

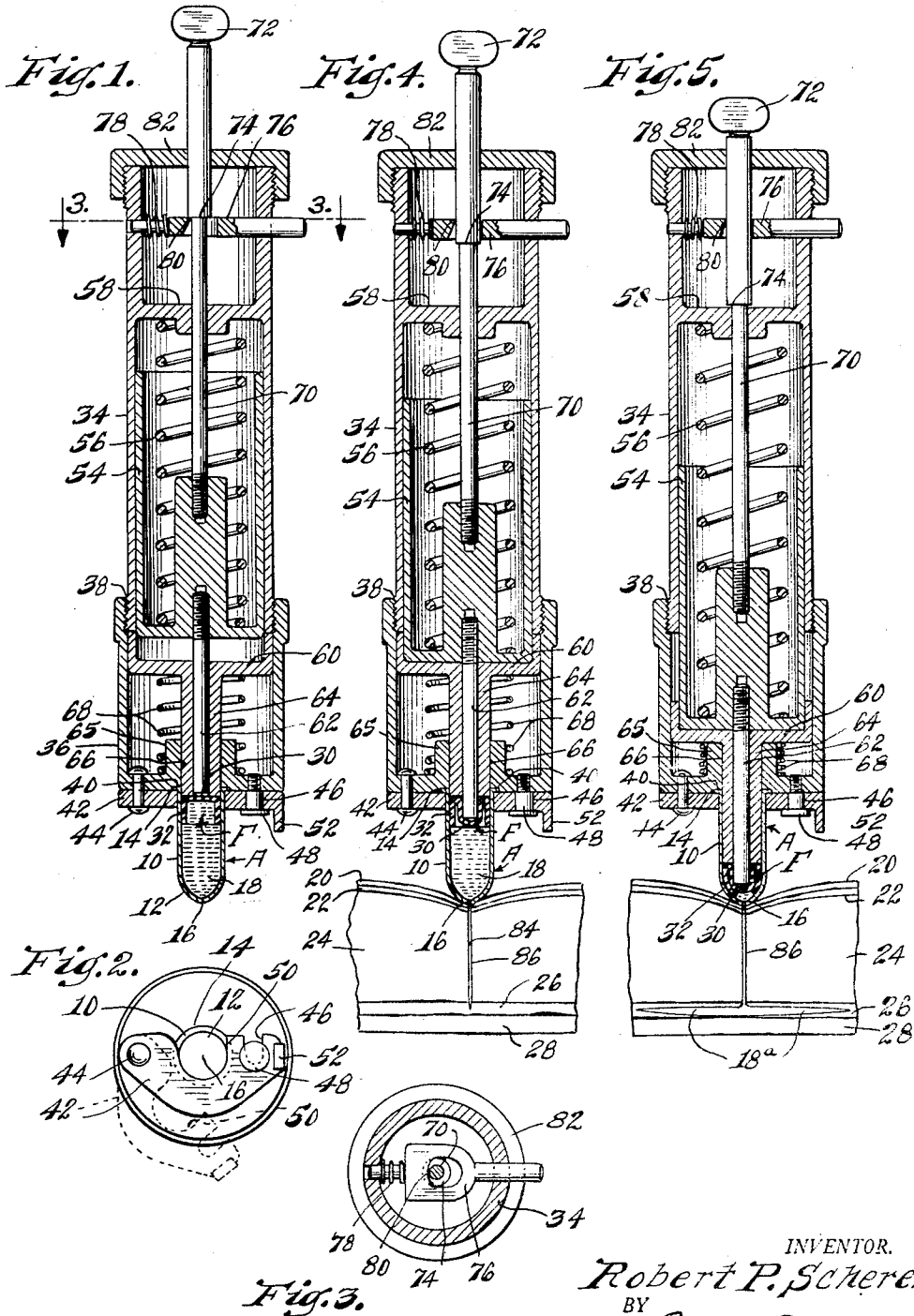
March 22, 1955

R. P. SCHERER
HYPO JET INJECTOR

2,704,543

Filed May 21, 1949

3 Sheets-Sheet 1



INVENTOR.

Robert P. Scherer.

BY

Baird Freeman

Attys.

March 22, 1955

R. P. SCHERER
HYPO JET INJECTOR

2,704,543

Filed May 21, 1949

3 Sheets-Sheet 2

Fig. 6.

