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M. S. ABEL

2,735,735

SYRINGE CONSTRUCTION

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Fig. 1

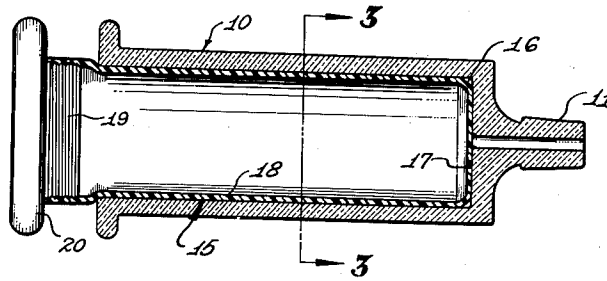


Fig. 2

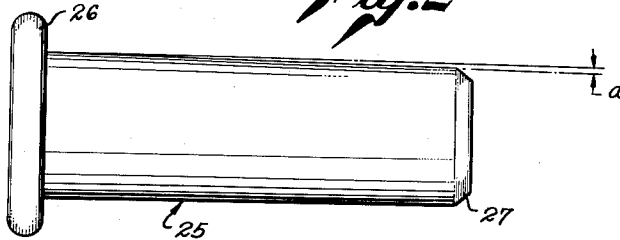


Fig. 3

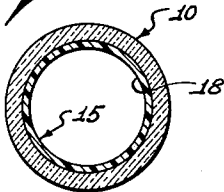


Fig. 4

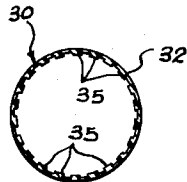
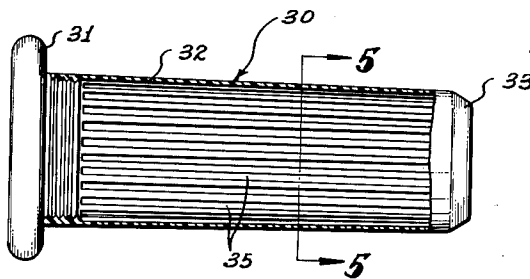


Fig. 5

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1

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SYRINGE CONSTRUCTION

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19 Claims. (Cl. 309—4)

My invention relates to syringes for handling, measuring and administering fluids. While the invention is broadly applicable to a wide range of fluid-handling devices of this general classification, the invention has special utility in the form of a hypodermic syringe. Such an embodiment of the invention will be described herein for the purpose of disclosure and illustration as well as to provide adequate guidance for those skilled in the art who may have occasion to apply the same principles to other specific purposes and embodiments.

Syringes of this type are precision devices since the syringe plunger must fit the syringe barrel snugly and in an air-tight manner to provide the desired pumping action for the effective aspiration and discharge of fluids. Since the desired closeness of fit must be maintained at various temperatures both the barrel and the plunger are usually made of the same material to avoid differences in coefficients of thermal expansion. Since the material selected must be relatively inert the material used for both the barrel and the plunger in a conventional syringe of this type is glass. To provide the required fit the plunger and barrel are made with close tolerances and a ground fit which precludes interchangeability of plungers and barrels. Each plunger is dimensioned to mate with only one particular barrel and the barrels and plungers must be numbered in pairs for identification to make sure that a plunger is used only with its own particular matched barrel.

It is readily understandable that the cost of fabricating plungers and barrels to such close tolerances with ground fit is relatively high, and that the necessity of continually matching particular plungers with particular barrels by close attention to their serial numbers is troublesome, especially when the separated plungers and barrels are sterilized in large numbers at one time.

Another disadvantage of making plungers and barrels to close tolerances is that losses by breakage are unduly high, especially since so many materials cause the usual glass plunger to stick in the glass barrel. In spite of careful cleaning, a glass plunger tends to accumulate a residual coating as it is exposed to different substances over a period of time, and such coatings make the plungers stick both by increasing its diameter and by forming an adhesive bond between the plunger and the barrel. A coated plunger is especially difficult to remove when the plunger is inadvertently left in the barrel for even a short period of time. The breakage cost is unduly high because the barrels and plungers are not interchangeable. Whenever either the barrel member or the plunger member of a syringe is broken the other member must be discarded.

