

June 15, 1965

R. R. STEPHENS

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HYPODERMIC INJECTION APPARATUS

Filed July 27, 1961

2 Sheets-Sheet 1

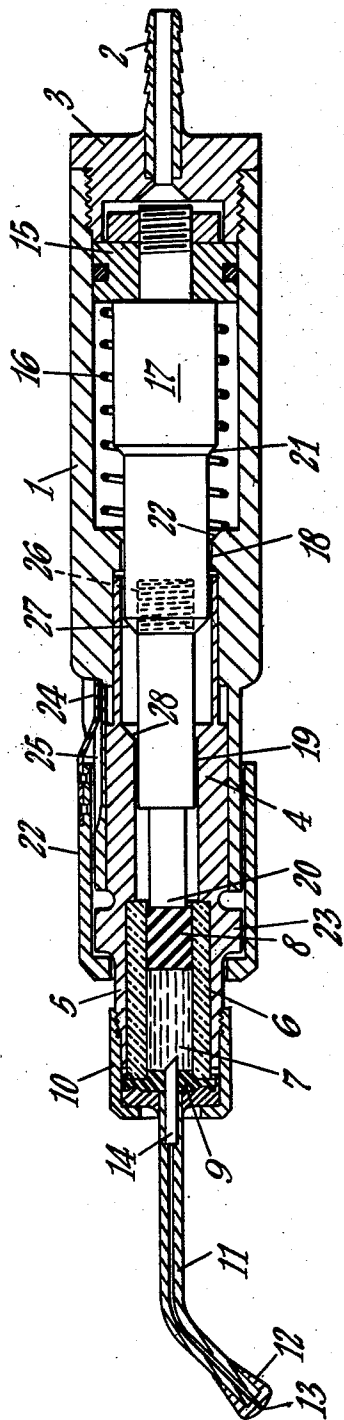


Fig. 1.

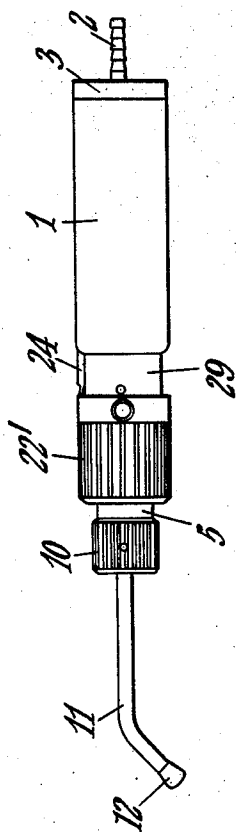


Fig. 2.

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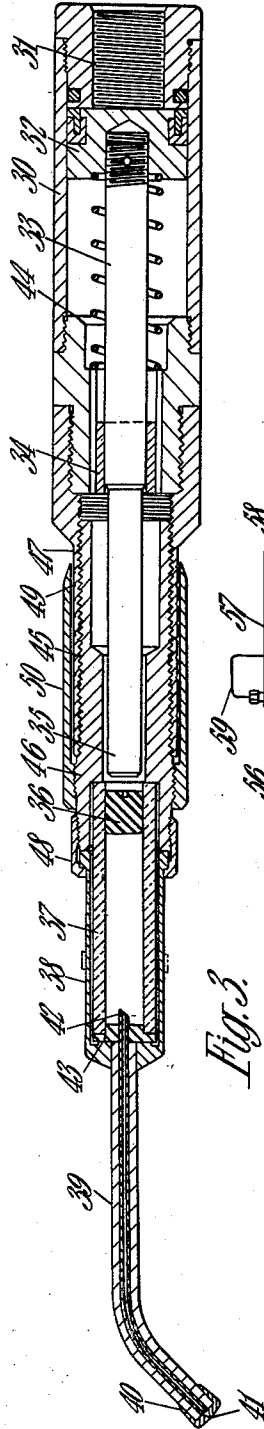


Fig. 3.

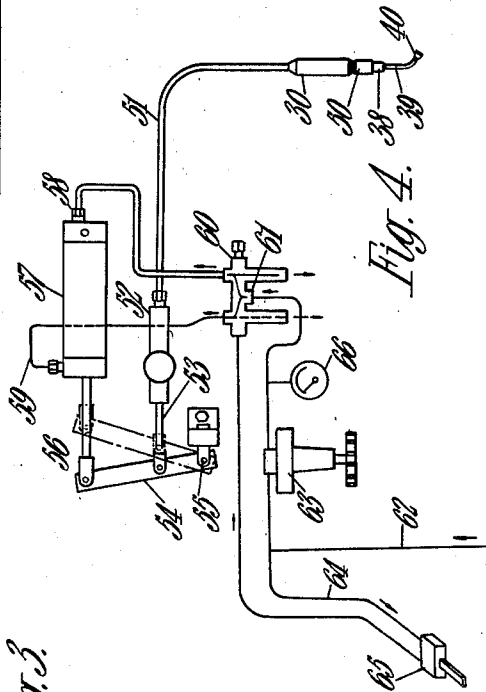


Fig. 4.

