

Aug. 19, 1958

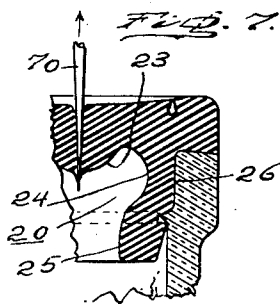
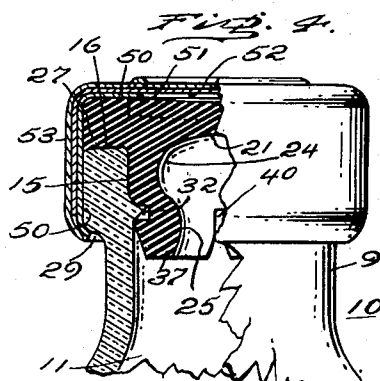
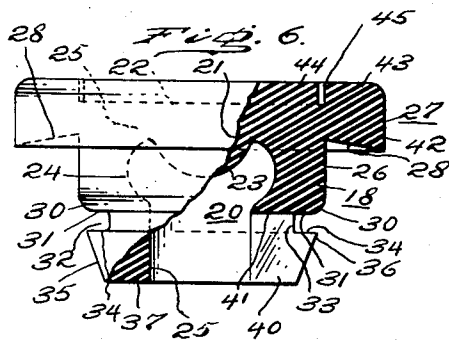
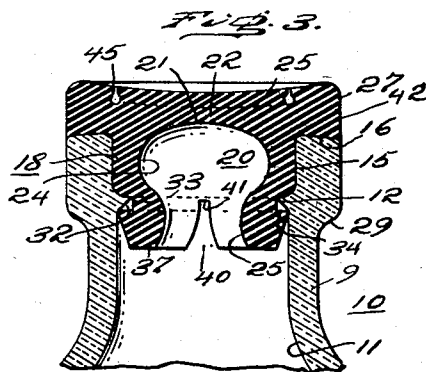
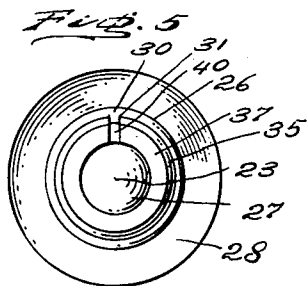
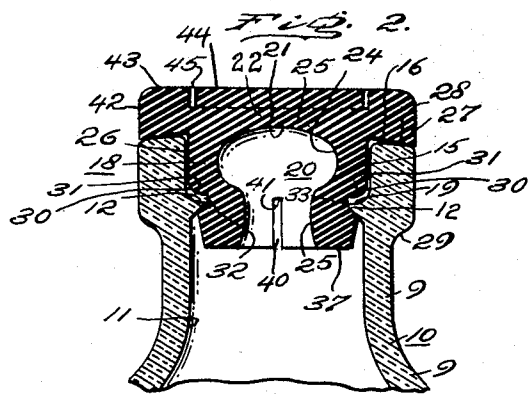
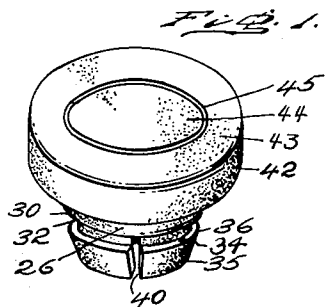
C. J. JESNIG

2,848,130

PRESSURE RESISTANT CLOSURES

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4 Sheets-Sheet 1



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Aug. 19, 1958

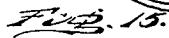
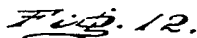
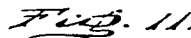
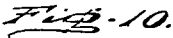
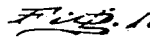
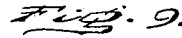
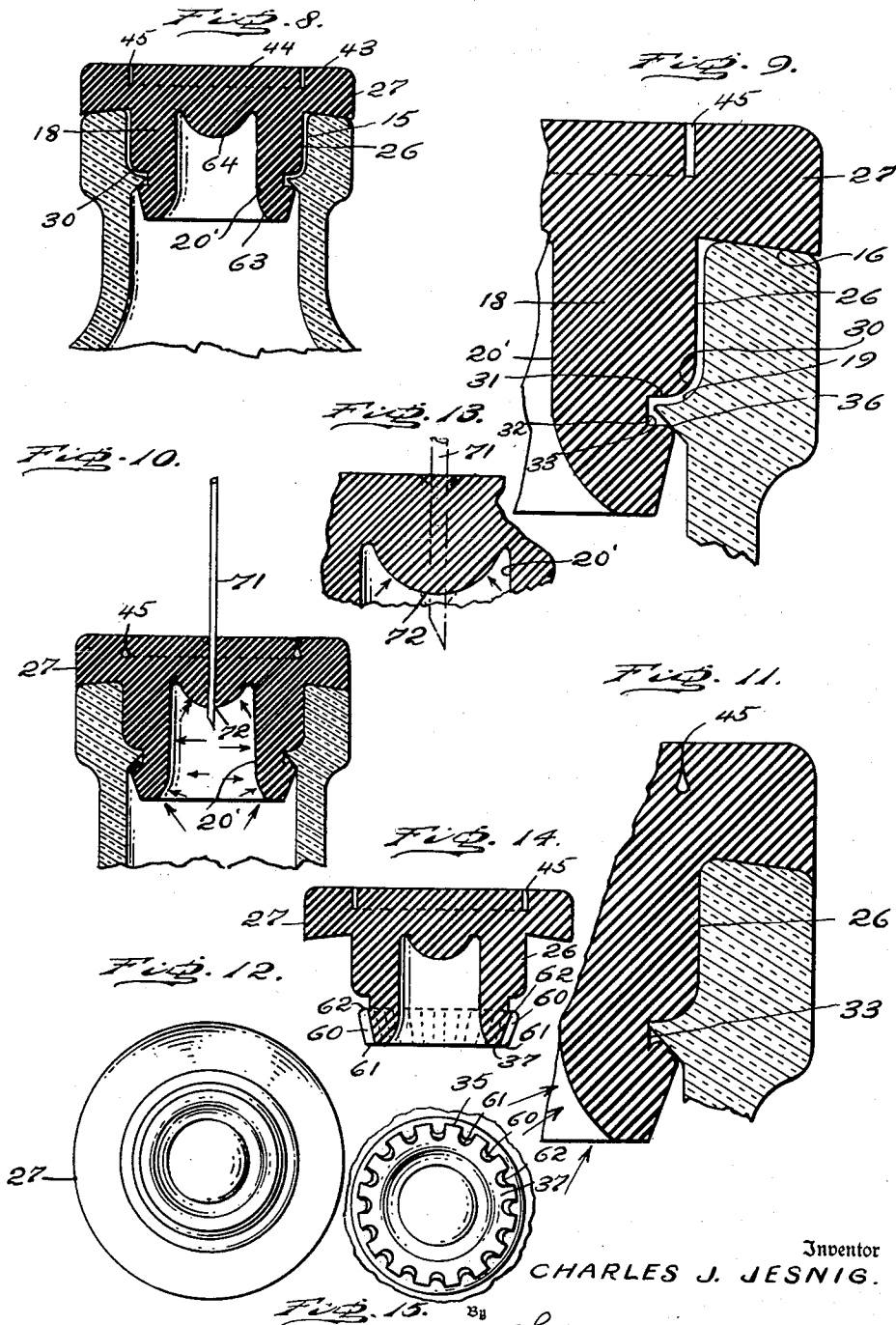
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2,848,130

