April 21, 1970 M. B. BURGESS 3,507,276

JET INJECTOR

Original Filed May 6, 1965 3 Sheets-Sheet 1

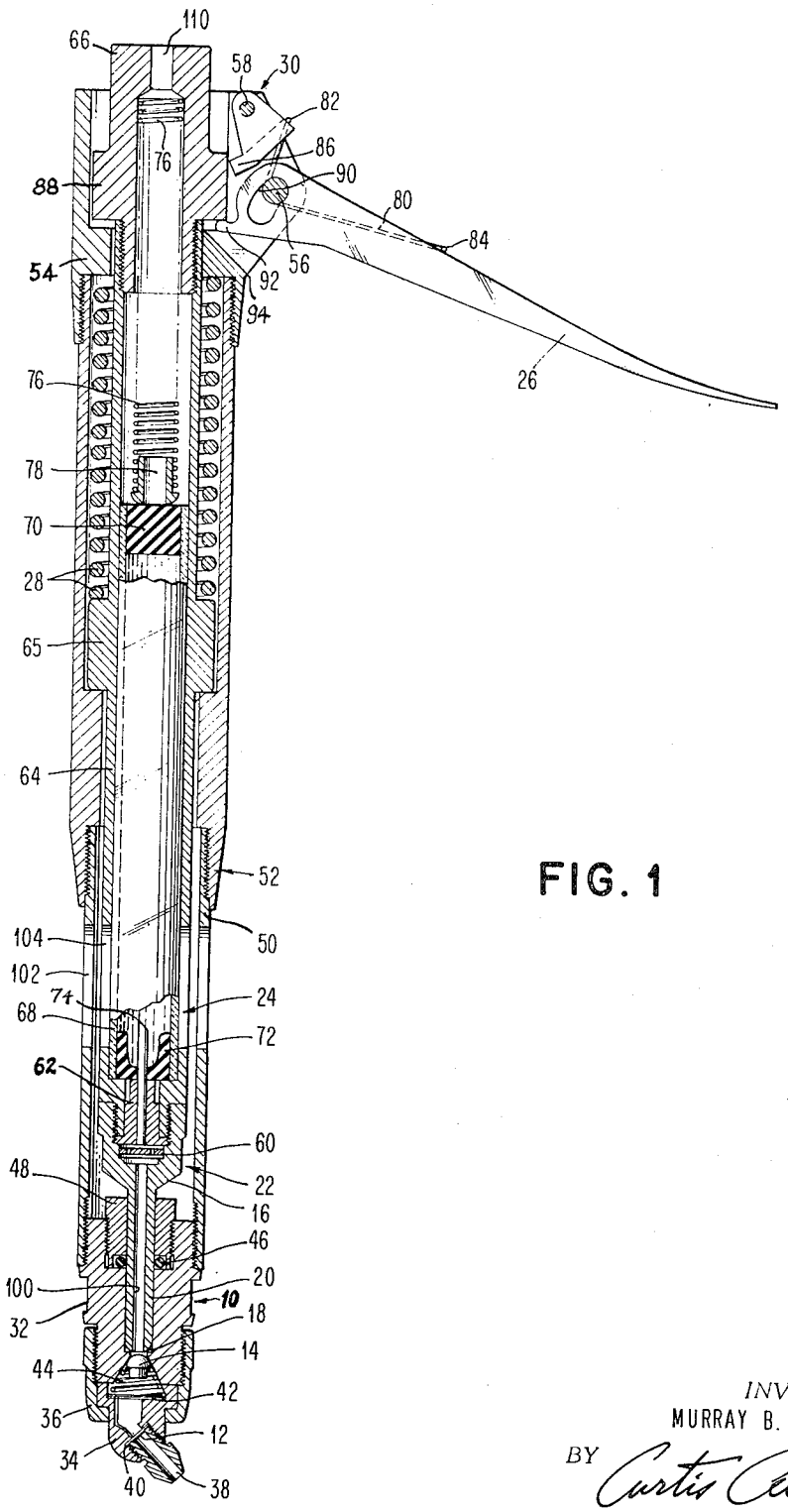

FIG. 1

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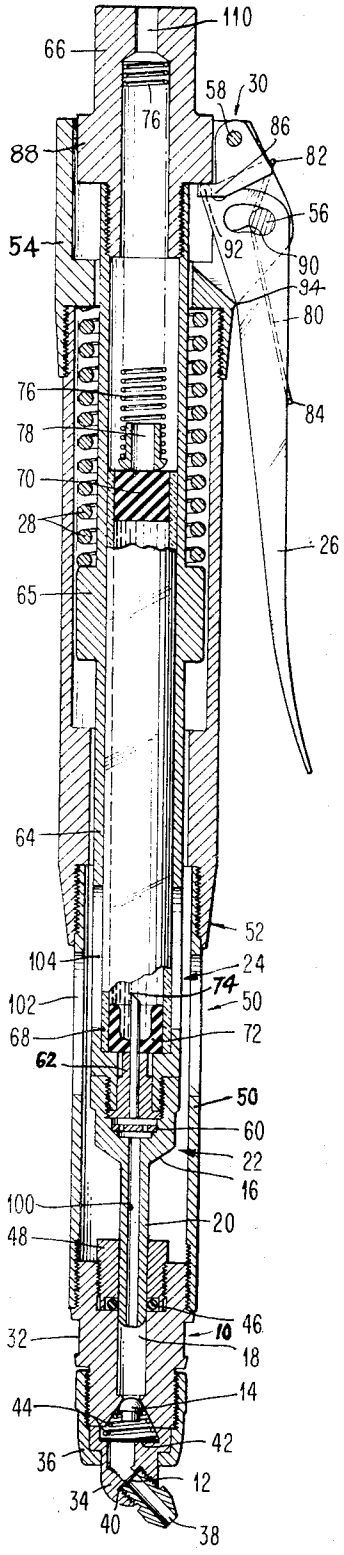
FIG. 2