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HYPODERMIC INJECTION APPARATUS

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6 Claims. (Cl. 128—173)

This invention relates to jet injection devices, that is to say, to hypodermic injectors of the needleless type able to inject liquid subcutaneously by virtue of the membrane piercing and penetrating qualities of the narrow, high velocity jet which they are constructed to emit.

Numerous injectors of this kind have already been proposed, but in the main, they are characterized by considerable weight and bulk, and by the incorporation of energy accumulator devices whereby the injection can be triggered by mechanical release of a plunger member initially subject to high thrust. It is found in practice that, in general, these devices exhibit an undesired degree of recoil as well as being unduly expensive and being inconveniently clumsy for dental use.

An object of the invention is to provide a lightweight jet injector which does not require an energy accumulator device, but at the same time retains the advantage of a high initial jet velocity necessary for membrane piercing. A further object is to provide a jet injector which is convenient to manipulate in dental practice where injection must often be made at positions within the patient's mouth to which access would be difficult, if not impossible, by existing jet injectors. A further object is to provide a convenient arrangement whereby successive doses may be ejected from a single cartridge. Yet another object is to provide a jet injector having low recoil characteristics.

This invention consists in a jet injector comprising a nozzle portion furnished with a fine jet, a holder for liquid to be injected communicating with said nozzle, and a plunger for expelling liquid from within said holder through the nozzle, the plunger being associated with a piston of substantially larger cross sectional area housed within a fluid-operated cylinder for the direct transmission of thrust from the piston to the plunger, the cylinder having a fluid inlet portion connectable to an external source of pressurized fluid by a flexible pipe.

In operation the jet injector will be connected with a source of pressurized fluid associated with means for supplying this fluid abruptly. It has been found most convenient to employ a compressed gas supply as the power source, and to feed this through a snap-acting valve to give rise to the necessary abrupt movement. By having the cylinder of the injector arranged for pneumatic operation, the simplest construction is derived, since the compressed gas (for example, air) can be fed through the snap-acting valve direct to the injector. However, a more forceful thrust, or a more compact injector, or a lower gas pressure, can be realized by the use of a separate pneumatic cylinder connected by a hydraulic linkage to the injector, the cylinder of which is then a hydraulic cylinder. This arrangement also facilitates the incorporation of a lever connection, giving a mechanical advantage, between the pneumatic cylinder and the hydraulic linkage.

In one aspect, the invention consists in a jet injector as set out above, in which the fluid-operated cylinder is arranged for pneumatic operation and is connected to a snap-acting valve for the admission of compressed gas from a suitable source.

In another aspect the invention consists in a jet injector as set out above, in which the fluid-operated cylinder is arranged for hydraulic operation and is connected by

way of a hydraulic linkage to a plunger operated by a pneumatic ram the latter being connected by a snap-acting valve for the admission of compressed gas from a suitable source.

By dispensing with energy accumulator devices (such as massive helical springs or pneumatic cylinders which have to be charged with gas under exceptionally high pressure) the complexity, weight and cost of the device are reduced, and the handling characteristics are improved. It has already been proposed to employ compressed air to actuate the plunger of a jet injector, but it has been found impracticable merely to admit compressed air under the necessary high pressure to the opposite end portion of the plunger. This would involve the use of gas under such pressures that the establishment of a regular connection between the injector and a source of correspondingly pressurized gas would be impracticable in a dental surgery. By constructing the injector in accordance with the invention, it becomes possible to employ gas under much lower pressure, for example, 200–300 pounds per sq. inch (where the injector cylinder is pneumatically operated) or say 25–50 pounds per sq. inch (where the injector cylinder is hydraulically operated) in respect of which the use of light-weight and flexible connecting pipes does not present any difficulty.