PRESSURE RESISTANT CLOSURES

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4 Sheets-Sheet 2



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PRESSURE RESISTANT CLOSURES

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4 Sheets-Sheet 3

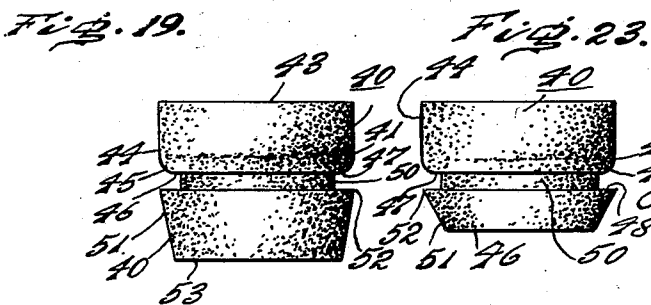
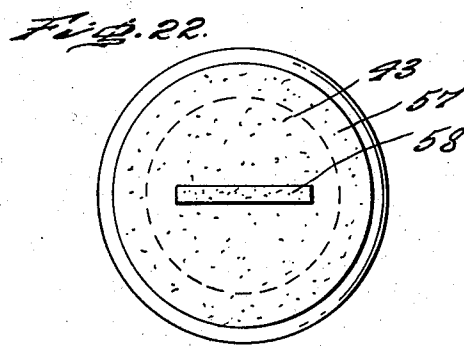
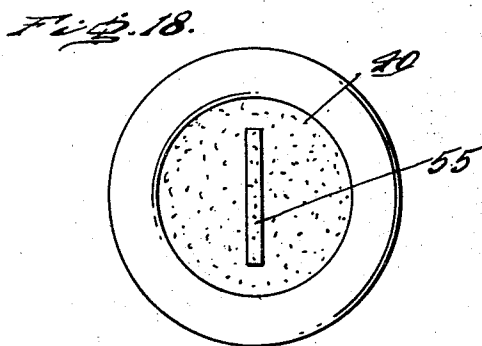
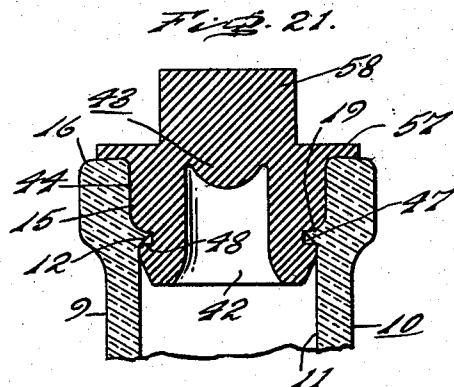
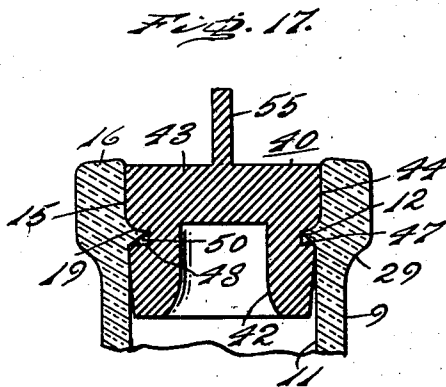
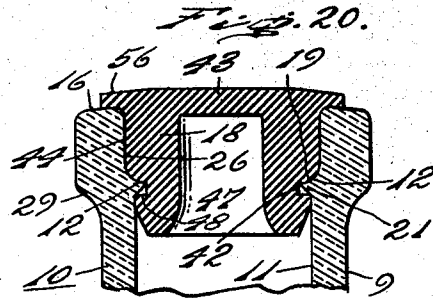
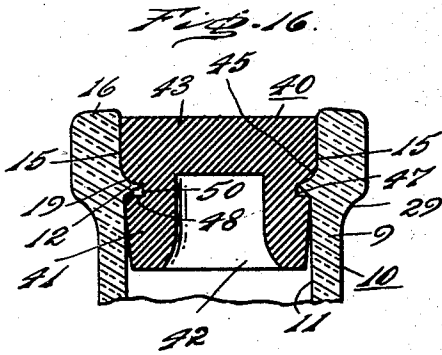
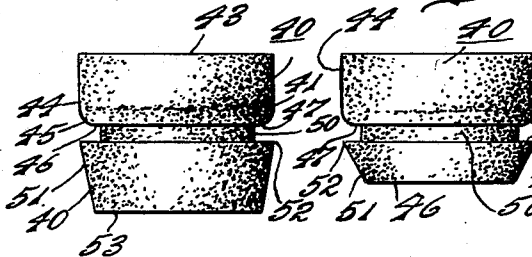


Fig. 23.



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Fig. 24.

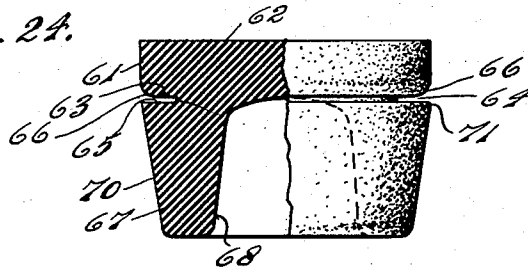


Fig. 25.

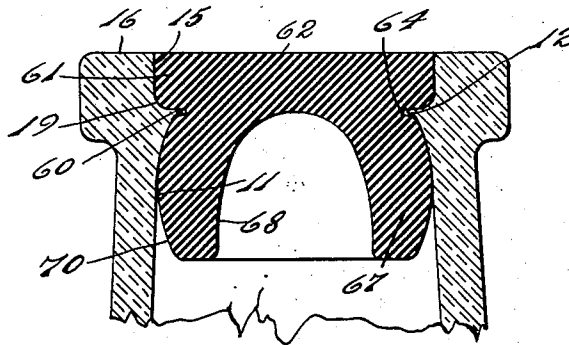
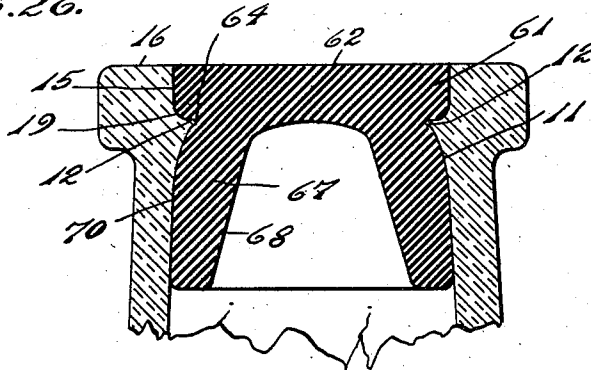


Fig. 26.



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2,848,130

PRESSURE RESISTANT CLOSURES

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Application October 7, 1953, Serial No. 384,687

3 Claims. (Cl. 215—31)

This invention relates to closures, including vacuum closures for bottles and the like.

In my earlier filed application, Serial No. 36,222, now abandoned, I disclosed an improved bottle and sealing plug closure invention, particularly adapted for evacuation and the maintenance of the created vacuum. This invention is not only of general interest in packaging, but also it is especially of interest in the pharmaceutical and biological fields, such as for packaging serums, antibiotics, and the like. It is a feature of the invention of that recited application to combine an inner ring on the neck of the bottle with a flanged rubber plug-insert grooved to engage the ring and having a flange arranged for overlying the end of the bottle as a sealing element. The assembly, after evacuation, was preferably provided with a metallic retaining tear-off closure which was spun on the bottle and anchored thereto by an external bead or shoulder on the neck thereof.

This present invention constitutes an improvement on the invention of said application, and in the art of closures, including vacuum closures generally.

It is among the objects of this invention to provide a valve and glass or like bottle assembly in which the valve can be anchored in the glass and be capable of maintaining a substantially complete vacuum; to provide a valve insert for a ringed bottle neck having two separate and independent sealing surfaces to enhance the seal of the valve; to improve the art of packaging, especially in the pharmaceutical and biological fields; to provide an improved valve element for glass and like containers by which a hermetic seal is accomplished internally of the neck of an associated bottle; to provide a valve and bottle combination in which without evacuation, if desired, a hermetic seal is established between the bottle and valve; to provide a valve unit and bottle by which a vacuum can be established by means of a needle passing through the valve unit, which latter is self-sealing to maintain a vacuum when the needle has been withdrawn; to coordinate the dimensions of a production line of molded bottles having an internal neck ring with a molded resilient valve unit having an anchoring groove for interlocking engagement with such neck ring so as to anchor the valve unit against undesired retraction while holding a flange element of the valve in sealing engagement with the end of the bottle neck; to improve the art of molded bottles; to provide an improved closure for bottles by which internal pressure higher than atmospheric can be built up or developed within the bottle or like container without leakage or loss of such internal pressure through or about such closure; to provide an improved closure for bottles disposed for sublimation of the contents; to provide a bottle and closure plug organization in which the plug enters the neck of the bottle and effects sealing interlocking engagement with an internal neck ring on the bottle without any flange overlying the end of the bottle neck; to provide a bottle and plug organization by which the expensive metal tear-off elements previously necessary

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in packaging certain types of goods is dispensed with; to provide a plug closure for special bottle necks which is more economical to produce than any of the prior art closure which it replaces; to provide a closure plug for bottle necks fitting within the bottle neck and without a flange whereby many more of the plugs can be made in a mold in a single common heat; to provide a closure plug comprising a shank having a peripheral groove separating upper and lower peripherally continuous sealing surfaces for interlocking and sealing engagement with a tapered internally projecting neck ring in a bottle neck; to provide a closure plug comprising a shank having a peripheral groove defining on the lower edge a generally sharp peripherally continuous shoulder for engagement under the internally projecting tapering neck ring to anchor the plug in the bottle neck and in which without any supplemental fastening means the plug remains anchored despite the build up of internal pressures as may be incident, for instance, to the insertion of a physician's needle for forcing air into the bottle to furnish pressure for withdrawal of bottle contents into a hypodermic needle, with enhanced interlocking and enhanced sealing so that the pressure is retained and the interlock of the plug and the bottle is maintained and so that the plug is not forced out of the bottle neck by such pressure; to improve the art of packaging, especially in the pharmaceutical and biological fields; to provide an improved plug element for glass and like containers by which a hermetic seal is accomplished internally of the neck of an associated bottle; to provide a closure and bottle combination in which a hermetic seal and anchorage is established between the bottle and closure by mere insertion of the closure; to provide an improved closure for bottles by which internal pressures higher than atmospheric can be built up or developed within the bottle or like container without leakage or loss of such internal pressure through or about such closure; to provide a closure for bottle necks having anchoring interconnections and so disposed that no leverage exerted by a closure-penetrating needle can pry out the closure; to provide a flangeless stopper plug and bottle combination, requiring no "tear-off," which can be autoclaved without leakage, seepage, or disruption of the continuity of its hermetic sealing; and other objects and advantages will become more apparent as the description proceeds.