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JET INJECTOR

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FIG. 3

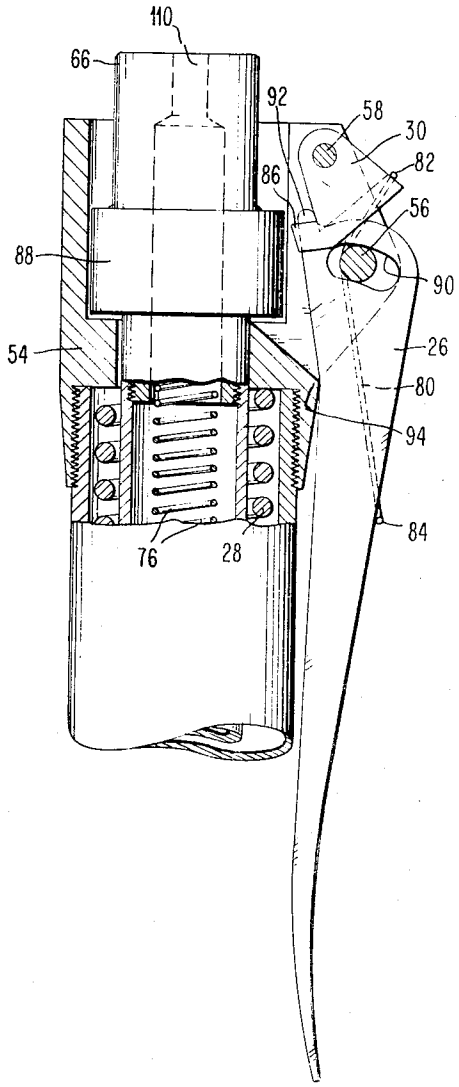
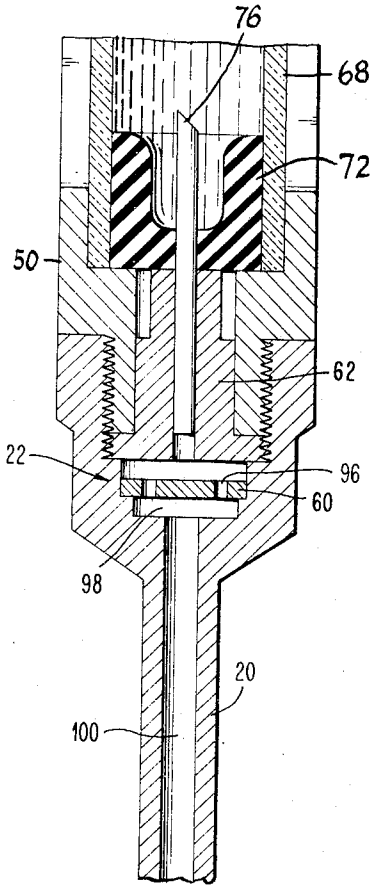


FIG. 4



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3,507,276

JET INJECTOR

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Continuation of application Ser. No. 453,580, May 6, 1965. This application Aug. 28, 1968, Ser. No. 764,009
Int. Cl. A61m 5/30
U.S. Cl. 128—173 8 Claims

ABSTRACT OF THE DISCLOSURE

The hypodermic jet injector (FIG. 1) has a jet orifice **12** to which fluid is applied under pressure through a one-way valve **14** from a cylinder **18**. The cylinder **18** is charged through a central opening **100** and a one-way valve **22** in piston **20** from a canula **24** carried by the piston. A single lever **26** cocks the firing spring **28** (FIG. 2) and then trips the latch **30** (FIG. 3) upon further movement to "fire" the device by releasing piston **20** to provide the injection.

This is a continuation of application Ser. No. 453,580 filed May 6, 1965, now abandoned.

This invention relates to improved jet injection apparatus which is particularly adapted as a hypodermic jet injector for the injection of medical liquids through the outer skin surface of either humans or animals, without the use of a hypodermic needle.

In recent years, there have been introduced a number of hypodermic jet injector devices for the injection of small amounts of medical liquids such as vaccines, medicines, anesthetics, and the like, without the use of a needle. The most obvious advantage of these devices is that they avoid the usual requirement of a newly sterilized needle for every injection because the patient's skin is penetrated only by the droplets of the liquid to be injected.

The jet injector apparatus of the present invention may be employed with an infinite variety of different medicines, vaccines, and anesthetics. For certain purposes, such as for opening shallow skin abcesses, the instrument may usefully employ sterilized water, or alcohol, or the like as the liquid to be injected from the instrument and injected into the skin of the patient. Throughout the present specification, all of these possible liquids to be injected may be simply referred to as "liquid" or "medical liquid," and these terms will be understood to encompass any of the liquids to be injected.

There is a tremendous need for small, portable, hand-operated jet injectors, even though such injectors are necessarily generally limited to low volume injections in the order of one-tenth to one-half cubic centimeters of liquid. Such a low volume injection is nevertheless very useful for various purposes such as inoculations, injection of high-concentration medications, and the injection of small volumes of local anesthetic. This is useful for minor dental, or other surgery, or to anesthetize to permit the insertion of a larger needle painlessly for higher volume injections, or for making blood donations.

Both in the small portable sizes, and in the large non-portable sizes, various common problems are encountered. One of the most serious problems is that of air entrapped within the instrument together with the liquid to be injected. Such entrapped air reduces the efficiency of the injection operation because the air acts as a pressure cushion to reduce the high peak pressure and to thus reduce the velocity of the liquid stream. If there is more than a very nominal amount of air present with the liquid in the instrument, the cushioning effect causes

it to fail to operate. Furthermore, when the instrument does operate in what appears to be a proper manner, the reduction in efficiency due to the presence of the air raises an immediate uncertainty as to the size of the effective dosage of the injected liquid.