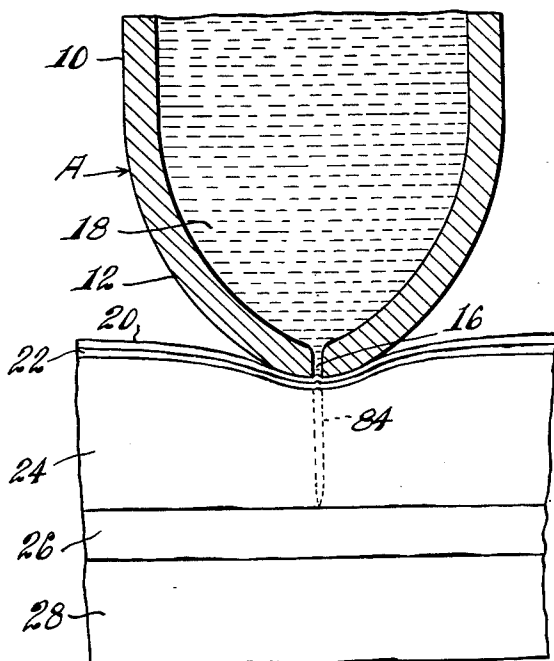


Fig. 8.

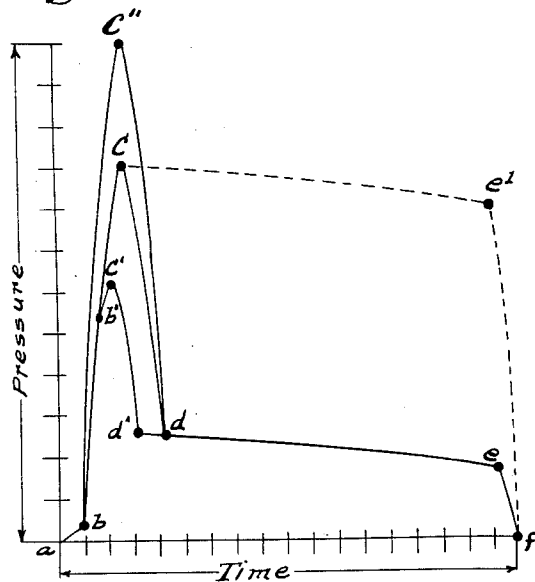


Fig. 7.

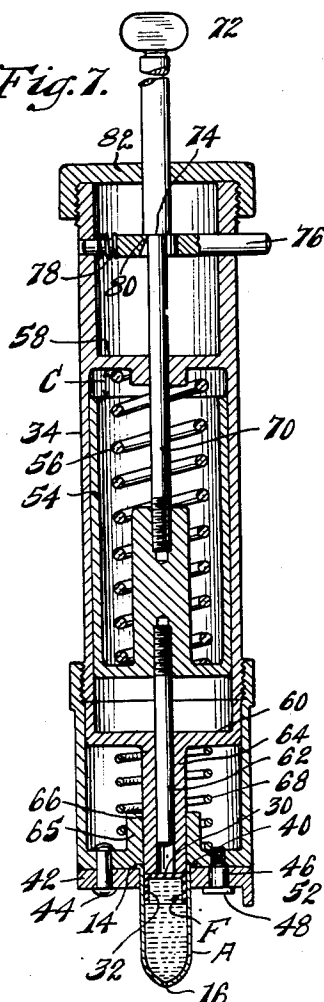


Fig. 7a.

INVENTOR.
Robert P. Scherer.
BY
Baird & Dreeman
Att'ys.