In the accompanying drawings:

Fig. 1 represents a perspective view of the preferred embodiment of the improved valve of this invention;

Fig. 2 represents a fragmentary vertical section through a portion of a bottle with the valve insert in position engaging the internal ring in the neck of the bottle and thus anchored to the bottle in the mouth thereof prior to the evacuation of air from the bottle;

Fig. 3 represents a similar fragmentary vertical section of the same parts after the internal evacuation of the bottle has been completed and the atmospheric air externally effective on the valve has partially distorted the valve in sealing same upon the bottle, showing the changed relationship of the anchoring groove of the valve on the fixed ring or internal bead of the bottle, by which the upper surface defining an anchoring groove of the resilient valve establishes sealing contact with and against the internal ring in the bottle neck, and the valve shank expands radially under the pressure to tightly engage against the inner walls of the neck of the bottle above the inner ring thereof;

Fig. 4 represents a similar fragmentary vertical section through the same parts after the enclosing, flange-anchoring "tear-off" cap has been spun thereon under axial pressure, forcing the lateral flange of the valve tightly against the bottle end in hermetic sealed relation thereto;

Fig. 5 represents a bottom plan view of a modification of the valve unit of Fig. 1;

Fig. 6 represents a fragmentary vertical section through the valve of Fig. 5 on an enlarged scale;

Fig. 7 represents a fragmentary section through a still further modified form of the invention;

Fig. 8 represents a fragmentary section through the neck end of a bottle with a modified, unventing, form of closure plug anchored therein and effecting a hermetic seal without either an internal vacuum or internal pressure;

Fig. 9 represents a fragmentary enlarged section of the assembly of Fig. 8 illustrating the general surface relations of the bottle and closure;

Fig. 10 represents the same fragmentary assembly as Fig. 8, but with an internal pressure produced by pumping air through a hypodermic needle, for instance, showing the expansion and enhanced hermetic sealing relation of the closure and bottle neck end;

Fig. 11 represents a fragmentary enlarged section of the assembly of Fig. 10;

Fig. 12 represents a bottom or reflected plan of the modified form of closure illustrated in Figs. 8 to 11, indicating and emphasizing the absence of venting means therein;

Fig. 13 represents a fragmentary section of the closure web showing in dotted lines the distortion occurring when a hypodermic needle is forced through the convex end of the web, with enhanced sealing of the puncture upon withdrawal to hold the added or inserted pressure against leakage through the closure;

Figs. 14 and 15 represent respectively a vertical transverse section through and a reflected plan of a still further modified form of closure according to the invention, having enhanced venting.

All of the foregoing are taken from application Serial Number 122,425, filed October 20, 1949, now abandoned, and of which this application is a continuation-in-part.

Fig. 16 represents a fragmentary section through a bottle neck and modified form of plug in which the plug has no flange and still effects complete sealing even under built up pressures internally incident on the plug, and further which has such degree of interlock and such skirt length that any incidental cocking of an inserted hypodermic needle is unable to cause undesired withdrawal of the plug even in the presence of internal preponderating purposes.

Fig. 17 represents a similar section of a slightly modified form of plug in which a thin web handle is provided by which the flangeless plug can be forcibly withdrawn from the bottle neck.

Fig. 18 represents a plan of the organization shown in Fig. 17.

Fig. 19 represents a side elevation of the plug closure of Fig. 16.

Fig. 20 represents a fragmentary section of a still further modified form of plug closure having a small and thin flange overlying the end of the bottle.

Fig. 21 represents a fragmentary section of a still further modified form of plug closure having both a thin flange and a web handle for desired retraction of the plug from the bottle neck.

Fig. 22 represents a plan view of the latter.

Fig. 23 represents a side elevation of another form of plug of shorter skirt than that of Figs. 16 and 19.

Fig. 24 represents a side elevation, partially in section, of a still further modified form of the plug.

Fig. 25 represents a section of the plug of Fig. 24 in anchored position in a bottle neck shown in section.

Fig. 26 represents a similar section after autoclaving of the organization of Fig. 25.

The bottle 10, forming the preferred but illustrative, substantially transparent, container for the goods to be sealed either out of or in vacuo, or under pressure, is preferably of glass and is molded as a production line of

automatically molded relatively heavy-necked articles. Obviously, other materials may be used in the container, such as plastics or the like, but glass is at present considered best for general purposes.

The bottle 10 has a neck 9, delineated internally by the lower surface 11, leading downwardly into and becoming the interior surface of the bottle, which starts at the edge of the internal radial bead or ring 12, formed part way down in the neck of the bottle spaced from the end 16 thereof. The neck 9 is completed by an upper internal surface 15, starting at the edge of the internal bead or ring 12 and extending upwardly, generally cylindrically, to the transverse end surface 16 at the mouth entrance of the bottle. In practice it is frequently found that the end surface 16 is not exactly normal to the axis of the neck of the bottle, but has a slight taper or flare creating in section a frustum of a cone. This has been exaggerated in the drawings to make this structure known, although in actual practice the angle of the surface 16 in any radial section therethrough relative to the longitudinal axis of the bottle in departure from the truly perpendicular or normal is usually a very few degrees. The ring or bead 12, interrupting the internal surfaces 11 and 15, is an accurately formed peripherally continuous internal projection, the dimensions and clearance of which from the end of the bottle mouth are correlated to the dimensions of the closure to be described. The neck ring 12 is generally tapering out of the surfaces 11 and 15, and preferably having, upwardly at least, a transversely curved surface merging into the neck surface 15 in a tangent thereto, to form a curved sealed surface 19, terminating toward the axis of the bottle in a relatively thin edge. The actual shape of the inner ring or bead in section axially of the bottle neck is not critical, although the upwardly curved seating surface thereon is preferred, shaped complementally to the surface of the valve above the anchoring groove thereof, as will be explained. The length of surface 15 and the internal diameter of neck ring 12 are both such as to comport with certain dimensions of the closure to be described. The mouth end of the bottle, externally at the outer end of the neck, is provided with a bead extension of the end surface 16, forming a lateral projection having a downwardly presenting shoulder 29, with which a metal cap enclosure can be engaged by spinning or the like, as shown in Fig. 4. The bottle as described can be made in any size, even as small as 10 cc. and as large as desired, even of 600 cc. or more. This bottle is substantially standard for all types of closures as later described, and is a high production molded unit, having uniformity, cheapness and adequate accurate internal bead proportions.

For operative association with the bottle as just described, a unitary plug closure in the form of a valve button or unit is provided, differing in certain details which will be pointed out, according to the functional advantages sought. It will be understood that broadly there are two primary divisions between the closure plugs. One division is directed to the broad proposition of maintaining a seal under a vacuum. This is exemplified by Figs. 1 to 7 inclusive, of which the latter is a modification. A still further modified form thereof is illustrated by Figs. 14 and 15, which comprises the preferred form in that in addition to the establishment and maintenance of a high vacuum similar to that of Figs. 1 to 6, it permits the rapid passage of gases past the closure, at least in contrast to that of Figs. 1 to 6, and is therefore of value in the art of subliming with the contents of the bottles held under vacuum during freezing. The second division among the plugs is comprised of ordinary sealing plug-closures which are automatically held in anchored relation to preclude undesired retraction while establishing at least one substantially hermetic seal regardless of the presence or absence of differential pressures internally and externally of the bottle. This second division is also of primary importance in maintain-

ing a hermetic seal during the introduction of pressure into the bottle to facilitate withdrawal of the contents, as will be explained later herein. The description will first take up and deal with the vacuum type of closure.

The valve element, in all forms of the invention shown in Figs. 1 to 15 inclusive at least, comprises a hollow lower shank 18 and an upper flange 27 having together the general outline of a T, in elevation, modified in important detail to be pointed out, and preferably comprises a unitary hollow molded-rubber or like resilient element. The shank 18 of the valve is hollow, as noted, and is of such thickness as to afford sufficient strength for the reception or assimilation of compressive and expansive forces to be described.