It has generally been recognized that it is important to provide for a very high initial liquid velocity. To this end, numerous more or less complicated devices have been proposed for incorporation into jet injectors. It is an important feature of the present invention that the discovery has been made that this essential effect can be achieved without making any provision for it within the injector, simply by the use of a snap-acting valve for the admission of pressurized gas to the pneumatic cylinder. Although (in the case of a pneumatic jet injector cylinder) this valve could be mounted to be carried with the cylinder, this would merely add to the weight of the injector, and it is generally convenient to mount the valve elsewhere and connect it by flexible tubing to the cylinder. It is remarkable that gas under only 200–300 pounds per sq. inch should be able to traverse several feet of tubing of, for example, only $\frac{3}{16}$ inch bore, which can be correspondingly narrow walled, and still impart a sufficient shock to the respective piston necessary for generating the membrane and tissue piercing jet.

In general, the snap-acting valve employed will be power opened. For example, it may be opened by pneumatic or spring means, the release of which may be occasioned by a trip device which may in turn be operated by remote control, for example, electrically by a micro-switch mounted on the injector itself, or by a pilot valve in a pneumatic circuit.

It has in the past generally been considered important to have the fine jet in the nozzle in immediate proximity to the container for the liquid to be injected. In dental use, where the site of the injection is often awkwardly placed, it is as already mentioned, in many cases difficult, if not impossible, to reach such site when employing an injector designed in accordance with previous proposals where the respective nozzle is situated at, or projecting only slightly from the end of the wide body of the injector. According to this feature of the invention, the nozzle in which the fine jet is formed, is furnished at the end of a cranked extension tube leading from the liquid holder. It will be understood in this connection that, although reference has been made herein to a fine jet, it is not precluded to have additional jets. Despite the positioning of the jet some inches away from the liquid holder, it is found that the necessary high initial jet velocity can still be attained when using gas pressures as low as 200 pounds per sq. inch or 40 pounds per sq. inch respectively, with an extension tube or bore no greater than

that employed in a standard capsule piercing needle, say $\frac{1}{16}$ inch.

The simple mechanism required for the jet injector of this invention readily lends itself to the incorporation of means for enabling successive injections to be made from the same charge of liquid. Thus, provision may be made for retracting the liquid holder, for example by screw mechanism, from the pneumatic or hydraulic piston. In association with stroke limiting means for the piston, this enables a restricted dose to be ejected from the liquid holder when the latter is in a retracted position. A calibrated scale may be incorporated to show the dosage corresponding to the different positions of the holder. In another arrangement, the liquid holder and the pneumatic or hydraulic piston are again relatively adjustable in an axial direction, suitable by screw mechanism, but in this case stroke limiting means for the plunger are arranged to move with the liquid holder, so that by displacement of the liquid holder in the direction of the cylinder, the plunger stroke is correspondingly shortened. In either case, to avoid any substantial free travel of the plunger at the initiation of an injection, which could give rise to objectionably heavy impact transmission to the injector nozzle, the piston-plunger assembly may be constrained to lengthen or shorten as required in accordance with the relative displacement of the liquid holder, to maintain the plunger in a thrust transmitting position. Thus, the plunger may be made in two portions one of which screws into the other, these portions being constrained to rotate respectively with the liquid holder and pneumatic cylinder screw mechanism for the latter members having the same pitch as the screw of the plunger. Since the transmission of a rotary thrust is not involved, elaborate splining is not necessary for this purpose.

The expression "liquid holder" will be understood broadly and need not itself constitute a liquid tight receptacle. Generally, this holder will be constructed to accommodate snugly a standard cylindrical glass capsule having a rubber cap at one end and a rubber plug at the other, the rubber cap being perforated by a needle extending from the nozzle or extension tube thereof when this is fitted to the liquid holder. It is found that the abrupt transmission of the necessary high pressure does not, in practice, result in fracture of the glass capsule.

The invention will be described further with reference to the accompanying drawings, of which:

FIGURE 1 is a longitudinal sectional view of an injector according to the invention, incorporating a pneumatic cylinder.

FIGURE 2 is a plan view of the injector of FIGURE 1.

FIGURE 3 is a longitudinal sectional view of a second form of injector, incorporating a hydraulic cylinder, and

FIGURE 4 is a schematic arrangement showing how the injector of FIGURE 3 is operated.