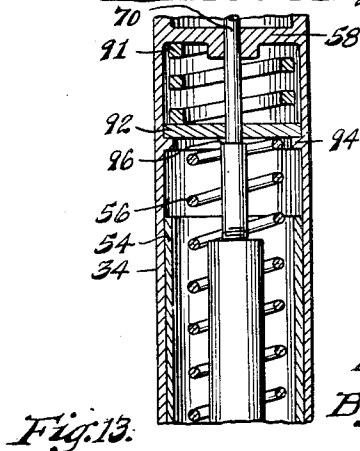
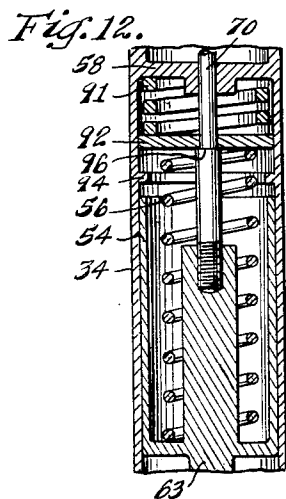
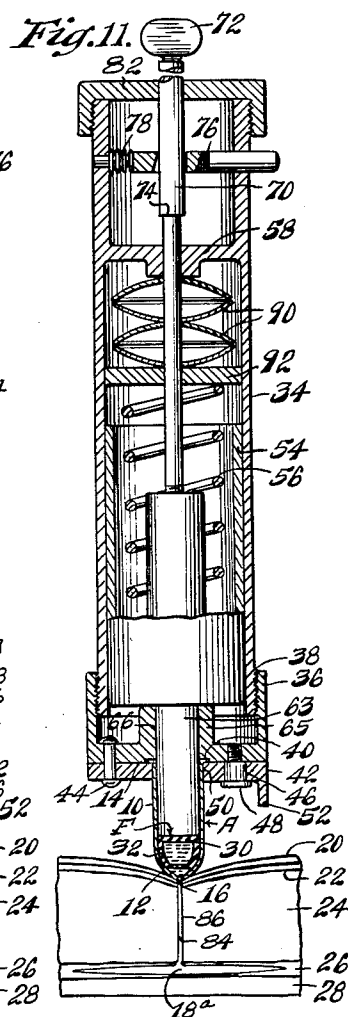
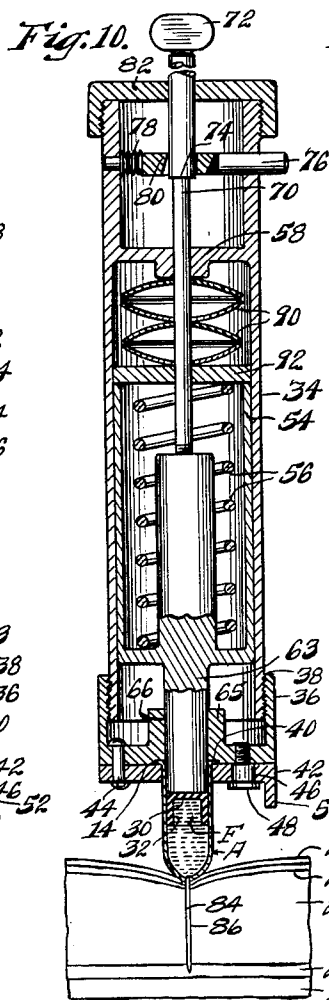
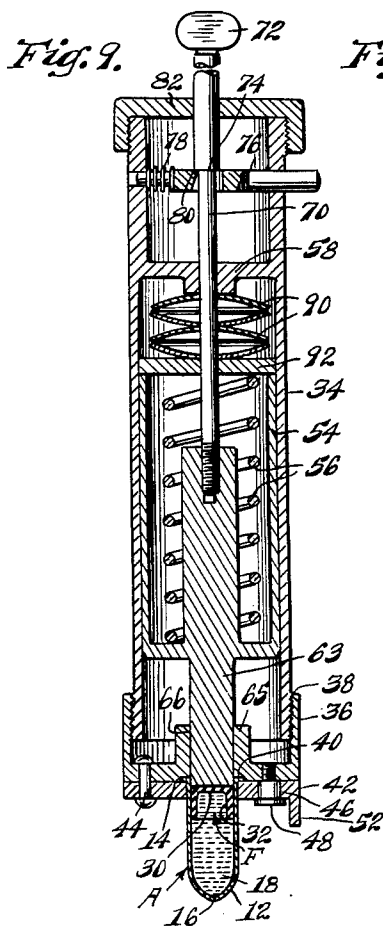
March 22, 1955

R. P. SCHERER
HYPO JET INJECTOR

2,704,543

Filed May 21, 1949

3 Sheets-Sheet 3



Inventor.
Robert P. Scherer.
By B. C. V. Freeman
Attys.

1

2,704,543

HYPO JET INJECTOR

Robert Pauli Scherer, Detroit, Mich., assignor to R. P. Scherer Corporation, Detroit, Mich., a corporation of Michigan

Application May 21, 1949, Serial No. 94,579

19 Claims. (Cl. 128—173)

This invention relates to an injector for hypodermically injecting fluid by the jet therapy method disclosed and claimed in my co-pending application, Serial No. 77,517, filed February 21, 1949.