The shank 18 is rendered hollow by an axial recess or bore 20, in the preferred form, open at the lower end and closed at the upper end by a transverse web portion 22 integral and continuous with the shank. The web 22 will be of the desired relative thickness as to conduce toward the desired functioning under differential pressures, as will be explained, and will be contoured in accordance with desired local results. Thus, in the form of invention in which the main purpose is the maintenance of differential internal and external pressures, whether internal vacuum or internal pressures, and without the adaptability for repeated penetrations by a hypodermic needle, the inner upper surface delineating the axial bore is formed of a generally flat or, and preferably, a concave surface 21. Where repeated penetrations by a needle are contemplated or are to be expected in the use of the container, the inner upper surface delineating the end of the axial bore is formed of a convexity 23, of the order of at least a segment of a sphere, as indicated in Figs. 5, 6, and 7, for instance. The axial bore may comprise the generally cylindrical bore 20' shown in Figs. 8 to 13 especially adapted to receive internal pressures to expand the shank into enhanced interlocking engagement with the internal neck ring or bead of the bottle, as will be explained, or it may comprise the internally laterally enlarged generally semi-spherical undercut surface 24 merging at the internal upper end of the preferred concave surface 21, and at the lower end constricting into the axial bore extension portion 25, as indicated in the forms of the invention shown in Figs. 1 to 7, relating to vacuum type closures. The surface 25 may comprise the substantially cylindrical surface indicated in Fig. 6, or the bore extension may be flared outwardly, as shown in Figs. 2, 3, and 4. Externally, the shank 18 comprises a straight concentric cylindrical portion 26, which merges angularly at the upper end into the laterally extending flange 27, having the outwardly inclined or downwardly sloping lower surface 23. Toward the lower end of the shank, transversely below the level of the lower portion of the bulbous inner surface portion 24, the external cylindrical portion 26 curves inwardly in a sealing shoulder 30, leading tangentially into the planar substantially horizontal radial sealing surface 31. The undercut surface 31 delineates one side of a peripheral recess or groove 32. The groove may be a substantial V in cross section, if desired, but is preferably rectangular, and is radially defined by the short axially extending cylindrical surface 33. The lower surface of the recess 32 is defined by the horizontal wall 34 generally parallel with the surface 31 which forms at and adjacent to the peripheral edge 36 thereof the hooking or anchoring surface of the valve unit. The hook edge 36 is formed by the angular intersection of the inclined generally axial guide surface 35 of the valve with transverse wall 34. The lower end of the valve is completed by the transverse surface 37 extending radially between the lower end of the sloping guide surface 35 and the inner cylindrical surface 25 of the valve. In the vacuum type of closure, venting means is provided for establishing communication between the interior of the container and the upper

surface 31 of the anchoring recess 32. While this may take any desired form, a simple structure is comprised of the axially extending slot 40 extending through end surface 37 to termination in a line or area 41 radially co-extensive with sealing surface 31, and extending radially of the valve from communication with the inner surface of the recess 23 through the anchoring and guide portion 35 and 36.

In the modified form of vent, illustrated, for instance, in Figs. 14 and 15, the external tapering guide surface 35 is interrupted peripherally by the plurality of venting channels 60, extending parallel to the surface 35 and having entrances 61 at the lower end in the surface 37, and extending to exits 62 in the surface 34. In this case, the venting is not from the interior of the valve unit, but axially from the end thereof to communication with the lower surface of the groove 32 adjacent to neck ring 12, from which venting gases find their way axially along the cylindrical surface 26 to passage beneath the flange 27. This form of venting plug closure is applicable to any vacuum-producing and holding uses in closures, but is particularly adapted for sublimation in which the frozen contents of the container are exposed to external vacuum for many hours, during which the moisture therein is evaporated through the channels 60.

In order to secure the desired cocking of the lower surface 28 relative to the purely radial, the flange 27 is preferably slightly thicker at the peripheral edge 42, than it is in axial alignment with the external cylinder 26. The upper flange surface 43 is initially in a common plane containing the upper surface 44 of the central "island" or semi-detached central portion formed in part by the web 22 and delineated by the annular groove or recess 45 extending normal to the surfaces 43 and 44, well down toward the shank 18. To control distortion under stress, one wall of annular groove 45 is preferably aligned with the outer surface 26 of the shank.

In use, the sterilized bottle is filled with the material to be packaged, to the desired level, then the sterilized valve is inserted axially into the neck. The insertion is facile because the slot 40, or channels 60, assist the entering guide portion to be readily collapsible upon itself, through reaction between guide surface 35 and ring 12, and the sloping guide surface steers the advancing end of the valve past the inner bead or ring 12, until the groove 32 registers generally with the bead 12, and the latter snaps into the groove and the valve and bottle assume the general relative position indicated in Fig. 2. At this point, the outermost peripheral portion of the flange 27 at least has engaged the outermost areas of the bottle end 16, and the hook portion 36 has engaged beneath and anchored the valve to the bead 12. The axial length between flange surface 28 and groove surface 34 is preferably predeterminedly a little shorter than bottle surface 15 and neck ring 12, so that when first inserted as in Fig. 2, flange 27 is hermetically sealed resiliently against bottle surface 16, although, at this juncture, if desired, the shoulder 30 may be out of sealing engagement with neck ring 12. Alternatively, the shoulder 30 may be resiliently pulled into hermetic sealing engagement with neck ring 12 when the plug is initially inserted to anchored connection, in addition to the seal from flange 27.

With the valve in the bottle neck in the position indicated in Fig. 2, the bottle is either individually, or as one of a larger group of similar bottles, subjected to sharply lowered external atmospheric pressures. This permits the relatively higher pressures internally of the bottle to expand, and, passing through the vent 40 or channels 60, to pass under the sealing surfaces 31 and 30, and between said surfaces and the ring 12, from whence they move axially along the outside of the cylindrical portion 26, and between flange 27 and the end of the bottle. This venting is facilitated by the loose engagement between the internal sealing portions of the valve and bottle. In other words, there is an initial predetermined clear-

ance between the surfaces 15 and 26 in the vacuum form of closure, greater than in the pressure plug type thereof. During the evacuation of the interiors of the bottles, the valve remains anchored in the neck, by the engagement of the enlarged hooked portion of the valve within ring 12. After the desired extremely low pressures have been attained internally of the bottle, the previously equal or lower external pressures are more or less suddenly returned to atmospheric pressure, which, being effective on the end surface of the valve, manifested as weight, i. e. the weight of the column of air creating the atmospheric pressure at the particular instant altitude, which is a substantially permanent measurable factor, causes pressure which pushes the flange of the valve against the bottle end surface 16, and, of greater importance, pushes the deformable central plug, defined by the moat or groove 45, the end web 22 and the tubular cylinder 18 axially inwardly. This moves the parts from the relative positions of Fig. 2 into the relative positions of Fig. 3. At this juncture, several important events have transpired, the most important of which is that the central semi-detached plug portion bounded by the groove 45 has moved inwardly and the upper central surface of the valve assumes the concave or dished appearance of Fig. 3. The annular slot or groove 45 defines the thickness of a web of reduced thickness, by which relative flexing can occur between the central plug portion and the outer flange 27, so the latter remains pressed tightly against bottle end 16. The central plug therefor forces the shank 18 axially downwardly until the surface 31 and rounded corner 30 engage and seal against the rounded upper surface 19 of the bead 12. Owing to the preferred internal configuration of the valve shank, the axial pressure on the shank between the upper flange and the line of sealing valve seat engagement on ring 12 causes the valve shank 18 to expand, forcing the outer surface 26 thereof tightly against the inner surface 15 of the bottle neck. This may be accompanied by the movement of the anchoring portion 35 and 36 of the valve unit downwardly slightly away from the lip or bead 12, but this makes no difference as its anchoring function at this point is not needed. It will be seen in Fig. 3 that the flange 27 has been slightly flattened out and has been forced into sealing engagement with the end surface 16 of the bottle, as a secondary seal. However, in an evacuated bottle this flange sealing is additive and while helpful, is not essential, as under certain conditions the flange may be dispensed with while maintaining the internal seal as described, as shown, for instance, in Figs. 16 to 19 inclusive and Fig. 23. However, for long shelf life of the packaged material, and for maintenance of the existing compound sealed arrangement, and especially for use as an ordinary cork or sealing plug, without necessarily evacuating the bottle fluid content, the flange is preferred. This flange conduces to the tear-off sealing arrangement shown in Fig. 4 or of any other type. With the sealed arrangement as completed by the evacuation, resulting in the disclosure of Fig. 3, a compound metallic foil sealing device of any desired sort is provided. Illustratively this comprises a permanent inner seal 50 having the upper axial opening 51 and the lower end spun over the shoulder 29. This mounts the removable closure cap 52, which when released can be manually removed or replaced. The two enclosures just mentioned are held in anchored relation upon and about the bottle end, compressing the flange 27 against the end of the bottle by the outer tear-off portion 53, also spun over the neck 29. The pressure against flange 27 is produced by mechanical means and is additive to any flattening due to air weight and pressure, and contracts the outer flange 27 against the bottle end surface 16. This magnifies and enhances the pressure on the cylinder 18 in the bottle neck and against the neck ring 12. Obviously, a single layer or thickness of tear-off can be used with the evacuated bottle and valve of this invention. The valve and

bottle assembly with an aluminum or like enclosing seal forms a perfect sealed and closed bottle, even without evacuation.