Another problem which is encountered when air becomes mixed with the injection liquid is that a certain amount of the air will be injected together with the liquid into the skin of the patient, and this causes undesired discomfort and distress to the patient, and may cause an embolism.

Accordingly, it is an important object of the present invention to provide an improved jet injector apparatus which substantially precent the introduction of air into the presence of the liquid to be injected.

Another problem with prior jet injections has been the risk of contamination to the reservoir of liquid by the introduction of atmospheric air into the instrument to displace portions of liquid already ejected. The air within medical treatment rooms is often badly contaminated with various infectious substances.

Accordingly, it is another important object of the present invention to avoid and prevent virtually all contact of atmospheric air with the reservoir of liquid.

One of the most common problems with prior jet injectors has been the difficulty in causing the liquid to enter the ejection chamber. This has been variously described as difficulty in "loading," "charging," or "priming." In many such instruments, gravity is heavily relied upon to enhance the charging or priming action, and in some instances, gravity is completely relied upon for this purpose. Where gravity is an essential force in the priming operation, the instrument must be carefully held in a particular attitude for the gravity priming, and the force of gravity is generally inadequate to provide for reliable priming without a long wait for the liquid to percolate into the ejection chamber.

Accordingly, it is another important object of the present invention to provide an improved jet injector apparatus which provides positive pressure priming without any reliance upon gravity, and without any requirement for a substantial waiting period or a special attitude of the instrument for priming.

Another problem encountered with prior jet injectors is the risk of contamination of the parts with which the liquid comes in contact during a reloading operation in which new liquid is placed in the apparatus.

Accordingly, it is another important object of the present invention to provide an improved jet injector apparatus which minimizes the surface areas of the instrument which are to be in contact with the liquid.

Another object of the invention is to provide an improved jet injector apparatus which prevents contamination of any parts which come in contact with the liquid during reloading.

Another object of the invention is to provide a jet injector apparatus which is essentially self-cleansing and which provides a minimum surface area to be contacted by the liquid so that it is possible to change the nature of the liquid to be injected by the apparatus merely by changing the contents of the liquid reservoir of the instrument and purging the remanents of the prior liquid by operating the instrument several times with the new liquid.

While the volume of liquid which can be injected by a portable jet injector is necessarily rather limited, many common medicines can be produced and packaged in much higher concentrations than those in which they are usually available, and in such high concentrations, with an accurate means of injection, adequate medication can be provided with very low volume injections.

Accordingly, it is another important object of the present invention to provide a portable jet injector for low volume injections which is extremely accurate in its operation so as to permit the use of low volume, high concentration medicines.

In accordance with the invention, in addition to the above objects, the apparatus of the present invention provides various important advantages, including simplicity of construction, ease and simplicity of operation, and ease and economy in repair and parts replacement.

Furthermore, another important advantage of the invention is in the provision, in one preferred form thereof, of means for accommodating a standard ampule or cartridge of injection liquid, the cartridge itself serving as the reservoir of injection liquid within the instrument.

Further objects and advantages of the invention will be apparent from the following specification and the accompanying drawings.

In carrying out the present invention in one preferred form thereof, there is provided an improved hypodermic jet injector apparatus having a housing member with a jet orifice therein and a first one-way valve operable to provide flow of the liquid to be injected to the orifice. A reciprocable member is associated with the housing member and includes a second one-way valve. One of the members forms a cylinder and the other one of the members forms a cooperating piston within the cylinder to define a variable volume chamber of restricted cross section between the first and the second valves, the second valve being arranged to provide free flow of liquid to the chamber. The reciprocable member includes an inlet passage and connections for a supply container of the liquid for conveying the liquid to the second valve. A quick release compression device is provided to impart a fast and powerful movement to the reciprocable member in the direction to reduce the volume of the chamber to cause ejection of the liquid from the chamber through the orifice with sufficient force to penetrate the skin of the patient.

In the accompanying drawings:

FIG. 1 is a side view, partially in section, of a preferred embodiment of the invention.

FIG. 2 is a similar view showing the apparatus of FIG. 1 in a cocked condition ready for an injection operation.

FIG. 3 is a partial detail view showing the operation of the latch to release and "fire" the jet injector of FIG. 1.

And FIG. 4 is an enlarged detail view of the second valve and the associated portions of the apparatus.

Referring in more detail to FIG. 1, there is shown a housing member **10** having a jet orifice at **12**, a one-way valve **14** arranged to provide liquid flow through the orifice. A reciprocable member **16** defines, together with the housing member **10**, a variable volume chamber **18**. The reciprocable member **16** includes a piston **20** which moves axially within a cylinder formed in the housing member **10** to accomplish the variation in the volume of the chamber **18**. The reciprocable member **16** includes a one-way valve **22** which provides for movement of liquid into the chamber **18** from a liquid reservoir generally indicated at **24**. The movable member **16** is retracted to enlarge the chamber **18** by clockwise rotation of a lever **26**. The resultant movement of the member **16** is in a direction towards the top of the drawing, as shown in FIG. 2. This upward movement of member **16** causes charging of the liquid from reservoir **24** through the one-way valve **22** into the chamber **18**. The upward movement also causes compression of a powerful spring **28**. When the reciprocable member **16** is later released, the energy stored in the spring **28** causes a rapid and powerful downward movement of the member **16**, closing the one-way valve **22**, rapidly reducing the volume of chamber **18**, opening the one-way valve **14**, and causing the jet ejection of the liquid through the orifice **12**.

FIG. 2 illustrates the retracted or "cocked" position of the reciprocable member **16**, in which the lever **26** has been rotated to retract the piston **20**, and to compress the spring **28**. In this cocked position, the movable member is engaged and retained by a latch member **30** until the jet injection operation is required.