One object of the invention is to provide an injector which is practical from both the manufacturing and utility standpoints, and efficient as a means to cause a true jet type of injection. Heretofore hypodermic injection without a needle was attempted as evidenced by the following Lockhart patents: 2,322,244, June 22, 1943; 2,322,245, June 22, 1943; 2,380,534, July 31, 1945; 2,398,544, April 16, 1946.

Another object of the present invention is to provide an efficient spring propelled type of mechanism which can be used in connection with a hypodermic jet ampule of the kind disclosed and claimed in my copending application, Serial No. 93,282, filed May 14, 1949 and now Patent Number 2,688,968 to operate the follower behind the medicament in the ampule in such manner as to effect true jet therapy of a practical quantity of liquid such as one cubic centimeter with a mechanism that is of practical size and weight for average use and is not prohibitively complicated to operate.

A further object is to provide a hypo jet injector which produces a two-stage jet injection in which the first stage is effected at a relatively high pressure and high velocity, that is, one which is high enough to produce a penetrating jet that opens a hole or channel by distending action through the epidermis to the desired depth in the underlying fat tissues, through them to the fascia overlying the muscles if desired, or if required through the fascia itself and into the muscle therebeneath for thereafter permitting an intramuscular injection to be made, most injections however, being intrafascial or merely hypodermic (in the fat tissues without going as deep as the fascia). With even less pressure it is possible to go through only the epidermis and make intradermal injections.

The second stage of the two-stage injection then consists of continuing the jet of medicament but with less pressure and velocity, which may be termed a "follow-through" jet so that the medicament is all discharged into the opening or channel formed by the high-pressure penetrating jet and is dispersed laterally from the bottom of the channel, generally parallel to the fibers of the tissues at the desired depth hypodermically. Insurance is had that all the medicament is properly injected by means of a hydraulic seal with the edge of the jet orifice of the ampule as more fully disclosed in my above referred to copending application covering the hypo jet ampule.

A further object is to provide either two plungers operated by a single spring or a single plunger operated by two springs in such manner as to secure the desired two-stage jet, that is, a primary or initial high-pressure, high-velocity penetrating jet and a secondary follow-through jet which has a pressure and velocity much lower than the penetrating jet.

Still a further object is to provide these two-stage arrangements in order to utilize a comparatively light spring for at least part of the operation as distinguished from a single stage operation in the Lockhart patents in which case the spring has to be many times heavier than I disclose in order to produce an initial high-pressure jet. The pressure for the follow-through jet need be only sufficient to produce follow-through action after cessation of the penetrating action of the initial jet, the major portion of the injection operation merely feeding the

2

medicament into the initial jet-opened channel to thereby result in lateral flow of the medicament from the bottom of the channel and result in a desired injection pattern which is thus under accurate control as to the depth of the injection.

5 An additional object is to provide an injector so constructed that the initial or high-pressure penetrating jet can be decreased by less spring tension, or increased by greater spring tension and/or by providing for a primary plunger to strike the follower with impact and a secondary plunger to provide the follow-through action depending upon the construction and proportion of the parts of the injector.

10 Another additional object is to provide a modified form of the invention in which a relatively heavy spring acts on a single plunger to provide an initial penetrating jet and after expulsion of a minor portion of the medicament a relatively light spring continues the movement of the same plunger to result in producing the follow-through jet.

20 With these and other objects in view, my invention consists in the construction, arrangement and combination of the various parts of my hypo jet injector whereby the objects contemplated are attained, as hereinafter more fully set forth, pointed out in my claims and illustrated in the accompanying drawings, wherein:

Figure 1 is a sectional view through a hypo jet injector embodying one form of my invention having primary and secondary plungers and a single spring, and showing 30 the parts in position for an injection operation;

Figure 2 is a bottom plan thereof;

Figure 3 is a detail sectional view on the line 3—3 of Figure 1;

Figure 4 is a view similar to Figure 1 showing the primary plunger operated to provide a high pressure penetrating jet and illustrating the projection of this jet to the fascia plane of the muscle;

Figure 5 is a similar view showing the low-pressure follow-through jet produced by operation of the secondary plunger and effecting lateral flow of the medicament, the injection illustrated being one in the fascia itself;

Figure 6 is a greatly enlarged sectional view through the end of the jet injection ampule which contacts the epidermis in order to illustrate the hydraulic seal between 45 the ampule and the epidermis;