In use, after filling and sealing as described, and any necessary shipment and storage, the outer tear-off is removed. The manually slidable cap is then removed, exposing the end web 22 of the valve through the cap aperture 51. Without any other disruption of the sealed end, a needle can be inserted through the web and into the contents of the bottle for venting the vacuum and then for withdrawing the sterilized contents. Of course, if this is not desired, the tear-off can be completely removed, the flange 27 can be forced up away from the bottle end and the valve manipulated sufficiently as to permit the higher external atmospheric pressure to pass under the sealing surfaces 30 and 31 over ring 12 to the venting slot 40 or channels 60, and into the bottle, until the internal and external pressures equalize, after which the valve can be removed preliminary to withdrawing part or the entire contents of the bottle from the bottle.

In certain cases the venting means is comprised of a suction needle 70, inserted through the self-sealing web 22 of the valve unit otherwise having no venting slot or related means, and withdrawing the entrapped air thereby. After complete evacuation, the needle is withdrawn and the aperture which it had formed in penetrating the web closes together and completes the sealed bottle closure of an evacuated bottle.

In the various manifestations of the invention heretofore described, the invention has been considered from the standpoint of its being a closure for an evacuated container. This is an important phase of the invention, but it will be seen that the provision of a closure which is anchored within the bottle neck, regardless of the question of evacuation, is itself a great advance in the known art, of especial importance in the biological, pharmaceutical and related fields. In these fields there are many preparations which do not require vacuum packaging, but they do require packages having the ability to withstand internal pressures without leakage or seepage of material, in facilitating withdrawal of the supposedly sterile contents of the bottles. An illustrative but typical use of such closure and bottle assembly is in the dispensing of a presently important penicillin derivative. This is provided as a liquid and is bottled in the presence of sterile atmospheric air at normal atmospheric pressures. The closure must not only be so tight as to hold air pressure within the bottle as it builds up, it must also be capable of receiving a multiplicity of needle penetrations without forming a path for leakage therethrough. It must also be such a sealing assembly as to prevent seepage of the material past the plug closure prior to the final bottling in order to minimize the spoilage of the contents by contact with untreated atmosphere. The plug closure illustrated in Figs. 8 to 12 is particularly adapted to serve all of these functions, as, of course, if desired, is the closure illustrated in Fig. 7.

The plug and bottle assembly of the just recited figures is identical externally in every way, and bears the same reference characters as the previously described closures, except that there is no vent provided therein, and the inner bore is generally cylindrical in the upper portion, as indicated at 20', merging at the lower portion into the outwardly flared curved surface 63. At the upper end the bore is preferably closed off and defined by the downwardly extending convexity 64, although, if desired, the concave surface of the earlier figures may be used.

The external diameter of the cylindrical surface 26 of the latter figures is closer to the diameter of the neck surface 15 than in the venting types previously described, so as more easily and quickly to contact and seal same. After the bottle has been filled to the proper level the closure plug of Figs. 8 to 11 is inserted under axial tension from above so as to cause the anchoring lip or rim 36

to engage on the under side of the neck ring 12. At this stage the plug is held in the bottle as shown in highly exaggerated fashion in Fig. 9. However, the plug closure is predeterminedly such in length that with the anchoring rim 36 engaged against the under surface of the neck ring 12, the flange 27 is pulled into resilient engagement against the end 16 of the bottle to hermetically seal the bottle. If desired, the dimensions thereof are so proportioned that when the locking rim 36 engages the neck ring 12, the sealing shoulder 30 is pulled against the upper sealing surface 19 of the neck ring 12 and inner circumference 15 of the bottle. Usually in due time after the insertion of the closure plug in the filled bottle, the assembly is held together by an automatically applied and spun metal closure element, such, illustratively, as shown in Fig. 4. This assists in forcing the closure plug axially inward to sealing in the bottle.

In due course the physician acquires the sealed bottle and in order to fill a hypodermic needle with a predetermined measured volume of the contents, the hypodermic, with a measured volume of air in the cylinder thereof, has the needle thereof forced through the web 22 and out through the convex surface of the protuberance 64, as shown in Figs. 10 and 13, with the bottle held in a vertical position with the closure at the top. The hypodermic is then discharged and the air entrapped therein is forced under pressure into the bottle. The plunger of the hypodermic is held in place while the bottle is inverted to a reversed vertical position. The plunger is then retracted, or permitted to be forced in retraction, as the entrapped air under pressure in the bottle forces the liquid constituent through the needle 71 and into the cylinder following the plunger. The needle is then withdrawn, the aperture 72 in the plug end substantially seals itself, some of the air pressure remains in the bottle ready to be augmented or used as it may remain for the withdrawal of the next "shot." Usually additional air is forced in just ahead of each "shot" withdrawn.

The plug is particularly well adapted for the reception and retention of internal pressure, in that it expands and enhances the tightness of the seal. As the pressure is manifested at right angles to the surface upon which it is incident the internal flared surface 63 under pressure pushes the lower end of the shank outwardly against the bottle to enhance the anchored lock with the neck ring. Simultaneously, the shank 18 expands to force the groove 32 into tight sealing engagement with the neck ring and the sealing surfaces thereof and the inner circumference 15, to assist in retaining the built up pressure without permitting the pressure to blow the plug out of the bottle. It is a feature that although the planar or concave upper surface of the internal bore of the valve unit assists in concentrating the last drops of material for entrance into a hypodermic needle, the internal pressure includes a component axially effective on the plug to urge it to move out of the bottle neck. This is minimized by the preferred convexity shown, as, although a small volume of fluid may exist and be incapable of withdrawal from the ring between the cylindrical bore and the adjacent edges of the convexity, this is relatively infinitesimal, whereas the pressure on the convexity is absorbed within or close to the convexity without the same axial component as would exist in the planar end of the web, and with the interesting and important forcing of the sides of the apertures 72 together to enhance the sealing of the needle apertures. The advantages of this form of the invention, as well as the obvious modifications thereof to attain the same or generally similar results will be understood.

In connection with the packaging of pharmaceutical products and the like, according to certain past practices, a plug is provided, of generally cylindrical or slightly tapered shank extent, merging at its upper end into a transverse relatively thick flange projecting radially of the shank and overlying the end of the bottle neck, and held

in place by a spun over "tear-off" similar to that shown in Fig. 4 herein. It will be understood from the previous discussion that this is at best highly expensive, and as pointed out hereinafter has certain inevitable disadvantageous features militating against successful use.

The previous plug organization mentioned enters a smooth generally cylindrical neck of the bottle, with as tight a frictional fit as is feasible for facile insertion, and reliance for sealing is laid upon the clamping action of the metal tear-off forcibly engaging the resilient flange with the end of the bottle. The only actual practical seal, if any, in this prior art organization, is between the stopper flange and the bottle end, and the shank contributes but little sealing effects. In any case, to prevent blowing the stopper out of the bottle under built up pressures, the relatively thick flange and the metal tear-off are absolute essentials, but, as will be discussed, it is not necessarily a seal, and leakage or seepage of the contents and contamination thereof can occur, even with the flange theoretically clamped against the end of the bottle neck. The minimization of the sealing effects is due to several variable factors, some of which attach in some degree to practically every production line of molded bottles. The end of the bottle neck, against which the flange is supposed to seal, while nominally and superficially lying in a plane normal to the axis of the bottle neck, may not lie in a true and exact plane, but, peripherally considered, may comprise relative "highs" and "lows." The outer periphery of the neck itself may not be truly cylindrical, but may be slightly oval. The downwardly presenting shoulder on the outer periphery of the bottle neck upon which the tear-off is to be spun may also have relative "highs" and "lows" and may not have a parallel planar relation with the supposed end plane of the bottle. Sometimes, also, the internal surface of the bottle neck may depart from the truly cylindrical toward the slightly oval. These fluctuations in the theoretically perfect bottle vary between bottles and are unpredictable and seem to be incidental to shrinking and warping in the production line of molded bottles.

When the molded stopper or plug of rubber or the like is inserted in the neck of the bottle and the flange is moved into contact with the end of the bottle neck, there may be a relative filling up of part of the bottle neck by the shank, but this may be less than that required to preclude a thin passage along the shank to and under the flange. This thin passage may be present at all times, or may be a latent weakness, simply waiting the application of force to develop. The "tear-off" is usually applied by a machine adjusted for the imposition of a given axial pressure on the end of the "tear-off," maintained as the latter is telescoped over the bottle neck and the outer flanged end of the stopper, while the lower or terminal edge of the tear-off is spun in against the downwardly presenting shoulder of the bottle neck. Owing to the unpredictable disparity of heights of adjacent bottles in a series, the axial pressure from the preset pressure element of the "tear-off" applying device varies between bottles. Owing to the relative highs and lows of the end surface of the bottle, the relatively thick flange of the stopper is more or less compressed against the highs, depending upon the actual pressure functional with the height of bottle for which the apparatus has been pre-set, and much less tightly compressed against the lows on the end of the bottle. The spun-on tear-off may be closer to the periphery of the bottle neck at some places than at others. Finally, the spun-over tear-off may be more or less tight against high points on the downwardly presenting external shoulder, depending upon the degree of conformance of the thickness of such external portion of the bottle neck to the average for which the apparatus is set, while being loose against the low points on such shoulder. As a matter of fact, with average variations in a production run of bottles, some tear-offs are loose enough to be rotatable by hand, while others are superficially

tight, but have the mentioned points of comparative looseness. What is deceptive about the final assembly is that superficially they all look alike and look properly stoppered and sealed. In every run, however, there is the potential of an unpredictable percentage not being completely sealed, and with autoclaving this potential is increased.