FIG. 3 illustrates how further clock-wise rotation of the lever **26** releases the latch **30** to "trigger" the jet injection operation.

The following is a more detailed decription of the structure and operation of the invention, as shown in the embodiment of FIG. 1.

The housing member **10** includes a cylinder **32**. A nose piece **34** is attached to the cylinder **32** by means of a collar **36**, the collar **36** having a threaded attachment to the cylinder **32**. Threadedly fastened into the nose piece **34**, there is a nozzle tip **38**. At the bottom of the threaded opening of the nose piece **34**, which receives the nozzle tip **38**, there is positioned an orifice plate **40**. The orifice plate **40** may conveniently consist of a small disk of stainless steel which is about two-hundredths of an inch thick, with the orifice **12** formed in the center as a hole approximately six-thousandths of an inch in diameter. The orifice plate **40** is firmly held in place by securely tightening the nozzle tip **38**. However, it may be easily removed for cleaning or replacement by simply unscrewing the nozzle tip **38**. The orifice plate **40** is preferably made very thin, as described, in order to prevent clogging, and in order to make cleaning easier, and also to generate a very small thin stream of ejected liquid, with a minimum of dispersion.

The tip **38** and the orifice plate **40** are conveniently arranged at an angle with respect to the remainder of the body of the instrument as a convenience in administering injections in confined locations. For instance, for dental use, the instrument may be inserted into the mouth of the patient, and the injection easily made in the angular direction into the gum tissue of the patient. The angle of the injection about the axis of the instrument can be simply changed by rotating the entire instrument, or by loosening the collar **36** and rotating the nose piece **34** to the desired angle. If desired, a short piece of rubber tubing may be fitted over the nozzle **38** to serve as a non-metallic contact tip for engagement with the skin surface of the patient. This serves as a spacing device to control the spacing between the orifice and the skin surface. It is important, for satisfactory and reproducable operation, that the orifice must be within a rather short uniform space from the skin of the patient in order that the jet stream will have sufficient power and momentum to penetrate in a uniform volume.

Within the bore of the nose piece **34**, there may be positioned one or more strainer screens **42** which are preferably from 200 to 400 mesh. These screens provide the useful function of straining the liquid so as to help prevent any obstruction of the orifice **12**. The screens **42** are held in place by a conical spring **44**, which is also the operating spring for the one-way valve **14**. The valve **14** consists simply of a member having a spherical surface which seats into a suitable restriction of the bore of the cylinder **32**. In order to improve the seal afforded by the one-way valve **14**, the portion containing the spherical surface may be composed of gum rubber having a durometer hardness in the order of fifty. In order to improve the pressure holding capabilities between the piston **20** and the inner surface of the cylinder **32**, a rubber O ring **46** may be provided, which is held in assembled relationship within the cylinder member **32** by means of a retainer plug **48** threadedly fastened into a suitable depression in the cylinder **32**. Both of the rubber parts **46** and **14** are preferably coated with materials having a pH factor to match the pH factor anticipated for the liquids to be injected. Furthermore, these parts may be composed of rubber or rubber-like materials which are capable of withstanding sterilization temperatures. Other materials such as nylon or "Teflon" (DuPont trademark for

polytetrafluroethylene) may also be used for the ball valve.

The remainder of the housing **10** of the apparatus consists of tube **50**, which is threadedly fastened to cylinder **32**, top tube **52**, which is threadedly fastened to tube **50**, and clevis block **54**, which is threadedly fastened to the tube **52**. The clevis block **54** includes pivot pins **56** and **58** for pivotally supporting the lever **26** and the latch **30**.

The reciprocable member **16** includes the one-way valve **22**, of which the most essential component is a check plate **60** positioned within a chamber formed within the piston member **20**. The upper wall of the chamber for the valve **22** is formed by a canula member **62** which is maintained in assembled relationship within the piston member **20** by means of screw threads which engage interior threads of the cylinder member **20**. The structure and operation of the valve **22** is described in greater detail below in connection with the enlarged detail view of FIG. 4.

The cartridge tube **64**, which is mounted to cylinder **20** by the same screw threads which mount the canula, provides a chamber for the reservoir of liquid to be injected. Tube **64** includes a flange **65** engaging spring **28**. Attached to the upper end of the cartridge tube **64** there is a spring cap **66**. The enclosure or chamber formed by the spring cap **66**, the cartridge tube **64**, and the canula **62** is preferably proportioned and arranged to receive a standard cartridge of medical liquid to be injected. Thus, the reservoir **24** is illustrated as consisting of such a standard cartridge. For instance, the cartridge may be the standard 1.8 cubic centimeter size having outer dimensions of approximately five-sixteenths of an inch by two and one-half inches. A 2.2 cubic centimeter cartridge of the same diameter, and slightly greater length may also be accommodated. The reservoir cartridge **24** is described in detail here as a part of the preferred structure of the present invention. However, it will be understood that the cartridge itself does not comprise a novel part of the present invnetion since the cartridge is a standard and well-known package for medical liquids. The reservoir cartridge **24** preferably consists of a glass tube **68** having a slidable rubber stopper **70** at its upper end, and a rubber membrane closure **72** at its lower end. The canula **62** includes a hollow hypodermic tube needle portion having a tip **74** which extends into the cartridge chamber so as to pierce the membrane **72** when the cartridge **24** is inserted fully. The membrane member **72** may take any one of a number of standard forms provided there is a thin wall at the central portion thereof which is easily penetrated by the tip **74**. Thus, it is quite apparent that the canula **62** provides communication with the reservoir cartridge **24**, for the flow of liquid through the valve **22** and into the chamber **18**.