Figure 7 is a view similar to Figure 1 showing the proportion of the parts for utilizing impact;

Figure 7a is an enlarged sectional view showing a modified construction;

Figure 8 is a graph showing pressure-time curves for a number of different operating mechanisms and conditions;

Figure 9 is a sectional view through a modified form of hypo jet injector showing a single-plunger, two-spring 55 type with the parts in position for an injection operation;

Figure 10 is a view similar to Figure 9 showing a relatively heavy spring expanded to provide a high-pressure penetrating jet and illustrating the projection of this jet to the fascia above the muscle;

Figure 11 is a similar view showing the low-pressure follow-through jet produced by operation of a relatively light spring on the same plunger and effecting lateral flow of the medicament;

Figure 12 is a sectional view similar to Figure 9 showing still another modification using a single plunger and two springs; and

Figure 13 is a view showing a stage in the operation similar to Figure 10 but illustrating the modification of Figure 12.

70 On the accompanying drawings, I have used the reference character A to indicate an ampule of the general type shown in my second mentioned copending application. The ampule A comprises a cylindrical wall 10 terminating in a rounded end 12 and having a holding flange 14 at its other end. The rounded end 12 is provided with a jet orifice 16 shown particularly in Figure 6 which should be anywhere from .002" to .005" in diameter.

75 The small size of the jet orifice is necessary to secure a jet discharge of the medicament illustrated at 18 with high velocity so as to penetrate or puncture the epidermis

80

20 and the underlying dermis 22 with a hole that is of minimum size, to minimize trauma yet produce a jet-formed passageway into the underlying tissues such as the fat cells 24, the fascia 26 or the muscle 28 as desired and yet accomplish the injection with imperceptible or at least minimum pain. In this respect I have found that a jet orifice of .003" diameter produces what might be termed a "microjet" when suitable hydraulic pressure is created on the medicament 18 to form a liquid column which is only $\frac{1}{16}$ of the area of a 26 gauge hypodermic needle, this size of needle being next to the smallest practical size in use at present.

The medicament 18 may be any suitable drug, fluid medicament or solution and so far I have found my hypo jet therapy method suitable for use with many different liquids among which I might mention insulin, diodrast, cocaine, penicillin, streptomycin, liver extract, promin, and procaine, as well as India ink, mercury, many different aqueous solutions, colloidal suspensions, oil solutions and emulsions which were injected into cadavers for the purpose of determining (1) depth of penetration under varying conditions and (2) the injection patterns resulting therefrom.

In the ampule A, I provide a follower F of rubber or the like preferably in the form of a central diaphragm 30 and a depending flange 32, the follower being thus in the form of a cup-like plunger. This follower backs up the medicament, and the ampule is preferably filled in such manner that there are no air bubbles present in the ampule to interfere with proper operation of the injector because bubbles would be highly compressible as distinguished from the liquid itself.

My hypo jet injector comprises a holder for the ampule A and operating means within the holder for the follower F. The holder and operating mechanism of Figures 1 to 5 will now be described.

A barrel 34 forms the body of the injector and has a cup-shaped lower head 36 connected thereto as by the screw threads illustrated at 38. The head 36 has a recess 40 receiving the flange 14 of the ampule A and the ampule may be held with its flange in the recess as by means of a retainer plate 42 pivoted at 44 and having a notch 46 to hook under the head of a shoulder screw 48. The latch plate 42 also has a notch 50 to receive the diameter of the ampule A and may be swung to the dotted position shown in Figure 2 for permitting removal of one ampule and insertion of another. A lip 52 on the latch plate is provided as an aid in swinging the plate.

Within the barrel 34 a primary cup 54, comprising part of a first mechanical operating means or force transmitting means or mechanism, is slidable and is normally urged in a downward direction by a spring 56 interposed between the lower wall of the cup and a partition 58. A secondary cup 60, comprising part of a second mechanical operating means or force transmitting means or mechanism, is slidable in the head 36. A primary plunger 62 is connected with the primary cup 54 and the secondary cup 60 has a tubular extension 64 surrounding the primary plunger 62 which serves as a secondary plunger. The plungers 62 and 64 operating individually or collectively constitute plunger means, or an actuating mechanism, for engagement with the follower F. The plunger 64 is guided by a central opening 66 in the head 36 and is biased upwardly to the position illustrated in Figure 1 by a light spring 68. In this position, the flange of the cup 60 is stopped by the lower end of the barrel 34.