The objects of the present invention include the following: to provide a syringe construction that permits interchangeability of plungers and barrels; to avoid the necessity of close tolerances in the manufacture of plungers and barrels; to eliminate the principal causes for breakage; to make possible the use of different materials with different coefficients of thermal expansion in the fabrication of the barrels and plungers, respectively, without sacrificing closeness of fit over a substantial temperature range; to provide a syringe plunger that may be kept clean and free of adhering matter with no difficulty; and to provide a substantially non-breakable syringe plunger

2

that will withstand considerable abuse without damage.

In general, these objects are attained by using a plunger that is resiliently deformable and by virtue of such resiliency it is readily adaptable to different syringe barrels.

The resiliency and radial yieldability of the plungers make the plungers adaptable not only to different barrel diameters but also to departures from true cylindrical configuration in the shape of barrel walls. Such adaptability achieved by a resilient plunger construction results in several advantages heretofore unattained in conventional syringes.

One outstanding advantage is the elimination of the usual necessity for close tolerances in the fabrication of the plungers and barrels. A further advantage of primary importance is that such a resilient plunger construction makes the plungers and barrels freely interchangeable with no need to match a particular plunger with a particular barrel. A third advantage of using widely adaptable plungers is that the ability of a plunger to accommodate itself to various barrel diameters may, in effect, compensate for differences in coefficients of thermal expansion so that a plunger and a barrel may be of different materials and yet maintain an effectively close fit between their co-acting surfaces throughout a substantial range of temperatures.

A still further advantage of the new plunger construction is the striking reduction in breakage cost. In part, the reduction in breakage cost follows from the interchangeability of plungers and barrels since breakage of one of the two members does not make it necessary to discard the other member. The flexibility of the plunger structure per se reduces the tendency of a plunger to stick in a barrel. In the preferred practice of the invention I practically completely eliminate the cause of a plunger sticking in a barrel by fabricating the plunger of a plastic material in the form of a synthetic resin that is not only inert to practically all fluids but is also substantially non-wettable and slides in the matching barrel with little frictional resistance.

The invention is characterized by the concept that the desired resilient compressibility on the part of the plunger may be achieved by using a suitable elastic material for the plunger and by making the plunger of hollow construction to provide an inner-space into which the material of the plunger may be deformed for contraction of the plunger in cross-sectional dimension. Various plastic materials may be used in various specific practices of the invention but in each instance the fluids to be handled by the syringe will be taken into consideration in selecting the plastic material for the plunger. It is contemplated that the resilient plastic plunger will be used with a conventional type glass barrel, and the invention will be so described but it is to be understood that the plunger may be used with barrels fabricated from materials other than glass.

A plastic that is especially suitable for the new plunger construction is a fluorinated polymer, which may be, for example, polymerized tetrafluoroethylene resin such as disclosed in the Plunkett Patent No. 2,230,654, issued February 4, 1941. This resin which has the property of plastic memory to a marked degree is available under the trade name Teflon. Another synthetic resin that is especially suitable for the new plunger construction with respect to inertness, non-wettability and low co-efficient of friction is a polyamide formed by the reaction of adipic acid and a diamine. This resin is available in commerce under the trade name Nylon.

It is contemplated that the hollow plunger will be in the form of a thin-walled cylinder that is oversize with respect to the syringe barrel with which the plunger is to cooperate. Thus, the plunger is resiliently contracted to fit into the relatively undersized barrel and preferably the

plunger has a short tapered nose to facilitate insertion into the barrel. In some practices of the invention at least a major portion of the working length of the plunger has a gradual taper to a minimum diameter near the leading end of the plunger, which minimum diameter is oversized with respect to the diameter of the barrel with which the plunger cooperates.