In this processing, which is understood not to attach to those goods designated as biologicals, the stoppers, bottles, and contents are usually preliminarily sterilized, and the filled, plugged containers have the metal tear-offs applied. The bottles always contain an air space between the contents and the plug closure. The packages are then placed in an autoclave, in which steam at approximately 250° F., and at about 15 p. s. i., is introduced and this temperature and pressure condition is maintained for approximately one hour. While this procedure effects complete sterilization instantaneously, it has two adversely complementary potential effects. The heat affects the rubber or like material of the stopper, tending to cause softening and shrinkage thereof, thus tending to loosen the effective grip of the tear-off on the flange, as well as the previously theoretically existing sealing of the internal surface of the neck of the bottle with the shank of the plug, and exaggerating the actual or potential paths of seepage potentially inherent in the entire organization prior to autoclaving. The heat also develops internal pressures in the bottle of appreciable magnitude adequate to force the stopper out of the bottle, if it were not restrained by the tear-off, and in any case adequate to tend to force the contents along the actual or potential paths of leakage or seepage, to establish a train of the contents between the exterior and interior of the bottle, conducting contamination into the bottle when exposed to normal ambient conditions.

Unfortunately, the packages which are improperly stoppered, either with or without the autoclaving, may not be discovered on inspection and the actual deficiencies of the seal may not be discovered or may not appear for long intervals after leaving the processor. In storage, or later in use by the physician, however, the improperly stoppered bottles develop or utilize then developed paths of seepage by which contamination of the contents occurs, which paths are those relatively shallow spaces of inadequate and impositive contact with relative lows in the surface to which the stopper is juxtaposed. If not already existent as an actual seepage path, the potential seepage paths are opened upon the insertion of the physician's hypodermic needle to force air into the bottle preliminary to withdrawing a measured charge of the bottle contents. With internal pressure thus created or built up, in either the packages which have been autoclaved or those which have not, these seepage paths are traversed by the bottle contents and move axially along the shank and under the flange and out of the bottle under the internal pressures, and owing to this inadequate sealing, the entrapped air pressure slowly dissipates, carrying with it part of the liquid contacts to establish a train of contamination, so that each succeeding "shot" from the same bottle must be first preceded by injection of additional air and by which time the bottle contents have become so contaminated as to be unsafe. This is an unsatisfactory packaging organization, both from the standpoint of improper sealing, and also from the standpoint of cost. The cost factors involved are those of the stopper itself, with its flange as an essential portion of the stopper, and the tear-off, which is expensive of itself, as well as in its application to the bottle, and yet is a heretofore absolute essential for this type of packaging. This prior development, poor as it is, is still better than another form of package once proposed for this type of product, and long since withdrawn, and so far as known, having no present use whatever. This latter device was a form of plug used in a blown tubing ampule type of package in which a constriction

was manually formed in a piece of tubing, of essentially rounded bead construction of variable size, with a form of plug having an upwardly presenting shoulder at the end of a tapered plug portion, with the tubing complementally inwardly tapered below the bead as the inconstant and theoretical means for limiting the inward motion of the plug and with a thin tubular extension of the plug rising above the shoulder, not for limiting the inward movement of the plug relative to a neck ring in a molded bottle, but as an inert element serving no sealing functions until after the ampule was cracked adjacent to the bead and the end removed, after which the tubular sleeve was bent about the jagged end of the severed ampule section to protect the physician from being cut thereby in withdrawing the ampule contents. This latter development was so unsatisfactory and so expensive that, as understood, it has been completely displaced by the flanged plug and tear-off just described.

It will be understood of this organization that if any internal pressure was developed internally adequate to expand the plug, the reaction between the tapered inner end and the parallel walls of the tapered tube below the rounded bead would have an outward axial component of such magnitude as to force the shoulder upwardly past the bead and blow the stopper out of the tubing. It would, of course, be impossible to subject the discussed package to autoclaving.

The cost of the plugs or stopper of the last used, passingly current package described above with the flange, is affected by two factors. One is the actual weight of the rubber or like material used, and with the thick flange conventionally provided, a heavy and relatively expensive plug is involved. Another factor in the cost of the plugs is the fact that with the heavy flange on the shank of the prior art plugs, each mold cavity is of such total diameter that the number that can be formed in a mold, and therefore the number of stoppers cured in a single "heat" is sharply limited, as contrasted, for instance, with the number of mold cavities and therefore the number of stoppers cured at a single "heat" if the total diameter of the individual cavity was not greater than the diameter of the plug shank without the flange, or, as shown, for instance, in Figs. 19 and 23 herein.

As noted, this previous practice in packaging various pharmaceutical products is unsatisfactory and expensive, and has only maintained over the years because no one prior to applicant has been able to satisfactorily solve all of the problems attaching to such packaging and to produce a package of greatly reduced cost, which may be used satisfactorily when desired, without any metal tear-off application, and yet will effect complete seal, retained even under appreciable internal pressures, in substantially one hundred percent of the production run of packaging.

Referring to Figs. 16, 17, 20, and 21, a bottle neck 9 of a bottle 10 identical with those of the earlier figures is shown, having the smooth inner neck surface 11 merging upwardly into the sloping lower surface of the inwardly tapering neck ring 12. The sloping upper surface of the neck ring 12, through curved surface 19, merges into the smooth neck surface 15, and the latter terminates at and merges into the end surface 16 of the bottle neck. The neck surfaces 11 and 15, adjacent to the neck ring 12, are both substantially cylindrical and each is concentric with a common neck axis with which the inner periphery of the neck ring is also substantially concentric. The neck surfaces 11 and 15 may be substantially coextensive, although, as indicated, in the usual molded formation of the neck with the neck ring 12, the internal diameter of the outer cylindrical surface 15 is a little greater than that of the surface 11. Of course, surface 11, conforming to the bottle contour at some point below the neck ring 12 flares outwardly from the generally cylindrical. In any case, the

neck ring marks the smallest diameter in the bottle neck and there is no reverse taper of surface 11 below the neck ring bringing this surface inwardly toward the common axis of the neck.

It has been mentioned that the flanged plugs of the earlier figures, effecting such unique anchoring and sealing internally of the bottle neck, does not need the flange, which may be dispensed with. It is a feature of this invention to provide for operative association with the neck portion of a bottle as described a molded stopper plug of such axial length that no part needs to project beyond the end of the bottle, so that the flange is eliminated, and which further effects such sealing closure when inserted into the described bottle neck that the metal tear-off, always previously considered an essential, with its concomitant expense both in material costs and the costs of application, can be obviated, which is composed of smaller amounts of rubber or other material from which it is fabricated than the prior art flanged plugs, is of smaller diameter than flanged plugs, so that the costs of the plugs is reduced because of the greater number of plugs that can be molded in a single "heat," and finally which is of such sealing efficiency that not only is an initially hermetic seal established by mere insertion, this seal is maintained and even enhanced by the introduction of internal pressures into the bottle, so that seepage and liquid or air leakage from the bottle is precluded, and whereby the introduction or internal development of reasonably preponderating internal pressures incident to normal use is ineffective to blow the stopper out of the bottle neck. Additionally, the simplified stopper plug can be used to retain an imparted vacuum in the bottles, when this use of the plug may be desired.

Referring to Figs. 16 and 19, an illustrative form of the simplified flangeless plug or stopper is disclosed. This is presently preferred for use in those situations in which the physician inserts a hypodermic needle through the end closure web of the plug to first insert a charge of air, followed by reinsertion of the needle for withdrawing a charge of the liquid in the bottle, as the longer skirt and the less acute angle at the termination of the skirt in a shoulder at the groove to be described assists in retaining the stopper in anchored relation even under the presence of appreciable internal pressures and an incidental cocking and careless withdrawal of the inserted needle, in contrast to the shorter skirt and more acute angle of the shoulder of the modified form of stopper of Fig. 23. It will be understood that the description which follows is the same for all of these figures and bear the same reference characters, except where specifically pointed out.