The entire space within the cartridge **24** is preferably filled with liquid. As the cartridge **24** is emptied, all of the displacement of liquid is accommodated for by downward movement of the slidable rubber stopper **70**. Preferably, this movement is assured by the provision of a light spring **76** having a tip **78** which is arranged to engage the rubber stopper **70**. The force of spring **76** is sufficient only to overcome a part of the static friction of the slidable rubber stopper **70** to insure that, as liquid is removed from the reservoir cartridge **24** into the chamber **18**, the slidable stopper **70** does the complete job of displacing the liquid space. Thus, no atmospheric air is permitted to enter the portion of the cartridge which continues to contain liquid, nad the liquid therefore is not subjected to possible contamination from such atmospheric air.

Mounted over the lever pin **56**, there is a latch spring **80** having double arms at **82** which straddle and engage the rotatable latch member **30** to bias it for rotation in a clockwise direction. The spring **80** also includes arms **84** which straddle and bias the lever **26** in a clockwise direction.

The latch **30** is provided with two engagement fingers **86**. The latch is normally held in a disengaged position with the ends of the fingers **86** resting against the outer surface of a radial flange portion **88** of the spring cap **66**. The lever **26** has a lost motion pivotal connection with the lever pin **56** by reason of the slotted lever pin opening **90**. When the lever **26** is raised to the extended position shown in FIG. 1, it is biased downwardly by spring **80**, at the pivot pin **56**, so that the finger portion **92** of the lever engages the bottom of the flange portion **88** of the spring cap **66**. Downward clockwise rotation of the lever **26** then raises the spring cap **66**, and the entire reciprocable member **16**, including the piston **20**. If this movement is continued far enough, the spring cap flange **88** is raised beyond the latch fingers **86**, so that the latch fingers **86** slide under the flange **88** and retain the reciprocable member in the raised or "cocked" position.

FIG. 2 illustrates the cocked condition of the device. During the upward movement, the chamber **18** is enlarged by the upward travel of the piston **20**, the valve **22** is opened by a slight downward movement of valve plate **60**, and the valve **14** remains closed. Liquid is thereby pumped from the reservoir cartridge **24** through the canula **62** and the valve **22** into the chamber **18**. This movement of liquid into the chamber **18** is accomplished largely by atmospheric pressure, as otherwise there would be essentially a partial vacuum within the chamber **18** as it is enlarged. This charging of chamber **18** is enhanced by the spring **76**, which helps to move the slidable rubber stopper **70** downwardly, as indicated in FIG. 2.

When the device is to be tripped or "fired," the lever **26** is given a further rotational motion in the clockwise direction. The lever **26** then engages a fulcrum pivot point **94** of the clevis block **54**. This causes the lever to rotate about the pivot point **94** through the lost motion provided by the slotted connection **90** with the pin **56**. As this motion continues, the lever finger **92** engages the latch **30** between the latch fingers **86**. This imparts a counter-clockwise rotation to the latch **30**.

FIG. 3 shows the operation, disengaging the latch and allowing the entire movable member, including the piston **20** to move rapidly downward under the force of the spring **28**. During this downward travel of the reciprocable member **16**, the one way valve **22** closes, and the one way valve **14** opens, so that the liquid previously contained within chamber **18** is forcibly ejected with considerable force and speed through the screen **42** and the orifice **12**.

There is a measurable volume within the housing between the valve **14** and the orifice **12** which must be filled with liquid before an effective injection operation is possible, the volume of this space is preferably somewhat less than a single injection charge. Accordingly, it is possible to fill this space with liquid by simply operating the device through one or more injection cycles at the beginning of a particular period for use, before actual injections are commenced. This also serves to purge all air from chamber **18**. Another convenient method for priming the injector and purging the air from the system is to insert a rod at the top of the instrument through center opening **110**, and through members **76** and **78**, to engage the slidable stopper **70**. Pressure exerted by the rod upon the stopper **70** causes downward movement of the stopper **70**, and movement of liquid through both one-way valves **22** and **14** until a small amount of liquid is seen to be emitted from the nozzle **38**.

FIG. 4 is an enlarged detail drawing showing the construction of the one-way valve **22**. As previously mentioned, the most essential element of valve **22** is a check plate **60** which is housed in the chamber defined by the inner surfaces of the piston **20** and the canula **62**. The sides of the chamber adjacent to the outer edges of the check plate **60** conform in shape with the check plate **60** so as to provide a slidable fit therewith. Conveniently, both the plate and the chamber are circular. The check plate **60** is provided with one or more axially aligned

through holes **96** which are radially displaced from the center of plate **60** so that they are not in alignment with the center hole of the canula **62**. Thus, when the plate **60** floats upwardly within its chamber and snugly engages with the lower surface of the canula **62**, both the through holes **96** of the plate, and the central opening of the canula **62**, are effectively closed. This is the condition which exists as the volume of chamber **18** is reduced the "firing" of the injector. At the bottom of the valve chamber, there is a portion of reduced diameter at **98**. The diameter of this portion is less than the outer diameter of the check plate **60**, but is great enough to form a communication with the through holes **96**. Thus, it provides a free passage through the central opening **100** in the piston **20**. Therefore, when the check plate **60** floats downwardly within its chamber, the center opening of the canula is uncovered and liquid can flow downwardly, through the chamber and through the openings **96**, and then through the central opening **100** of the piston **20**. The central opening **100** is considered to be a part of the chamber **18**.