By "working length" is meant the longitudinal portion of the plunger that extends into the barrel when the leading end of the plunger is in abutment with the nozzle end of the barrel. It is further contemplated that the plunger will be sufficiently oversized with respect to the barrel for close fit with the barrel over an extensive temperature range.

The features and advantages of the invention may be appreciated from the following detailed description considered with the accompanying drawings.

In the drawings, which are to be regarded as merely illustrative,

Fig. 1 is a longitudinal sectional view of a syringe constructed in accord with the teachings of the present invention;

Fig. 2 is a side elevation of a syringe plunger of the new type that is formed with a gradual longitudinal taper;

Fig. 3 is a transverse section taken as indicated by the line 3—3 of Fig. 1;

Fig. 4 is a view partly in elevation and partly in section showing an internally ribbed plunger that may be employed in some practices of the invention; and

Fig. 5 is a section taken as indicated by the line 5—5 of Fig. 4.

The syringe shown in Fig. 1 has a barrel, generally designated 10, fabricated from a suitable type of glass; for example, a glass known by the trade name Pyrex, the barrel being formed with the usual tip 11 to receive hypodermic needles. The bore of the barrel is preferably substantially uniform in diameter throughout its length.

The syringe plunger generally designated 15, which is made of suitably resilient material and is oversized with respect to the internal diameter of the barrel 10, is of hollow construction so that the plunger may be readily contracted in diameter to slide in the barrel with a suitably snug fit. By "oversize" is meant that the unrestrained outside diameter of at least the major portion of the working length of the plunger, and preferably the whole of the working length, is greater than the internal diameter of the barrel 10. Preferably the leading end of the plunger 15 has a short steep taper 16 to form a nose the leading end of which is smaller than the internal diameter of the barrel 10. Forming the plunger 15 with such a nose facilitates insertion of the plunger into the relatively undersized barrel.

In the preferred construction shown in Fig. 1, the plunger 15 is in the form of a thin-walled cylinder and preferably has a leading wall 17 that is on the same order of thickness. It is further preferable that the thickness of the end wall 17 be somewhat less than the longitudinal extent of the nose taper 16.

In general, the thickness of the cylindrical wall 18 of the plunger 15 and the oversize of the outside diameter of the plunger with respect to the barrel 10 will be determined by two contrary considerations. On the one hand, the unrestrained diameter of the plunger must be sufficiently greater than the inside diameter of the barrel and the thickness of the cylindrical wall 18 must be great enough to provide the desired magnitude of radial pressure against the surrounding barrel for an effectively snug fit. On the other hand, the unrestrained outside diameter of the plunger must be small enough and the cylindrical wall 18 must be thin enough to avoid excessive radial pressure against the surrounding barrel and also to permit the plunger to be readily contracted in diameter to conform with barrels of a range of inside diameters or to fit a given barrel at various degrees of thermal expansion of the barrel. For

the two plastic materials suggested above, the thickness of the cylindrical wall 18 may be, for example, approximately in the range of .02 to .05 inch.

Whether the oversize of the plunger 15 relative to the barrel 10 increases or decreases with increasing temperature of the plunger and barrel depends on the relative coefficients of thermal expansion and this further consideration is taken into account in deciding upon relative dimensions. Thus when the above-mentioned preferred plastics are used for fabricating the plunger, the plunger has a higher coefficient of thermal expansion than the glass barrel and care is taken that the plunger is oversize relative to the barrel at the low limit of the range of temperatures in the contemplated use of the syringe. For example, if it is desired that the plunger fit the barrel with effective snugness over the temperature range of 10° C. to 80° C. the plunger will be dimensioned for oversize relative to the barrel at 10° C. since the plunger will expand faster than the barrel with rising temperature and will, therefore, maintain adequate radial pressure against the inner surface of the barrel throughout the temperature range.

