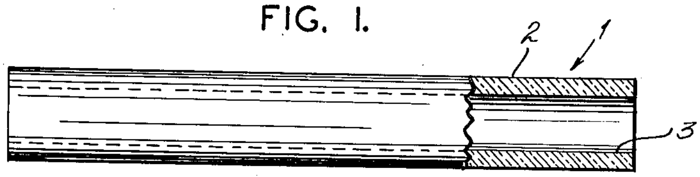

FIG. 2.

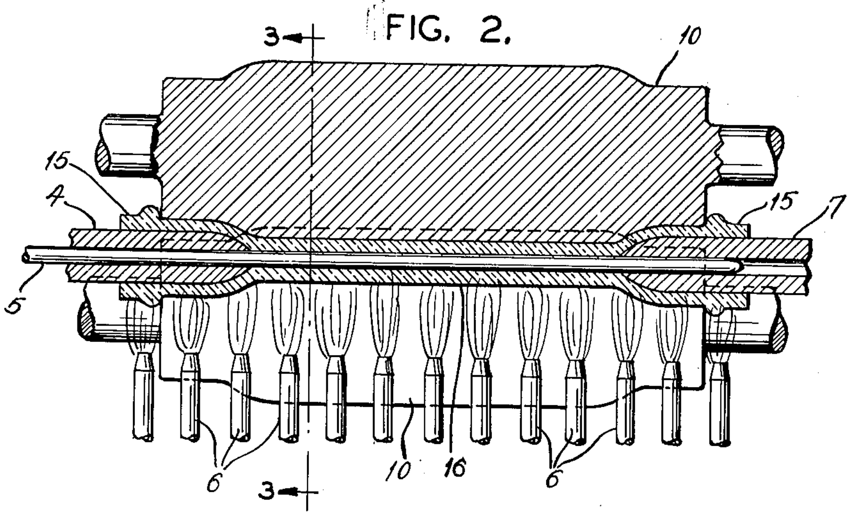

FIG 3

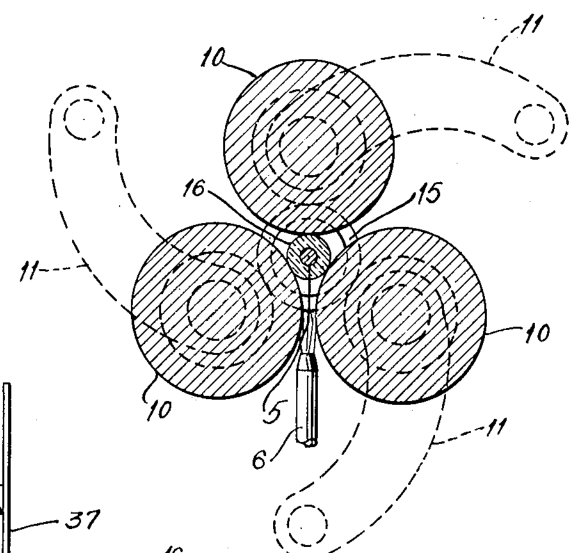

FIG. 6.

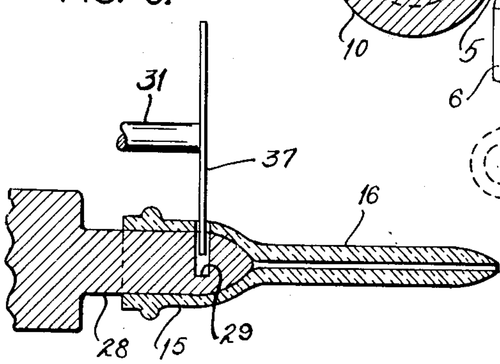

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FIG. 4.