One of the outstanding features of the present invention is the positive filling operation provided by the cooperation of the two valves **14** and **22**. Thus, whenever the chamber **18** is enlarged by upward movement of piston **20**, valve **22** opens and the liquid is provided in a continuous flow through the valve **22** and the central passage **100** into the chamber **18**. During this operation, the increased displacement within the chamber **18** must be satisfied entirely through valve **22** because valve **14** is automatically retained in the closed position, the slightly reduced pressure within the chamber **18** causing the valve **14** to close securely. Upon the injection operation, when the piston **16** descends, the valve **22** closes and the valve **14** opens to provide for one-way flow of liquid out through the orifice **12**. It is apparent that the valves **14** and **22** cooperate with the cylinder of the housing **10** and the piston **20** to provide a double action pump operation. The continuous action of the valves, and particularly of the action of valve **22**, during the upward travel of the piston **20**, which provides continuous access of liquid to the chamber **18** assures that there is a complete filling of the chamber with the liquid and no opportunity for any atmospheric air to enter the chamber **18**. As previously mentioned above, the entry of air into the liquid system is very undesirable for a number of reasons.

The tube **50** of the housing **10**, and the cartridge tube **64** of the reciprocable member **16** are respectively provided with window openings **102** and **104**. These windows are preferably provided on both sides of the tubes **50** and **64** and thus they provide a visual indication when the cartridge **24** is almost emptied. This will be clearly indicated by the approach of the slidable stopper **70** into the window area. Providing the windows on both sides of the tubes promotes full visibility of the stopper **70** through the glass walls of the cartridge **68** because back lighting is thus provided from the side of the cartridge opposite to the side which is viewed.

Since the reciprocable member **16** is freely rotatable within the housing **10**, the windows **102** and **104** will not always be perfectly aligned. However, they can be easily aligned with one another by manual rotation of the reciprocable member by engagement of the fingers of the operator with the upper tip of the spring cap **66**.

Sterilization of the jet injector of this invention can be easily accomplished by simply placing the entire injector structure into the autoclave. However, the used reservoir cartridge **24** should be first removed from the interior of the device. This can be accomplished very simply by unscrewing the spring cap **66** where it is attached to the upper end of the cartridge tube **64**. The outer periphery of the upper tip of the spring cap **66** is knurled to give the fingers a good purchase on this part. The cartridge tube **64** can be held against rotation to permit the removal of the spring cap **66** by inserting the fingers of the other hand through the windows **102** and **104**. However, the constraint offered by spring **28** is usually sufficient to prevent rotation of cartridge tube **64** during removal of cap **66**. After removing the spring cap **66**, the spring **76** and the spring tip **78** easily slide out of the cartridge tube **64** together with the reservoir cartridge **24**. The reservoir cartridge **24** is easily disengaged from the needle **74** of the canula **62** by manipulation through the windows **102** and **104**. A new cartridge can then be inserted through the upper end of the cartridge tube **64**, and forced down over the canula needle tip **74** by manipulation through the windows **102** and **104**. The spring **76**, the spring tip **78**, and the spring cap **66** are then reassembled and tightened in place. If desired, to assist and maintain the assembly of the cartridge tube **64** over the tip **74**, a spring member (not shown) may be arranged within the cartridge tube **64** and between the upper edge of the glass tube portion of the cartridge **68** and the lower edge portion of the spring cap **66**, and surrounding the spring **76**.

It is one of the important features and advantages of the structure that a used reservoir cartridge **24** can be removed, and a full reservoir cartridge **24** can be inserted, without exposing any of the parts of the injector apparatus which must be sterile to any serious possibility of contamination. Thus, it is possible to use the jet injector for a considerable number of injections, employing a succession of different cartridges, without the necessity for resterilization. Furthermore, it is even possible to change from one injection liquid to another, provided such liquids are not seriously incocompatible, by simply loading the new reservoir cartridge **24** and purging the apparatus by operating it several times with the new cartridge before beginning injections.

It is to be understood that each of the cartridges **24** holds a sufficient volume of liquid for a number of jet injections. With the proportions illustrated, in the order of twenty injections may be made from a single liquid reservoir 24 of 1.8 cc. capacity.

A practical diameter for the piston **20** in the embodiment illustrated, is approximately 0.15 inch, and the travel of the piston **20** may be in the order of one-quarter of an inch. This provides a displacement of about 0.08 cc. The other dimensions of the apparatus, which have not been particularly specified, are preferably in proportion as illustrated in the drawings.

While the entire device is constructed so that it can withstand sterilization heating, it is preferable to sterilize only those parts which absolutely must be sterile and to avoid sterilization heating of certain parts such as the springs **28** and **76**. For the purpose of this limited sterilization, the outer housing can be conveniently disassembled at the connection between tube **50** and upper tube **52**, and all of the parts of the housing shown below the disassembly point may then be sterilized. With the movable member **16**, the disassembly preferably is at the connection between the cartridge tube **64** and the piston **20**, the entire assembly of the movable members shown below this point being sterilized. Except for the ball valve **14**, and the O ring **46**, the entire instrument is composed of metal. This statement is made with the understanding that the cartridge **24** is not considered to be a part of the instrument. Generally, the preferred material for all of the metal parts, including springs **28** and **76**, is stainless steel so that the moisture conditions during sterilization of the entire instrument do not cause any problem.

The pressures required within the chamber **18** during an injection operation are appreciable. Generally, with the specific dimensions given by way of example above, the pressures should be generally in excess of 450 pounds per square inch. The actual theoretical design pressures for the embodiment shown are in the range from about 500 to about 650 pounds per square inch. Higher pressures

in the order of 750 pounds per square inch, or more, may be required for difficult injection conditions.

The preferred arrangement of the liquid reservoir **24** is as shown in the drawings. It is one of the important advantages of the present invention that it is particularly adapted to accommodate standard sized medical liquid cartridges. However, the structure is also adapted, without substantial change, to operate with a rather large exterior reservoir of medical liquid. For this purpose, the reservoir cartridge **24**, and preferably the spring **76** and the spring tip **78** are removed. A small flexible tubing leading from a large medical liquid reservoir bottle is threaded through the central opening **110** in the spring cap **66**. The end of this tubing is then fitted over the tip **74** of the canula **62**. Preferably, such an external reservoir bottle may be of a collapsible plastic type so that atmospheric air need not be introduced into the bottle to make up for the displacement of liquid from the bottle as it is emptied.