Referring then to Figs. 16, 19, and 23, the plug 40 is provided, comprising a hollow shank 41 having the internal bore 42 and the upper transverse closure web 43. The plug on its exterior peripheral surface adjacent to the closure web is substantially cylindrical as at 44 and of such diameter as to have a tight but slidable fit in the outer most internal cylindrical surface 15 of the bottle neck, which merges through the peripherally continuous rounded shoulder 45 into the upper surface 46 of the peripheral groove 47, and spaced from the outer face of the web 43 by a predetermined axial extent such as to permit the rounded shoulder 45 to abut against and seat upon the complementary upper curved surface 19 of the neck ring 12 in the bottle neck with the said outer surface generally flush with the end 16 of the bottle neck. This flush relation does not need to be exact and this surface may actually extend a little beyond or inwardly of said end 16. The groove may be a V formation, if desired, but it is preferred to define the groove 47 by generally parallel spaced surfaces comprising the upper surface 46 already mentioned, the lower planar surface 48, and, internally, by the short axially extending generally cylindrical surface 50, substantially normal to the

upper and lower groove surfaces 46 and 48. The plug shank below the groove is formed by the more or less slightly tapered external skirt surface 51, in Fig. 19, and by the shorter and more acutely tapered skirt surface 51', in Fig. 23, and the related Figures 20, 21, and 22 to be described. The tapered surface 51 or 51' meets the lower groove surface 48 in the sharply angled shoulder portion 52. While, as shown in some of the earlier figures, the diameter of the shoulder 52 may be a little less than the diameter of the cylindrical shank portion 44, in the instant form it is preferred that the shoulder 52 or 52' be very close to the said diameter as that of the shank at the curved shoulder 45, for a reason to be pointed out. It will be understood that both the curved shoulder 45 and the sharp shoulder 52 are peripherally continuous.

When the plug 40 is forced into a bottle containing liquid pharmaceutical or the like being packaged in the bottle, the tapering end 53 engages and is deflected inwardly by the neck ring to such degree that the sloping surface 48 is guided by the thin edge of the neck ring in restrained inward distortion or collapse until the shoulder 52 or 52' passes beyond the thin edge of the neck ring. This may not occur until after the curved shoulder 45 has substantially abutted against the curved upper surface 19 of the neck ring. Upon passage of shoulder 52 past the relatively sharp edge of neck ring 12, the shank portion immediately expands with the sharp shoulder 52 crowded or forced by the resilience of the shank against the sloping lower surface of the neck ring, as the plug continues to be forced axially inward, until, if not already accomplished, the curved shoulder 45 abuts the upper curved neck ring surface. The axial distortion of the plug under axial pressure conduces toward seating against the curved upper neck ring surface, while establishing the angular shoulder in expansive intimate forced engagement against the lower surface of the neck ring or against the neck surface 11, adjacent to the neck ring. Owing to the angularity of the shoulder, any incidental irregularities of the internal neck surface or of the neck ring are equalized by the crowding pressure of the shoulder 52 or 52' thereagainst, and mere insertion of the plug effects hermetic seal between the plug and the internal surfaces of the neck including the neck ring. It is to be observed that additionally, when anchored in position, the surfaces defining the groove and the respective shoulders are in axial tension trying to pull the shoulders closer together from the position they are forced to assume when properly anchored, because of the relative displacements thereof caused by the axial extent and proportions of the neck ring.

Owing, it is believed, to the width of the groove of the plug of Fig. 19, entrapping moisture, the plug, while completely suitable for biological packaging and immune to adverse effects of any kind from elevated internal gas pressures, does not withstand autoclaving, and in many cases, during this recited rigorous procedure, the plug of Fig. 19 has been forced out of the bottles. To correct this feature and to provide a plug accounting for all of the vicissitudes to which a plug may be subjected, while effecting and maintaining complete seal without leakage, seepage or forcing out during autoclaving, or when internal air pressure is effective thereon by injection through the plug, a plug as disclosed in Figs. 24, 25, and 26 is preferred.

Referring to these figures, a plug closure is provided comprising an upper plug element or portion 61, which is predeterminedly of slightly greater O. D. than the I. D. of the neck surface 15 of the bottle, and of axial extent from its upper end surface 62 to the upper surface 63 of the external peripheral groove 64 usually not greater than the axial extent of bottle surface 15 from upper neck ring surface 19, to the end 16 of the bottle. This brings the end 62 into general transverse alignment with the end 16 of the bottle, in the preferred organiza-

tion, when the plug is inserted and fully seated on the neck ring. It may be of shorter or longer axial extent than the length of the surface 15, if desired.

The lower surface of the groove 64 is usually a planar surface 65 separated from upper planar groove surface 63 by a very slight axial surface 59, and preferably upper surface 63 and lower surface 65 are initially in parallelism. Owing to the slight width of the groove, which, for purely illustrative instance, may be of the order of $\frac{1}{16}$ of the axial length of the plug portion or element 61, the groove may be a mere slit or an inwardly convergent tapered slit, with the groove-defining surfaces converging inwardly to mergent jointure in a substantial line at 59. The mergence of the upper generally planar groove-defining surface 63 with the outer peripheral generally cylindrical surface of the plug portion 61 is on a curve 66 in section, such as to be complementary to the upper surface of the neck ring 12 and its fairing curve 19 and the inner neck surface 15, so that it conforms substantially completely to these surfaces upon forced insertion into the bottle neck. Owing to the slightly greater diameter of plug portion 61, however, it will be seen that insertion into the bottle neck places the plug portion 61 under compressive strain, enhancing both the seal and the frictional engagement of the plug portion and the bottle neck surface 15. The lower end of the plug comprises a hollow shank 67 having an internal bore 68, preferably terminating axially inwardly generally in line with the groove 64. The hollow shank is axially tapered as in the outer surface 70 thereof, merging upwardly into the lower groove-defining surface 65 in a preferably acutely angled peripherally continuous edge or shoulder 71. It is preferred for reasons already developed as to Fig. 19, i. e., to preclude removal of the plug by prying out leverage from improperly angled hypodermic insertion, as well as for its enhanced frictional effects, that the skirt or shank 67 be of appreciable length, and illustratively this length is of the order of twice the axial length of the plug portion 61. The skirt or shank portion 67 is flexible and is subject to resilient distortion in both senses radially. This is facilitated by the partial division between the plug portion and shank effected by the peripheral groove 64, enabling the flexing of the shank in either direction radially of the shank without disturbing the solidity of the plug portion.

In use the plug is forced axially into the bottle neck after the bottle has been partially filled with the material to be packaged, during which forced insertion the shank guides past the edge 60 of the neck ring 12. The axial pressure is maintained on the plug until the sharp edge 71 of the shank passes beyond the edge 60, and until the plug portion has been forced into positive seating abutment on the upper surface of the shelf effected by the neck ring. This forms a positive stop to the axial insertion of the plug. During this motion and the initial inward and immediately subsequent outward flexing of the shank, any moisture remaining in the groove 64 has been so substantially eliminated as to be negligible, and the groove itself has almost disappeared as the upper surface defining same is in tight engaging contact with the upper surface of neck ring continued axially into tight engagement against neck surface 15, and the acute edge 71 and the surface 65 engage the surface 11 in its mergence into the lower surface of the neck ring, with the latter engaging the neck ring up to and possibly slightly inwardly beyond the inner peripheral edge 60 of the neck ring.

The resilient expansion of the shank, after the forced insertion into the bottle neck brings an appreciable portion at least of the outer surface 70 of the shank into conforming contact with the reversely tapering neck surface 11 of the bottle neck, and groove surface 65, edge 71 and surface 70 effect anchoring engagement with the

surface 11 and the lower surface of the neck ring to preclude withdrawal of the plug unit.

When the plugs of Fig. 19 or Fig. 24 are inserted under axial pressure as described, until the upper groove-defining surface abuts the upper neck ring or shelf surface, and the shank expands by its own resilience under the neck ring and against the downwardly flaring neck surface 11, the plug is anchored securely in hermetically sealed relation and requires no tear-off or other supplemental anchorage or covering means. The packages may be shipped and stored until use without leakage. The exposed end of the plug may be wiped with alcohol or the like to sterilize same, a needle can then be inserted through the plug into the bottle without any fear that misplaced angles of insertion or awkward withdrawals may be able to force the withdrawal of the stopper. The needle may be used to force air into the bottle preliminary to withdrawal of a charge of the bottle contents, and this charge of air pressure can be repeated as often as is necessary or practical without forcing the stopper out of the bottle, even in the absence of the expensive tear-off.

When properly fully inserted the plug has an initial anchorage of the resiliently expanded shank, in the position to which it springs back after passing through the constriction presented by the inner peripheral edge 60 of the neck ring. This expansion of the shank toward its initial molded position or attitude being effective against an upwardly convergent surface 11 has frictional and other anchorage effects as to be adequate of itself to make it extremely difficult to remove a plug once it has been fully inserted and seated, even without internal positive air pressure. When air pressure begins to build up in the bottle, through the charges of the needle or otherwise, the expansive forces are normal to all of the surfaces of the shank of the valve, and the small axial component thereof on the shank is inadequate to force the plug out, as this force is insufficient, initially at least to overcome the anchorage effective from the mere return-expansion of the shank upon insertion, and the much larger radial or substantially radial components of expansive force on the tapered bore surface are effective to progressively force the shank in expansion against the downwardly flaring surface 11, to so increase the friction between these surfaces, that even a larger value of the axial component of the expansive force is inadequate to blow the plug out of the bottle.