The injector of FIGURES 1 and 2 comprises a pneumatic cylinder 1 having a connection 2 for the attachment of a flexible tube leading to a snap-acting gas valve (not shown). In practice, this valve may be connected to a reduction valve affording a pressure of 200-300 pounds per sq. inch to a high pressure gas cylinder. The cylinder is closed at one end by a plug 3 and at the other end by an extension sleeve 4 of a liquid holder 5. The latter is formed to accommodate a glass cartridge 6 containing liquid 7 to be injected. The cartridge is closed at one end by a resilient plug 8 and at the other end by a resilient cap 9, and is held in position by a cap 10 fitting over the liquid holder and securing an extension tube 11 of relatively narrow bore leading to a nozzle 12 furnished with a fine jet 13. Suitable sizes of jet are well known to those skilled in the art, and may be of the order of a few thousandths of an inch. A piercing needle 14 mounted in extension tube 11 is arranged to pierce the cap 9 on assembly of the injector.

A pneumatic piston 15 associated with a return spring 16 is housed within cylinder 1 and is attached to a plunger

17 maintained in alignment by a guide surface 18 formed within the cylinder 1 and by a guide portion 19 formed within the extension sleeve 4 of the liquid holder. The plunger is stepped, and at its leading end 20 where it engages the plug 8, is several times, for example 10, smaller in cross sectional area than is the piston 15. In this way, a pressure at the order of 2000-3000 pounds per sq. inch is attained with a gas pressure of only 200-300 pounds per sq. inch.

The stroke of the piston is limited by an angled shoulder 21 thereon coming into engagement with a correspondingly angled shoulder 22 formed within the cylinder 1. A cap 22' fitted over a collar 23 formed about the liquid holder 5 carries a resilient tongue 24 arranged to seat in a longitudinal groove 25 formed in the forward portion of the cylinder 1. This engagement serves to locate the angular piston of the liquid holder relative to the pneumatic cylinder and by unscrewing the former, it is possible to discharge a limited dose from the cartridge 6 since the latter will recede from the plunger 17.

To avoid the free travel of the piston and plunger when the liquid holder is retracted as just described, a screw connection 26 may be provided between the forward and rearward portions of the plunger, these portions being constrained to rotate with the liquid holder and cylinder respectively, for example by a projection or grooves or splined arrangement at positions 18 and 19. By making the screw connection 26 of the same pitch as the screw connection between the liquid holder and cylinder, the plunger can be kept substantially in engagement with the plug 8.

In a modification, in which the shoulder portion 21 may be dispensed with, engagement surfaces 27 and 28 are formed on the plunger and liquid holder extension 4 respectively. In this case, the dose ejected from the cartridge 6 may be reduced by screwing the liquid holder towards the cylinder, that is to say, in the reverse direction to that required by the embodiment just described, the plunger being shortened in length by the same movement by virtue of the threaded connection 26.

As shown in FIGURE 2, a scale 29 may be formed in the pneumatic cylinder to show the dosage corresponding to the position of the cap 22'. The possibility of ejecting only part of the contents 7 enables successive doses to be ejected from the same cartridge.

For actuating the snap-acting gas valve, a microswitch (not shown) may be mounted on the cylinder 1. The connecting tubes may be of flexible plastic braided with a high tensile continuous filament yarn.

Referring now to FIGURES 3 and 4, it will be seen that, in this modification, the pneumatic cylinder is separated from the injector itself, and a hydraulic linkage is inserted between these two members. Additionally, to give some degree of mechanical advantage, and to provide full utilization of the long stroke of the pneumatic cylinder, a lever linkage is inserted.

The injector itself is, broadly, very similar to that illustrated in FIGURES 1 and 2. It comprises a hydraulic cylinder 30 having an inlet 31 at its outer end, and housing a piston 32. The latter is fitted centrally with a piston rod 33 passing through a guide bearing 34, and at its forward end 35 it thrusts directly, in operation, against the rubber piston 36 of a capsule 37 housing material to be injected. This capsule, which will normally be of glass, is received in an outer sleeve 38 the forward end of which carries a cranked extension tube 39 leading to a nozzle 40 having a jet 41. This jet may, for example, be 0.003 to 0.005 inch in diameter. At its inner end, there protrudes from the tube a tubular concentric needle 42 which serves to pierce the seal 43 at the forward end of the capsule 37. The forward travel of the piston 32 is arrested by a shoulder 44 at the inner end of the cylinder 30, so that the piston rod end or plunger 35 describes a predetermined stroke. The quantity of liquid ejected from the jet 41 is determined by the setting of the screw-threaded

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connection 45 coupling a central body portion 46 of the injector with a forward extension 47 of the cylinder 30. A union cap 48 secures the sleeve 38 to the central body portion 46. The more the latter is screwed forwardly on to the extension 47, the more liquid is ejected. Grooves 49 are progressively uncovered by an outer sleeve portion 50 carried by the central body portion 46, to show the amount to be ejected; these grooves may be marked in any convenient manner. Starting from a full cartridge, several of the grooves may be covered, to secure the ejection of a substantial quantity of liquid; alternatively, only one may be covered at a time where successive small quantities are to be injected.