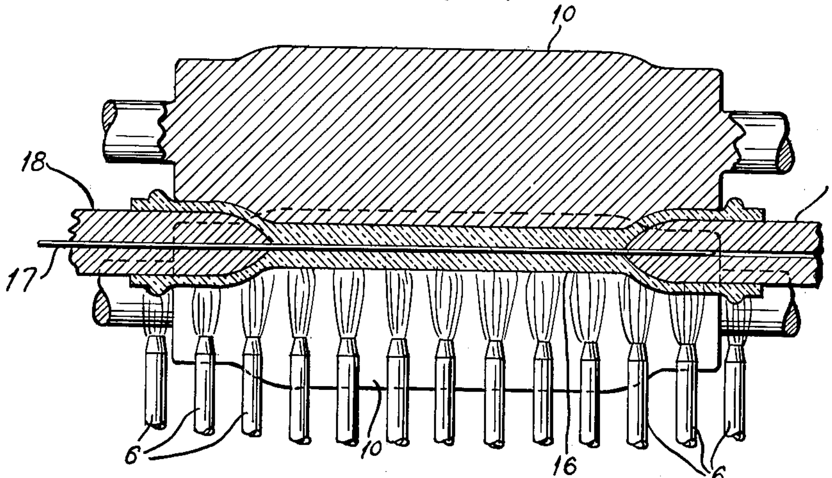


FIG. 5.

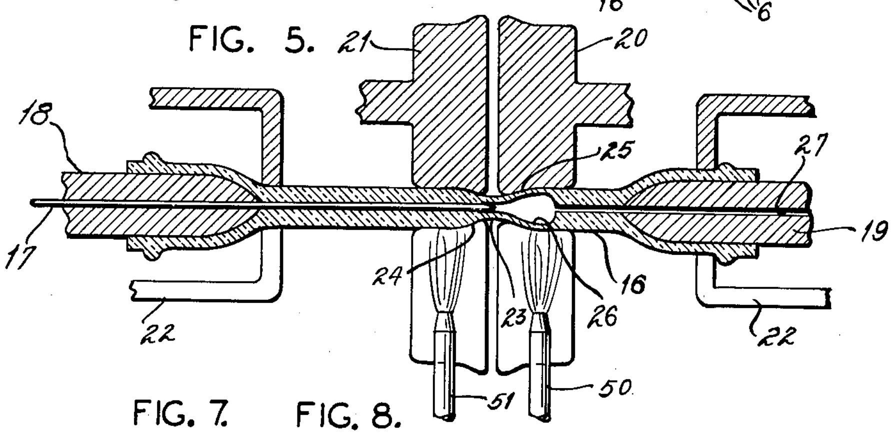


FIG. 7.

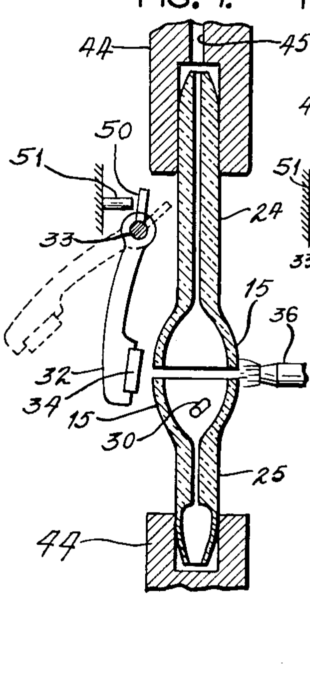


FIG. 8.

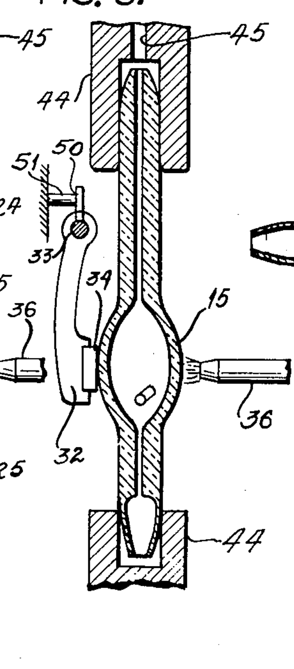
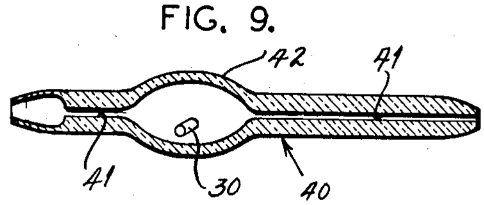


FIG. 9.



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United States Patent Office

2,735,230

Patented Feb. 21, 1956

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PROCESS OF FABRICATING GLASS ARTICLES

Vaughan Morrill, Jr., Clayton, Mo.