Moreover, due to the fact that the formation of the neck ring presents the surface 11 forming the inner surface of the bottle neck and the lower surface of the neck ring as a downwardly outwardly flaring surface, the lateral or radial force on the expanded shank develops a downward axial component on the shank developing tension on the plug effective on the upper plug portion thereof and pulling it down into increased and enhanced sealing engagement with the upper surface of the neck ring. This radial expansion of the shank against the reversely tapered neck surface 11 and its functioning under inserted or added pressure, as noted, is characteristic of the plugs of Figs. 19 and 24. But the plug of Fig. 24 is additionally susceptible to autoclaving, and then to subsequent insertion of added air pressure without causing leakage, seepage, or blow-out of the plug.

Referring to Fig. 25, the plug shown in Fig. 24 is slightly greater in diameter than the internal diameter of the neck surface 15 and when inserted as shown the initial inward deformation of the shank is followed by outward resilient expansion in which the shank 67 may assume an attitude relative to the bottle neck as shown. In this the groove 64 has substantially disappeared, except for a mere vestigial indentation, and the outer surface 70 conforms to a large area of the sloping neck surface 11. Owing to the effects of the reaction between the expanding shank 67 and the sloping wall surface, especially if the contacting surfaces are initially moist,

the axial component developed by reaction exerts strong tension on the plug portion 61, pulling it toward its sealing seating on the surfaces of the bottle neck with which it contacts.

When placed under the heat and pressure of the autoclave, the air entrapped in the bottle beneath the plug expands and develops internal pressure in the bottle. This is increased by the formation of steam therein by the heat of the autoclave. This presents an internal compression of considerable magnitude effective among other areas on the internal bore surfaces of bore 68, progressively effective to force the surface 70 of the wall of the shank 67 to conform tighter and tighter to and against the sloping walls 11, with an actual elongation of the shank substantially to the position shown in Fig. 26. This is accompanied by enhanced sealing of the plug portion 61. The dimensions of plug portion 61 do not change with autoclaving. As the plug is softened and dried with a loss of some of its resilience, it is probable also that any pre-existing moisture between the neck surface 11 and the external conforming surfaces of the shank of the plug is driven off, with an enhancement of the frictional effects therebetween, to assist in maintaining the plug in sealing relation in the neck. At any rate, despite the heat, and the internal pressures, the plug maintains hermetical seal, precludes seepage or leakage and does not blow out, and requires no tear-off to complete a perfect package. After autoclaving the package remains one in which the physician can force air from a hypodermic through the plug and into the bottle, to elevate the internal pressures for the withdrawal of charges of the bottle contents, without disruption of the permanent non-leaking, non-seeping hermetic seal, and without danger of blowing the stopper from the bottle.

It will be understood of any of the plugs described that although rubber may be the preferred material, any available alternates may be used, whether they be artificial or synthetic, rubber, or a mixture thereof, or any of the polymeric materials, or the like provided a useable degree of resilience attaches thereto.

There are many situations in which a permanent or semi-permanent closure is sought in cases where tight seal and low cost are factors, even without the ability to withstand prying-out forces of a needle or the like, as when the packaged product is not in fluid form, and such highly efficient anchored closure effected by the slightly smaller and cheaper plug shown in Fig. 23. In some cases it is desired to provide modifications of the plugs whereby the tight seal effected may be negated by manual manipulations. This is provided as indicated in one form of plug in Figs. 17 and 18, in which a plug, otherwise identical with that of Figs. 16 and 19, is provided with a small thin axially projecting tab or tongue 55, by which the inserted plug can be manually forcibly withdrawn when desired, for reinsertion and use in re-establishing hermetic anchored engagement and seal, when desired.

In some cases where the goods are not so critical it is desired to provide plugs with enhanced releasing possibilities. As shown in Fig. 20, the plug, otherwise like that of Fig. 23, may have a thin flange 56 for overlying the end of the bottle to assist in prying same out. Finally, a plug like that of Fig. 23 may be provided with a thin flange 57, and also mount a tab or tongues 58 for manual withdrawal, and when it is desired to withdraw the stopper completely for withdrawal of the contents, as is also contemplated of the form of invention shown in Fig. 17.

An important feature of the plug closures of Figs. 19, 23, and 24 is that although both are capable of complete anchorage and retention of seal under internal pressures, although the plug of Figs. 19 and 24 is more immune to undesired and inadvertent dislodgement by action of an inserted needle withdrawn at an angle to the truly axial, both plugs are capable of maintaining

a complete seal under vacuum conditions, even without the vent of some of the earlier figures. In using these "pressure" plugs for vacuum purposes, the package can be placed in an evacuated receptacle, to remove air therefrom, and the plugs forced into the bottles by appropriate means operative in said receptacle during its evacuation. Thus, a single flangeless plug can be used interchangeably for vacuum or internal pressure conditions.

The high commercial value and the manifold advantages of the invention, both in the bottle, in the closure, and in the combination will also be understood.

Having thus described my invention, I claim:

1. A bottle and stopper combination susceptible to autoclaving pressures comprising a bottle having an internal neck surface of predetermined diameter, a neck ring projecting inwardly from said surface and terminating in a peripherally continuous edge of acute angularity axially of the bottle neck, a closure plug of resilient material comprising a solid plug portion of generally cylindrical form, the external diameter of which is not less than the internal diameter of said neck, a tapered hollow shank portion integral with the plug portion, a peripherally continuous slit-like groove partially defined by a generally planar upper surface merging by a curve into the generally cylindrical plug portion and of general conformance in profile with the upper surface of the neck ring, said groove defined in the other part by a generally planar surface merging into the shank by an acutely angled edge, said groove defining surfaces being so close together that upon insertion of the closure into the neck the groove surfaces are stressed into intimate contacting engagement with the respective surfaces of the neck ring with inappreciable spacing of material of the closure and the neck ring whereby the shank and plug are placed in tension stress adjacent to said neck ring to enhance the seal on both surfaces of the neck ring and liquid retention space between the neck ring and said closure is substantially obviated.

2. A bottle and stopper combination susceptible to autoclaving pressures comprising a bottle having an internal neck surface of predetermined diameter, a neck ring projecting inwardly from said surface and terminating in a peripherally continuous edge of acute angularity axially of the bottle neck, a closure plug of resilient material comprising a solid plug portion of generally cylindrical form, the external diameter of which is not less than the internal diameter of said neck, a tapered hollow shank portion integral with the plug portion, a peripherally continuous groove notch like in section partially defined by a generally planar upper surface merging by a curve into the generally cylindrical plug portion and of general conformance in profile with the upper surface of the neck ring, said groove defined in part by a generally planar surface merging into the shank by an acutely angled edge, said groove defining surfaces being so close together that upon insertion of the closure into the neck the groove surfaces are stressed into intimate contacting engagement with the respective surfaces of the neck ring with inappreciable spacing of material of the closure and the neck ring whereby the shank portion and plug portion are placed in tension stress adjacent to said neck ring to enhance the seal on both surfaces of the neck ring and liquid retention space between the neck ring and said closure is substantially obviated, the internal surface of the bottle neck having a downward outward flare from said neck ring and said shank expanding against said internal surface under increased internal pressures to enhance its frictional engagement beneath said neck ring and developing an axial force tending to force said plug portion into tighter engagement against the outer surface of the neck ring.

3. In combination, a bottle having a neck formed internally with a generally cylindrical outer surface merging inwardly into a transverse internally tapered integral

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neck ring the lower surface of which tapers outwardly into a generally cylindrical inner neck surface below the neck ring, and a sealing plug therefor, said plug comprising an integral closure unit of resilient material forming an upper plug portion of not smaller diameter than the said outer neck cylindrical portion and of axial extent not appreciably greater than the axial extent of said neck outer surface, said unit having a single peripheral groove spaced from both of its ends, the said plug portion merging axially into said groove in a first shoulder substantially curvilinear in section and being substantially solid for its effective axial extent and relatively highly resistant to resilient deformation whereby when disposed in said neck the plug engages laterally the outer cylindrical surface of said neck with said first shoulder in sealing positive abutment against the upper surface of said neck ring, said unit further comprising a tapered shank portion forming at its upper external end a second shoulder merging into said groove and engaging the lower surface of said neck ring, said shoulders being axially spaced in the outer periphery of the unit to define the groove as inwardly tapering and slit-like so that the respective shoulders engage the neck ring under axial tension when fully inserted in said neck, said shank portion being hollow and much less resistant

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to resilient deformation than said plug portion whereby internal pressures on said shank portion in expanding same against the lower surface of the neck ring and the inner neck surface therebelow exerts additional tension on the plug portion pulling it down to enhance sealing by said first shoulder against said neck ring, while maintaining and augmenting a seal against the lower surface of said neck ring.

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