In the particular construction shown in the drawings the plunger 15 is made in two parts. One part comprises the cylindrical wall 18 with the end wall 17 integral therewith. The open end of this cylindrical part is internally threaded to receive the threaded shank 19 of a handle piece 20. Preferably, the shank 19 of the handle 20 and the surrounding portion of the cylindrical wall 18 are united by a heat sealing technique. One advantage of such a sealed construction is that the resiliency of the body of air trapped inside the plunger is added to the resiliency of the plunger structure. In some instances it is desirable to trap the air at a pressure somewhat higher than atmospheric pressure. Obviously the hollow plunger may be constructed and fabricated in various ways.

The configuration of the wall 18 of the plunger may be that of a true cylinder but some practices of the invention are characterized by a graduated taper throughout at least a major portion of the working length of the plunger.

Fig. 2 shows a plunger, generally designated 25, which as viewed in longitudinal profile has a gradual taper that extends uniformly from the plunger handle 26 to the tapered nose 27. The taper represented by the angle "a" may be, for example, on the order of a one-half a degree. Preferably the minimum diameter of the taper adjacent the nose 27 is oversize with respect to the barrel with which the plunger is to be used.

In some practices of the invention, especially in the fabrication of relatively large plungers, it is contemplated that the plunger will be stiffened longitudinally by internal longitudinal ribs integral with the peripheral wall of the plunger. By way of example, Figs. 4 and 5 show a plunger, generally designated 30, having a handle 31, a tapered peripheral wall 32, and a short tapered nose 33. The peripheral wall 32 is formed with spaced longitudinal ribs 35. In the particular construction shown, the spacing between the ribs 35 is approximately equal to the width of a single rib.

A typical internally ribbed plunger, for use in a syringe barrel having an inside diameter of one inch, may, for example, taper at an angle of ½° to a minimum diameter of 1.05 inch to 1.10 inch adjacent the nose, these dimensions being taken at the lower limit of the contemplated temperature range. Such a plunger may have a wall thickness between the ribs on the order of .016 inch and a wall thickness at the ribs of .032 inch.

The addition of such internal longitudinal ribs substantially stiffens the plunger without corresponding increase in resistance of the plunger to radial contraction. When the plunger is contracted radially by insertion into the associated syringe barrel the material of the peripheral wall 32 deforms or flows in the spaces between ribs. The leading end wall of the plunger is free to bow slightly under radial compression but with the end wall thinner

than the longitudinal extent of the tapered nose as may be seen in Fig. 1, and with the diameter of the end wall somewhat less than the inside diameter of the surrounding barrel, there is little tendency for the end wall to bow.

Both the fluorinated polymers and nylon can withstand high temperatures for sterilization and both are inert chemically with respect to most fluids and both slide relatively freely in glass barrels. Teflon is outstanding in these respects. Teflon is especially advantageous because it has plastic memory so that a hollow plunger made of Teflon will remain its original shape when deformed by maltreatment.

It may be readily appreciated that the adaptability of the described hollow plungers with respect to fitting barrels of different diameters makes it possible to use relatively liberal manufacturing tolerances and yet permit interchangeability. Any given plunger will fit a range of barrel diameters over an extensive range of temperatures and will maintain an effective sliding fit with a given barrel notwithstanding irregularities in the barrel configuration. The hollow plunger has a constant tendency to return to the original unrestrained diameter and this tendency actually increases at the higher temperatures required for sterilization.

My description in specific detail of preferred practices of the invention will suggest to those skilled in the art various changes, substitutions and other departures from my disclosure that properly lie within the spirit and scope of my appended claims.

Having described my invention, I claim:

1. A plunger for use in a medical syringe barrel, said plunger being made of resiliently deformable material and being hollow to provide an interior space for radially inward yielding action whereby the plunger may be contracted from its inherent unstressed diameter through a range of smaller diameters, the inherent unstressed diameter of the plunger being greater than the internal diameter of the syringe barrel, with said range of diameters including the internal diameter of the syringe barrel so that the plunger may operate in the syringe barrel with radially outward pressure to insure a snug sliding fit and so that the plunger will maintain such sliding fit throughout a range of change of the internal diameters of the barrel and plunger caused by thermal expansion and contraction, said plunger having a continuous peripheral wall and an end wall at its leading end united thereto in a fluid-tight manner to seal off the interior of the plunger from the interior of the barrel when the plunger is in operating position in the barrel.