Application January 10, 1952, Serial No. 265,749

9 Claims. (Cl. 49—79)

This invention relates particularly to process for fabricating glassware of the character of pipettes and the like, though the process disclosed is not limited in its application to glassware.

This invention has particular application to pipettes such as those used for obtaining blood counts. In such pipettes, the stem is graduated to indicate the amount of blood contained within it, and the bulb of the pipette, into which a dilutant is sucked, is dimensioned to have a capacity of a high multiple of the amount of blood contained within the stem, generally one hundred times that amount. It is apparent that in such a pipette the stem must be calibrated with great nicety since errors in calibration of the stem are multiplied one-hundredfold when the bulb is filled with dilutant.

Pipettes of the character described have heretofore been made by hand and calibrated individually. The bore of drawn glass capillary tubing from which such pipettes are made is not uniform. It has thus been impossible to produce uniformly accurate pipettes by blowing bulbs of a uniform size. The volumes of the bulbs must vary with the capacities of the stems to obtain the proper proportionate capacities. Furthermore, the non-uniformity of the bores has made uniform calibration of the stems themselves impossible. These facts have necessitated using laborious and expensive trial and error manufacturing methods, both to obtain the proper diluting ratio between the stem and bulb and to calibrate the stem.

It is often desired, particularly in pipettes of the character described, to insert within the enlarged bulb section a mixing bead or like element. In inserting such beads, it has heretofore been necessary to cut off an end or to cut out a small section of the bulb or to blow a hole therethrough and to reseal the opening.

One object of the present invention is to provide a process for producing hollow articles having an enlarged portion intermediate restricted sections in which the capacity of such articles is uniform, known and predetermined when these articles are produced.

Another object is to provide process for producing such articles containing within the enlarged portion elements incapable of passing through the restricted sections.

Other objects will be apparent to those skilled in the art when the following description is read in connection with the drawings.

In accordance with an illustrative embodiment of this invention, a process is provided in which a blank of glass tubing, the bore of which may be irregular and the wall thickness of which may vary from place to place, is shaped upon a mandrel or a succession of mandrels to produce a shaped blank having an accurately formed bore, and an enlarged section the internal dimensions of which are exactly known. Two such enlarged sections may be produced in the same blank, one at either end. The enlarged sections produced by the profiled mandrel are open-ended and are shaped to allow the mandrel to be pulled therefrom. A tip may be formed on the stem of the blank while the mandrel is still in position or is partly withdrawn.

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When two enlarged sections are formed on the same blank, the stem portion intermediate the enlarged section may be divided. The enlarged sections may be trimmed to give to each section a known desired capacity. Two enlarged sections, which need not be identical but whose exterior dimensions should be practically identical at their open edges, are butted. If it is desired to insert an object within the bulb of the pipette to be made, that object need only be placed within one of the enlarged sections before those sections are finally butted. The butted enlarged sections are then fused together in such a way that the exterior dimensions of the finished pipette are the same as those of the unfused sections. By this process, a pipette is produced in which the volume is accurately known and predetermined, and in which the bore of the stem is so uniform that the pipette may be calibrated with a simple screen process.

Referring now to the drawings:

Figure 1 is a view in side elevation, partly broken away, of a blank of glass tubing.

Figure 2 is a somewhat diagrammatic view, partly in section, showing the forming of the glass blank on a mandrel.

Figure 3 is a sectional view taken along the line 3—3 of Figure 2.

Figure 4 is a view similar to the view in Figure 2, showing the forming of the glass blank shown in Figures 1 and 2 on a finishing mandrel.

Figure 5 is a somewhat diagrammatic view showing the forming of tips on the stem intermediate the enlarged end sections.

Figure 6 is a view, partly in section, showing the trimming of an enlarged section.

Figure 7 is a somewhat diagrammatic view, partly in section, of fusing and gauging means.

Figure 8 is a somewhat diagrammatic view showing two enlarged sections fused together, while the gauging means is in contact with the pipette; and

Figure 9 is a sectional view showing a finished pipette made in accordance with the process of this invention.

Referring now to the illustrative embodiment shown in the drawings, 1 represents a blank of glass tubing having a wall 2 not of uniform thickness, and a bore 3, also not uniform.