While the jet injector, as it is disclosed in the accompanying drawings, is basically a single dosage charge volume device, it is apparent that the injection dosage volume can be very simply increased by increasing the length of the cylinder **32**, and correspondingly increasing the length of the piston **20**, and by designing the lever **26** and the associated latching arrangements to provide for greater piston travel. One such arrangement is to provide a number of spaced flanges on the spring cap **66** corresponding to flange **88**, and arranged in such a way that repeated up and down motions of the lever **26** will successively engage the different flanges and thereby give the movable member an additional cocking displacement for each clockwise cocking operation of the lever **26**. In this manner, the device may be set to deliver a single charge, a double charge, or an additional number of charges for which the device is designed. Minor changes and adjustments in the charge volume may be made by cutting away the lower surface of the flange **65** of the cartridge tube **64**, or the lower surface of the flange **88** of the spring cap **66**. Reducing the flange **65** increases the stroke and the displacement, and reducing the flange **88** decreases the displacement by decreasing the travel of the movable member to the point where latch **30** engages the flange **88**. A very simple adjustment of the stroke, and the displacement, may be accomplished by unscrewing the cap **66** at its screw threaded fastening to the cartridge tube **64**. This is equivalent to cutting away the lower surface of the flange **88**. The amount of unscrewing rotation of the cap **66** will determine the amount of reduction of volume of the ejection. For purposes of absorbing the mechanical shock at the end of the stroke of the movable member **16**, a washer of a non-metallic material such as nylon may be inserted beneath the flange **65**, if desired. This alternative is not illustrated. A washer of only one thirty-second of an inch in thickness has been found to accomplish this purpose very well. It is obvious that the presence of the washer changes displcaement volume, and minor adjustments of the displacement volume may be accomplished by employing washers of different thickness.

Various modifications may be made in the latching structure. For instance, instead of employing the latch member **30**, a latch may be provided for holding the lever **26** in the "cocked" position. This arrangement can take the form of a latch arm similar in appearance to the spring arm **84**, but which is pivoted closer to the center of the casing than the lever pivot **56**. This latch arm is arranged to drop into a notch on the outer surface of lever **26**.

While arrangements for manual cocking of the instrument have been illustrated and described in connection with the preferred embodiment, it is quite apparent that other structures may be employed for cocking the instrument by means of powered devices such as electric motors. One such arangement can employ a motor-operated screw jack for raising the movable member to a point where the latch **30** can engage it. However, such power arrangements increase the weight and bulk of the device and thereby reduce its portability. Accordingly, such a power operated version of the invention is not preferred.

It is believed to be apparent from the drawings and the above description that all of the objects and advantages of the invention have been achieved.

While this invention has been shown and described in connection with a single preferred embodiment, it is apparent that various changes and modifications, in addition to those mentioned above, may be made by those who are skilled in the art without departing from the basic features of the invention. Accordingly, it is the intention of the applicant to protect all variations and modifications within the true spirit and valid scope of this invention.

What is claimed is:

1. A hypodermic jet injector comprising a housing member defining a jet orifice arranged in a blunt terminal portion thereof, a first one-way valve formed within said housing member and operable to provide flow of the liquid to be injected to said orifice and to prevent backward flow through said valve, a member mounted for reciprocable movement with respect to said housing member, one of said members forming a cylinder and the other one of said members forming a cooperating piston within said cylinder to define a variable volume chamber of restricted cross section, one of said members including a second one-way valve communicating with said chamber and arranged to provide free flow of liquid to said chamber, said last-named member further defining an inlet passage for conveying liquid through said second valve to said chamber and including connections for a supply container of the liquid, said last-named member also defining a cartridge chamber for engaging and holding a pre-packed liquid cartridge of the type having a pierceable seal at the outlet end and a slidable rubber stopper at the opposite end and serving as the liquid supply container, said connections for the supply container including a canula with a hollow tip extending into the cartridge chamber adjacent to said second valve for piercing the seal at the outlet end of the cartridge, and a quick-release compression device comprising a spring engaged between said members and restrained by a latch supported by said housing member and engageable with said reciprocable member, a cocking lever pivotally mounted on said housing member and engaging said reciprocable member for moving said reciprocable member against the pressure of said spring to enlarge said chamber, said compression device being operable upon release of said latch to impart a fast and powerful movement to said reciprocable member in the direction to reduce the volume of said chamber to cause ejection of liquid from said chamber through said orifice with sufficient force to penetrate the skin of the patient.

2. A hypodermic jet injector comprising a housing member defining a jet orifice arranged in a blunt terminal portion thereof, a first one-way valve formed within said housing member and operable to provide flow of the liquid to be injected to said orifice and to prevent backward flow through said valve, a member mounted for reciprocable movement with respect to said housing member, said reciprocable member having formed therein a second one-way valve, one of said members forming a cylinder and the other one of said members forming a cooperating piston within said cylinder to define a variable volume chamber of restricted cross section between said valves, said second one-way valve being arranged to provide free flow of liquid to said chamber, said reciprocable member further defining an inlet passage for conveying liquid through said second valve to said chamber and including connections for a supply container of the liquid, a quick-release compression device comprising a spring engaged between said members and restrained by a latch supported by said housing member and engageable with said reciprocable member, said compression device being operable upon release of

said latch to impart a fast and powerful movement to said reciprocable member in the direction to reduce the volume of said chamber to cause ejection of liquid from said chamber through said orifice with sufficient force to penetrate the skin of the patient, said reciprocable member defining a cartridge chamber for engaging and holding a pre-packed liquid cartridge of the type having a pierceable seal at the outlet end and a slideable rubber stopper at the opposite end and serving as the liquid supply container, said connections for the supply container including a canula with a hollow tip extending into the cartridge chamber adjacent to said second valve for piercing the seal at the outlet end of the cartridge.