In operation the jet injector of FIGURE 3 is connected by an inflexible pipe 51 (FIGURE 4) to a hydraulic cylinder 52. In a particular example, this cylinder is of $\frac{3}{4}$ inch bore and 1 inch stroke. It is operated by a plunger 53 the outer end of which is pivoted to an intermediate position of a lever 54. This lever, pivoted at the adjacent end to the fixed fulcrum 55, is pivotally connected at its other end to the piston rod 56 of a relatively large pneumatic cylinder 57. In a particular example, this cylinder is of $2\frac{1}{4}$ inch bore and of 3 inch stroke, the lever 54 affording a mechanical advantage of 3:1. For convenience, the cylinder may as shown be double acting, with an inlet 58 for the admission of compressed air or other gas on a power stroke, and an inlet 59 for the corresponding return stroke. These inlets, also serving as exhausts, are connected to a remote controlled two-way snap-acting valve 60 having an inlet 61 for the admission of compressed air or other gas. This gas is conveniently fed along a pipe 62 from an air compressor (not shown) through a pressure regulator 63 which may for example be set to provide an operating pressure of 40 pounds per square inch. A branch pipe 64 leads to a pedal valve 65 and from there to the valve 60, for the operation of a spool or other internal movable member serving to switch the connection through the valve from the one outlet to the other; this member in the arrangement shown is spring returned. It will be appreciated that the arrangement illustrated provides for an abrupt admission of compressed air to the cylinder 57, assuming that the piping and other auxiliary devices are suitably dimensioned.

In operation, with the jet injector charged and the sleeve 50 set to the required dose, the pedal 65 is operated. The resulting abrupt movement of the piston rod 56 is transmitted by the lever and hydraulic linkage to the piston in the jet injector, which then operates as described with reference to FIGURES 1 and 2. The essential difference is that the pneumatic cylinder 57 is much larger than could be accommodated in the jet injector, and the resulting mechanical advantage enables use to be made of a much lower air pressure.

The arrangement illustrated in FIGURE 4 may if desired include a pressure gauge 66 to indicate the operating pressure. Members 52 to 63, and also the gauge 66

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where provided, may be mounted on a common support for example a small table, cabinet or trolley, while the pedal 65 and the associated flexible piping may be positioned conveniently on the floor. Alternatively, a push button may replace the pedal 65, in which case the button may be mounted on the aforesaid common support. It is an important advantage of the arrangement illustrated in FIGURES 3 and 4, that it can be served by the same compressed air source as is utilized for a dental turbine hand-piece.

I claim:

1. A jet injector comprising a fluid-tight cylinder provided with a connection for the admission of pressurized fluid thereto, a piston slidably mounted within said cylinder for axial movement therein under the action of the pressurized fluid, a plunger mounted for axial movement with said piston, said piston having a substantially larger cross-sectional area than said plunger, a holder for liquid to be injected so mounted with respect to said cylinder that on axial movement of the piston and plunger under the action of the pressurized fluid, the plunger moves inwardly of said holder for expelling liquid therefrom and a nozzle portion provided with a fine jet operably connected to the holder for transmitting liquid expelled from the holder by the plunger.

2. The jet injector as claimed in claim 1 in which said pressurized fluid is compressed air and a snap action valve serves for admitting compressed air into the connection.

3. The jet injector as claimed in claim 1 in which said pressurized fluid is compressed gas, a pneumatic ram, a plunger operated by the ram, hydraulic linkage operably connected to the connection of the cylinder and said plunger, and a snap action valve connecting said ram for admitting compressed gas into the connection of the cylinder.

4. The jet injector as claimed in claim 3 including lever means for transmitting thrust between said plunger and hydraulic linkage for affording a mechanical advantage in thrust ratio.

5. The jet injector as claimed in claim 3 including a pneumatically operated snap action valve, and an operator controlled pilot valve operably connected to the snap action valve.

6. The jet injector as claimed in claim 1 in which said nozzle portion is defined by a cranked tube having one end communicating with the holder for liquid and the other end being provided with the fine jet.

References Cited by the Examiner

UNITED STATES PATENTS

2,653,603	9/53	Hein	128—173
2,757,667	8/56	Bronk	128—173
2,762,370	9/56	Venditty	128—173
3,057,349	10/62	Ismach	128—173

ADELE M. EAGER, *Primary Examiner.*