In Figures 2 and 3, the blank 1 is mounted upon enlarged profiled mandrels 4 and 7 and a thin, rigid mandrel 5. The blank is heated by burners 6 and formed on mandrels 4, 5 and 7 by three rollers 10 pivoted on arms 11. At the stage shown, a blank 1 has been shaped to give enlarged sections 15 and a stem section 16.

In Figure 4, the thin mandrel upon which the stem 16 is formed is a finishing mandrel 17. The enlarged mandrels 18 and 19 at this stage may or may not have the same contours as mandrels 4 and 7.

In Figure 5, chucks 22 are shown holding the partly formed blank. Finishing mandrel 17 is partly withdrawn and six profiled rollers 20 and 21 are positioned about stem section 16. Burners 50 and 51 are positioned to cooperate with rollers 20 and 21 respectively. Stem section 16 is shown as provided with a constricted section 23, defining a lower tip section 24 and an upper tip section 25. In upper tip section 25 is blown a bubble 26.

In Figure 6, an enlarged section 15 is revolvably mounted on a finger 28 having a groove 29 into which a sawblade 37 rotating on a shaft 31 extends.

In Figure 7, a mixing bead 30 has been inserted within the enlarged section 15 of upper tip section 25. The upper tip section 25 and lower tip section 24 are mounted in chucks and the trimmed enlarged sections are aligned for abutment. In the embodiment shown, a gauging device 32 is frictionally mounted on a rotatable shaft. The shaft 33 is provided with a fixed lug 50 which meets stop

51. Gauge **32** is provided with a backing plate **34**. Burner **36** is positioned to heat the edges of the enlarged sections **15**.

In Figure 8, backing plate **34** is shown in contact with the bulb formed by the enlarged sections **15**.

In Figure 9 is shown a completed pipette **40**, with its accurately-formed bore **41** and bulb **42**.

In operation, a blank **1** is first shaped to exactly known internal dimensions. In the illustrative embodiment this is accomplished as follows:

Rollers **10** are swung outwardly on arms **11**. The blank **1** is set on mandrels **4**, **5** and **7**. The mandrels are set in rotation, all rotating in the same direction at the same speed to rotate blank **1**. As the blank is rotated, it is heated by burners **6**. As the glass of the blank softens under the influence of the heat from the burners **6**, the shaped rollers **10** are swung inwardly, moving equally toward the axis of rotation of the mandrels to cause the interior surface of the blank to assume the form of the mandrels. As has been noted, thin mandrel **5** is rigid so that the bore of stem section **16**, as well as the internal dimensions of the enlarged sections **15**, is made accurate and true. Furthermore, the rigidity of mandrel **5** allows the glass of the walls of the stem **16** to be distributed uniformly by the rollers **10**, although the absolute thickness of the wall can vary from one blank to the next without affecting the accuracy of the finished pipette.

When the desired shape of the blank and the desired distribution of glass in the walls thereof has been obtained on the mandrels **4**, **5** and **7**, the blank is cooled sufficiently to retain its shape, rollers **10** are swung back, and mandrels **4**, **5** and **7** are removed. Mandrels **17**, **18** and **19** are next inserted. The bore of a finished pipette is desirably made so small, on the order of .02 inch, that it is difficult at present to find a finishing mandrel which has sufficient rigidity to allow the blank to be formed upon it. However, by first producing a straight bore and a uniform distribution of glass in the wall of the stem on the rigid mandrel **5**, a finishing mandrel **17** of the desired fineness but without the rigidity of the mandrel **5** may be used, since, when the rollers **10** are brought uniformly toward the mandrel **17** against the uniformly distributed wall of the stem, the finishing mandrel **17** has only to perform a sizing function, and the bore remains true.

Mandrels **4**, **7**, **18** and **19** may have identical outside contours. However, this is not necessary. It is only necessary that at the blanks' cut-off points, i. e., the place at which they are trimmed for joining, the mandrels **18** and **19** have the same outside dimensions.

In the embodiment shown in the drawings in which an enlarged section **15** is formed on each end of the blank **1**, two tips may be formed in the stem section **16** intermediate the enlarged sections **15** while the blank is still on mandrels **17**, **18** and **19**. These tips may be identical or may be different.