2. A plunger for use in a syringe barrel as set forth in claim 1 in which the plunger has a short tapered nose with a leading end diameter less than the internal diameter of the syringe barrel to facilitate insertion into the barrel.

3. A plunger for use in a syringe barrel as set forth in claim 1 in which the circumferential wall of the plunger has a surface of resinous fluorinated polymer.

4. A plunger as set forth in claim 3 in which said resin is polymerized tetrafluoroethylene resin.

5. A plunger for a syringe as set forth in claim 1 in which the plunger has a surface of a synthetic resin formed by the reaction of adipic acid and a diamine.

6. A hollow plunger as set forth in claim 1 in which is permanently sealed a gaseous fluid.

7. A plunger for a syringe as set forth in claim 1 which comprises a shell of generally cylindrical configuration with an integral wall closing the leading end of the shell and in which a handle member is seated in the other end of the shell.

8. A plunger for a syringe as set forth in claim 1 in which the plunger has a gradual taper extending over at least a major portion of its working length with the minimum diameter of the taper at the leading end of the plunger.

9. A plunger for a syringe as set forth in claim 8

in which said minimum diameter is greater than the inside diameter of said barrel at a relatively low temperature of the plunger and barrel.

10. A plunger for a syringe barrel as set forth in claim 9 in which the leading end of the plunger has a nose tapering to less diameter than the inside diameter of the barrel.

11. A plunger for a syringe barrel as set forth in claim 1 in which the plunger has the general configuration of a thin-walled cylinder for relatively high peripheral resiliency and to provide a relatively large internal space for radially inward yielding action.

12. A plunger for a syringe barrel as set forth in claim 11 in which said plunger is formed with circumferentially spaced internal longitudinal ribs for increase in the longitudinal rigidity of the plunger with relatively little increase in resistance to radially inward yielding of the plunger wall.

13. A plunger for a syringe barrel as set forth in claim 12 in which the leading end of the plunger is tapered to a diameter less than the inside diameter of the barrel to form a nose for facilitating insertion of the plunger into the barrel.

14. A plunger for a syringe barrel as set forth in claim 1 which has a relatively thin peripheral wall formed with circumferentially spaced internal longitudinal ribs and in which said peripheral wall is gradually tapered throughout at least the major portion of the working length of the plunger.

15. A plunger for a syringe barrel as set forth in claim 14 in which the leading end of the plunger is tapered to a diameter less than the inside diameter of barrel to form a nose to facilitate insertion of the plunger into the barrel.

16. A hollow plunger as set forth in claim 1, which is of sealed construction to prevent the entrance of fluid into either end of the plunger.

17. A plunger for use in a medical syringe barrel, said plunger being made of resiliently deformable material, said plunger being hollow with sealed walls for permanently confining fluid therein; and a body of gaseous fluid permanently trapped inside said plunger and completely cut off from the exterior of the plunger at all times, said gaseous fluid being under greater than atmospheric pressure to place the circumferential wall of the plunger under stress, the outside diameter of the gas-filled plunger when the plunger is out of the syringe barrel being greater than the internal diameter of the syringe barrel whereby the plunger, when in the barrel, is contracted by the barrel and presses radially outward against the barrel in a fluid-tight manner.

18. A plunger for use in a medical syringe barrel, said plunger being made of resiliently deformable material, said plunger being hollow and having a conical circumferential wall providing a gradual outside taper extending over at least a major portion of its working length with the minimum diameter of the taper at the leading end of the plunger, the unrestrained minimum working diameter of the plunger being greater than the inside diameter of said barrel.

19. A plunger for a syringe barrel as set forth in claim 18 in which the leading end of the plunger has a nose tapering to less diameter than the inside diameter of the syringe barrel.

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