3. A jet injector as claimed in claim 2 wherein said reciprocable member is operable in cooperation with said valves to cause the charging of said variable volume chamber as said chamber volume is increased by outward movement of said reciprocable member, said charging being carried out under positive atmospheric pressure through said second one-way valve to fill the enlarged volume of said chamber.

4. A jet injector as in claim 2 in which a biasing spring is positioned within said reciprocable member for engagement with the rubber stopper of the liquid cartridge for biasing the stopper into the cartridge as the cartridge is emptied to thereby displace the liquid without introducing atmospheric air to the liquid within the cartridge.

5. A jet injector as claimed in claim 2 wherein said second valve comprises an axially reciprocable plate floating within a chamber defined within sad piston member conforming to the outer periphery of said plate and having an axial dimension greater than the thickness of said plate, said plate having at least one axial opening therethrough, and the wall of said chamber on one side of said plate being completely closed in the radial position opposite to said aperture to thereby close said valve whenever said plate engages said closed chamber wall, the opposite wall of said chamber being relieved in the radial position opposite to said aperture to thereby open said valve whenever said plate engages said opposite wall.

6. A hypodermic jet injector comprising a housing member defining a jet orifice arranged in a blunt terminal portion thereof, a first one-way valve formed within said housing member and operable to provide flow of the liquid to be injected to said orifice and to prevent backward flow through said valve, a member mounted for reciprocable movement with respect to said housing member, said reciprocable member having formed therein a second one-way valve, one of said members forming a cylinder and the other one of said members forming a cooperating piston within said cylinder to define a variable volume chamber of restricted cross section between said valves, said second one-way valve being arranged to provide free flow of liquid to said chamber, said reciprocable member further defining an inlet passage for conveying liquid through said second valve to said chamber and including connections for a supply container of the liquid, a quick-release compression device comprising a spring engaged between said members and restrained by a latch supported by said housing member and engageable with said reciprocable member, said compression device being operable upon release of said latch to impart a fast and powerful movement to said reciprocable member in the direction to reduce the volume of said chamber to cause ejection of liquid from said chamber through said orifice with sufficient force to penetrate the skin of the patient, a pivoted cocking lever for moving said reciprocable member against the pressure of said spring to enlarge said chamber, said latch being engageable with said reciprocable member for retaining said reciprocable member in the cocked position, said lever having a lost motion pivotal connection with said housing member and being movable at said lost motion connection to engage and release said latch upon continued excursion of said lever after completion of the cocking operation.

7. A hypodermic jet injector comprising a housing member defining a jet orifice arranged in a blunt terminal portion thereof, a first one-way valve formed within said housing member and operable to provide flow of the liquid to be injected to said orifice and to prevent backward flow through said valve, a member mounted for reciprocable movement with respect to said housing member, said reciprocable member having formed therein a second one-way valve, said housing member defining a cylinder and said reciprocable member including a portion forming a cooperating piston within said cylinder to define a variable volume chamber of restricted cross section between said valves, said second one-way valve being arranged to provide free flow of liquid to said chamber, said reciprocable member further defining an inlet passage for conveying liquid through said second valve to said chamber and including connections for a supply container of the liquid, a quick-release compression device comprising a spring engaged between said members and restrained by a latch supported by said housing member and engageable with said reciprocable member, said compression device being operable upon release of said latch to impart a fast and powerful movement to said reciprocable member in the direction to reduce the volume of said chamber to cause ejection of liquid from said chamber through said orifice with sufficient force to penetrate the skin of the patient, said piston and said cooperating cylinder having a small cross section to provide a high force per unit area from said quick-release compression device, said second one-way valve being axially displaced from said piston portion of said reciprocable member in a portion thereof having a larger cross section than said piston portion, said piston portion including a central bore extending from said second one-way valve and forming part of said chamber.

8. A jet injector comprising a cylinder member and a piston member arranged for cooperative engagement to define a variable volume chamber, each of said members including a one-way valve communicating with said chamber, said cylinder member including a jet orifice, and the valve of said cylinder member being arranged to provide flow from said chamber to said orifice, the valve of said piston member being arranged to provide flow into said chamber, said piston member valve comprising an axially reciprocable plate floating within a chamber conforming to the outer periphery of said plate and having an axial dimension greater than the thickness of said plate, said plate having at least one axial opening therethrough, and the wall of said chamber on one side of said plate being completely closed in the radial position opposite to said aperture to thereby close said valve whenever said plate engages said closed chamber wall, said piston member defining a cartridge chamber for engaging and holding a prepacked liquid cartridge of the type having a pierceable seal at the outlet end and a slidable rubber stopper at the opposite end to serve as the liquid supply container, a connection for the supply container including a canula with a hollow tip extending into the cartridge chamber adjacent to said second valve for piercing the seal at the outlet end of the cartridge, a biasing spring positioned within said piston member for engagement with the rubber stopper of the liquid cartridge for biasing the stopper into the cartridge as the cartridge is emptied to thereby displace the liquid without introducing atmospheric air to the liquid within the cartridge, said piston member being operable in cooperation with said valves to cause the charging of said variable volume chamber as said chamber volume is increased by outward movement of said piston member, said charging being carried out under positive atmospheric pressure through said second one-way valve to fill the enlarged volume of said chamber, a spring connected between said

cylinder member and said piston member for biasing said piston member in the direction to reduce the volume of said chamber, a pivoted cocking lever for moving said piston member against the pressure of said spring to enlarge said chamber, a latch member pivotally connected to said housing member and engageable with said piston member for retaining said piston member in the cocked position, said lever having a lost motion pivotal connection with said cylinder member and being movable at said lost motion connection to engage and release said latch member upon continued excursion of said lever after completion of the cocking operation.

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