In the illustration shown in Figure 5, both upper and lower tip sections are formed in the same blank so that, reversed, the two sections together will form a complete pipette. In producing the tips, the blank and mandrels are placed within chucks **22**, at least one of which is capable not only of rotational movement but longitudinal movement with respect to the axis of the blank. Mandrel **17** is partly withdrawn. The burner **50** is turned on and the glass in the area which it covers is softened sufficiently to allow a small bubble to be produced, in the section from which mandrel **17** has been withdrawn, by gas pressure supplied through a hole **27** in mandrel **19**. The gas pressure is then stopped and the chuck **22**, with its mandrel **19** and the section of the blank which is softened, are moved to the right a small amount to produce an elongated bubble. While the glass is still softened, profiled rollers **20** are swung equally toward the center of the bore of the stem to form the upper tip section **25**. The glass is then allowed to cool, with rollers **20** still in place, by turning off the burner **50**.

Burner **51** is next turned on to heat the section immediately adjacent the upper tip just produced, and profiled rollers **21** are brought to bear on the stem section containing mandrel **17** to produce the lower tip section **24**, having a uniform bore determined by mandrel **17**. The blank is then allowed to cool, after which the rollers are swung away and the blank removed from chucks **22** and mandrels **17**, **18** and **19**.

The form of the upper and lower tip sections and the provision of the elongated bubble in the upper tip section as shown in the drawings are more or less peculiar to the manufacture of blood count pipettes but the technique has general application. The stem section is now cut at the restricted zone **23** between the upper and lower stem sections at a point at which the bore of the lower tip section is accurately known as a result of the presence of the mandrel when that section is formed, since in a pipette of the character here described, the capacity and calibration of the lower tip section are of paramount importance, while the internal dimensions of the bubble section of the upper tip section are unimportant.

The enlarged sections **15** are now trimmed to a size to give a known volume. In the embodiment shown in Figure 6, this is accomplished by rotating the enlarged sections about the finger **28** while the walls of the section are cut by the saw **37** running within the groove **29** in that finger.

In the final operation, the two sections are butted and joined in such a way that the external dimensions of the finished pipette are the same as those of the component parts and the capacity of the pipette is known exactly. In general, this is accomplished by gauging the external dimensions of the component parts before they are joined; heating the edges of the component parts above the softening temperature of said parts, whereby the external dimensions of the component parts are altered but the quantity of matter in the parts remains constant; fusing the component parts together; and restoring the united component parts to their original external dimensions. The external dimensions of the parts determine their total volume, which is made up of the volume of the glass and of the cavity. It can be seen that as long as the volume of glass remains constant, and the external dimensions of the parts before and after they are fused are the same, the internal volume (capacity) must be the same, no matter what the internal configuration may be. In the embodiment shown in Figures 7 and 8, this is accomplished by placing the upper and lower tip sections within revolvable, aligned chucks **44**, at least one of which may be displaced longitudinally. In making blood count pipettes, the mixing bead **30** may simply be placed within one of the enlarged sections when that section is mounted in its chuck **44**. The two enlarged sections, whose volumes are accurately known and whose exterior dimensions at the open edges are the same, are brought into abutment. The gauge **32** is moved toward the butted sections by revolving shaft **33** until the lug **50** engages the stop **51**. Gauge **32** is then rotated about shaft **33** until backing plate **34** contacts the walls of the butted sections. Thus when gauge **32** is swung away, rotating shaft **33**, it may be restored to its gauging position by rotating shaft **33** until the lug **50** engages stop **51**, as shown in Figure 8. The provision of such a gauging device renders the absolute thickness of the walls of the enlarged section **15** immaterial because the gauge is capable of restoring the external dimensions of the joined sections to those of the sections before fusing. Gauging device **32** is swung away. The position of the chucks **44** with respect to one another is noted and the enlarged sections are slightly separated by moving one of the chucks **44** away from the other. Chucks **44** are now made to revolve and the edges of the sections **15** are heated by burner **36**. When the glass being heated reaches the sealing temperature, the chucks **44** are again moved toward one another until the edges of the sections **15** meet and are sealed. Burner **36** is then extinguished and gauge **32** is swung back to the position determined when the sections were first butted so that backing plate **34** restores the pre-fused external dimensions of the joint. A slight, internal pressure may be applied through a hole **45** in the chuck **44** to insure that the softened joint is maintained in contact with backing plate **34**. At the same time, chucks **44** are restored to the positions at which they were relative to one another when the unfused sections were butted. The pipette is allowed to cool and is now ready for calibration.

The backing plate **34** extends far enough to either side of the softened section of enlarged sections **15** during the sealing operation to bear against unsoftened glass, so that the external dimensions of the joint must be the same as they were when the two sections were butted but unfused. Since the pipette has the same length as the two unfused sections combined, and the same external dimensions circumferentially, the internal volume of the bulb **42** must necessarily equal the sum of the exactly known volumes of the two enlarged portions **15**. The bore **41** of the finished pipette has been determined exactly by the dimensions of the finishing mandrel **17**. By producing a stem of a given length, the ratio of stem volume to bulb volume can be exactly predetermined. Furthermore, since the internal dimensions of the bore **41** are known exactly, calibration of the lower stem and of the stem above the bulb can be uniform from one pipette to the next, and can be applied by means of a simple screen process instead of the laborious, manual, trial-and-error method heretofore employed.

The process described has produced a complete pipette from a single blank. It is clear that in practice a single upper or lower tip section may be produced from one blank, or two upper or lower tip sections may be produced, to be joined with complemental sections produced separately. Within very close tolerance, the process described produces completely interchangeable sections so that it is not necessary to preserve the identity of any single section in assembling the pipettes. This is true in spite of the irregularity in wall thickness of the commercial tubing used because the variations, while great in terms of the accuracies required in pipettes of the character described, are small in terms of the capacity of the apparatus and process of this invention to produce even distribution of the glass in the walls of the sections. When the sections are finally shaped on the mandrels, the external dimensions of the sections are practically identical.

If it were desired to produce a joint between two sections, which, while having the same contour were not identical so as to form a collar at the joint, the backing plate would only have to be offset to match the joint. Again, if irregularly contoured pieces are to be joined, the backing plate could be cammed to move mechanically or could be made in the form of a cam itself.

In each of the forming operations described, it is necessary that the amount of heat applied be carefully controlled since if the glass is heated too hot, it will wet the mandrels and fuse thereon.

It can be seen that the process here described is applicable with slight variations within the skill of the art to forming many glass articles having an enlarged intermediate section, the capacity of which must be known accurately. The ease with which objects may be incorporated within the enlarged cavity also commends this method to the production of apparatus, the capacity or calibration of which is important, which is to contain elements which are too large for introduction through the restricted portions of that apparatus.

It can also be seen that while in the usual case, the bore of a pipette or apparatus will be made uniform throughout its length, a tapered bore is entirely feasible since the mandrel on which it is formed can readily be pulled in producing such a bore. Similarly, it can be seen that the configuration of the enlarged sections can be varied and may include a relatively long cylindrical section so long as the mandrels forming those enlarged sections can be pulled. Furthermore, by a suitable system of cams or by properly shaping the rollers and mandrels, enlarged sections and stems having irregular internal or external contours may be produced.

Numerous variations within the scope of the specification and the appended claims will be apparent to those skilled in the art in the light of the disclosures of the specification with respect to the fabrication of glass articles. It can be appreciated that a similar method, i. e. forming two sections of an article of the character of a pipette to exact internal dimensions, butting those sections, and so sealing the sections as to produce an integral article having the exact external dimensions and hence capacity of the component sections, can be applied to other materials such as plastic.

Thus it can be seen that a process for fabricating articles in the nature of pipettes is provided, which insures uniformity and which allows the capacities of such articles to be known and accurately predetermined.

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

1. The process of fabricating pipettes having uniformly accurate volumes from blanks of glass tubing, the wall thickness and bore of which may be irregular, comprising shaping a blank of glass tubing on a mandrel to produce an accurate bore and to produce an open-ended wide section, having known inside dimensions through at least a portion of its length, mounting two of the shaped blanks in rotatable chucks so that the open-ended wide sections of said blanks abut one another, positioning backing means against the outside walls of the abutting sections to gauge the outside dimensions of said sections, moving said backing means away and said chucks apart, rotating said chucks, heating the edges of said sections above the softening point of said tubing, moving the rotatable chucks toward one another to put the edges of said sections into engagement to fuse the said sections, moving the said backing means into its previously gauged position, supplying pressure to the interior of said blanks, and restoring said blanks to their pre-fused abutting position relative to one another and to their gauged outside dimensions with respect to said backing means.

2. The process of fabricating pipettes having uniformly accurate volumes from blanks of glass tubing, the wall thickness and bore of which may be irregular, comprising shaping a blank of glass tubing on a mandrel to produce an accurate bore and to produce at each end of the blank an open-ended wide section having exact inside dimensions through at least a portion of their lengths, withdrawing said mandrel from a portion of said blank, shaping the tip sections over one end of the mandrel intermediate the wide sections, forming an enlargement adjacent said tip section, while said mandrel remains in position, dividing the shaped blank at the tip section, inserting a mixing bead in one of the open-ended wide sections, mounting the shaped blanks in rotatable chucks so that the open-ended sections abut one another, positioning backing means against the outside walls of the abutting sections to gauge the outside dimensions of said sections, moving said backing means away and said chucks apart, rotating said chucks, heating the edges of said sections above the softening point of said tubing, moving the chucks to put the edges of said sections in engagement to fuse said sections, positioning the said backing means into its previously gauged position, supplying pressure to the interior of said blanks, and restoring said blanks to their pre-fused abutting position relative to one another and to their gauged dimensions with respect to the backing means.

3. The process of fabricating pipettes having uniformly accurate capacities from blanks of tubing, the wall thickness and bore of which may be irregular, comprising shaping the blanks on a mandrel to produce in each an accurate bore and an open-ended wide section, each open-

ended wide section having a known capacity; positioning two of said sections with their open ends in abutment; gauging the external radial dimensions of said sections while in abutted position; heating the open ends of said sections above the softening point of said tubing whereby the external configuration of the sections is altered but the quantity of matter in the sections remains constant; fusing together said softened open ends of said two sections; and, in the said abutted position, restoring the fused sections to their gauged external radial dimensions.

4. The process of claim 3 wherein a mixing bead is inserted within one of the open-ended sections before said open-ended sections are fused together.

5. The process of claim 3 wherein at least one of said two blanks is shaped in two stages: first, shaping the blank on a rigid mandrel until the internal dimensions of the blank conform to the external dimensions of the mandrel, and second, withdrawing said rigid mandrel, inserting a thin, flexible finishing mandrel, and reducing the bore of said blank on said finishing mandrel to its finally desired size while supporting the said blank against external disalignment.

6. The process of claim 3 wherein, after an accurate bore and an open-ended wide section is produced in one of the blanks, a tip section at the end of said blank opposite the open-ended wide section is shaped over one end of the mandrel, and an enlargement is formed adjacent said tip section, before said blank is positioned in abutment with a blank having a complementary open-ended wide section.

7. In the art of fabricating integral hollow bodies of accurately known capacity, the process comprising forming complementary open-edged members of known capacity, positioning said members with the edges of said members in abutment, gauging the external radial dimensions of said members while in abutted position, heating the edges of said members above the softening temperature of said members whereby the external configuration of said members is altered but the quantity of matter in said members remains constant, fusing said members together at said edges and, in the said abutted position, restoring the fused members to their gauged external radial dimensions.

8. In the art of fabricating integral hollow bodies of accurately known capacity, the process comprising forming complementary open-edged members of known capacity, positioning said members with the edges of said members in abutment, gauging the external radial dimensions of said members while in abutted position, heating the edges of said members above the softening temperature of said members whereby the external configuration of said members is altered but the quantity of matter in said members remains constant, fusing said members together at said edges while changing the relative positions of said members to work the softened edges together, and restoring the fused members to their abutted position and to their gauged external radial dimensions.

9. In the art of fabricating integral hollow bodies of accurately known capacity, the process comprising forming complementary open-edged members of known capacity, gauging the external dimensions of said members, heating the open edges of the members above the softening temperature of said members, whereby the external configuration of said members is altered but the quantity of matter in said members remains constant, fusing said members together at said edges and restoring the fused members to their gauged external dimensions.

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