For compressing the spring 56 to the position shown in Figure 1, I provide a pull rod 70 connected with the cup 54 and terminating in a knob 72. The pull rod 70 has a latch shoulder at 74 with which a latch plate 76 is biased to coact by means of a spring 78. The latch shoulder of the plate 76 is illustrated at 80. The pull rod is guided by a cap 82 screwed on the upper end of the barrel 34.

Referring to Figure 7 the typo jet injector disclosed therein is similar to the one shown in Figure 1 except that the cup 54 is higher than the barrel 34 in the cocked position of the injector and thereby raises the primary plunger 62 out of contact with the wall 30 of the follower F. Accordingly, before the parts reach the position shown in Figure 1 there is travel of the primary plunger 62 which produces an impact against the wall 30 at the time the parts reach the position of Figure 1 so that this impact is added to the initial high-pressure stage of operation which terminates when the parts reach the position of Figure 4 and after which the low pressure stage of the

operation as illustrated in Figure 5 finishes the jet injection.

In order to raise the plunger 62 enough in Figure 7 to secure impact as just described the portion of the barrel 34 above the partition 58 is made longer so that the latch plate 76 can be mounted higher and therefore hold the shoulder 74 at a higher elevation in the latched position.

The parts in Figures 9, 10 and 11 that differ from Figure 1 will now be referred to. Instead of primary and secondary plungers, a single plunger 63, constituting plunger means, is provided and it is connected with the cup 54, the plunger 64 and its cup 60 in Figure 1 being entirely eliminated. The spring 56 is still provided but in addition to this spring a second spring 90 which is much stiffer is utilized to initially propel the single plunger 63 to produce the high pressure penetrating jet. As illustrated this spring may comprise a stack of spring discs which are cupped and therefore relatively stiff and in fact much stiffer than the coil spring 56. The discs 90 are perforated at their centers and surround the pull rod 70, a washer 92 being interposed between them and the upper end of the cup 54.

In Figures 12 and 13 a relatively heavy coil spring 91 is provided in place of the discs 90 and the washer 92 below them is confined in its movement by an intumed flange 94 in the barrel 34. The pull rod 70 may then be provided with a shoulder 96 adapted to at times engage the washer 92 for a purpose which will hereinafter appear.

In Figure 7a I show a preferred shape for the primary plunger 62 in order that the follower diaphragm 30 will collapse completely against the flange 32 of the follower. This is accomplished by providing a bullet shaped end 62a on the plunger 62 of substantially similar shape to the rounded end 12 of the ampule A itself so that no liquid will be left in the ampule when the plungers are all the way down as possible with the arrangement shown in Figure 5. Also the single plunger 63 of Figure 11 can be shaped as shown for both plungers 62 and 64 in Figure 7a so that liquid is not left in the ampule as in Figure 11.

Practical operation of Figures 1 to 5

The parts are caused to assume the position of Figure 1 by pulling the knob 72 upwardly from the position of Figure 5 to the position of Figure 1 whereupon the latch plate 76 snaps to position under the shoulder 74 of the rod 70. The spring 56 is thus compressed and latched in the compressed position. In the position of Figure 5, it is desirable that the spring also be somewhat compressed to provide complete follow-through jet operation as will hereinafter appear. When a hypo jet injection is to be made, an ampule with proper medicament therein is placed in the recess 40 while the retainer plate 54 is in the dotted position of Figure 2 and the retainer plate is then swung to the full line position for retaining the ampule in operating position. The injector is then ready for performing the jet injection operation.

The injector is held usually at right angles to the skin surface where the injection is made and the ampule is pressed against the epidermis 20 as illustrated in Figures 4 and 6 to effect a hydraulic seal between the edge of the jet orifice 16 and the epidermis.

The end 12 of the ampule is preferably rounded or bullet shaped to present a jet orifice edge which is an acute angle and thereby produces the greatest sealing pressure against the epidermis right at the edge of the orifice itself, although I have found that the lower end may be honed off or polished to provide a narrow marginal flat spot surrounding the orifice and still provide an effective hydraulic seal between the ampule and the epidermis. The epidermis of course will bulge into the orifice slightly thus increasing the effectiveness of the seal.

If such a seal is not effected I have found that a film of liquid results between the ampule and the epidermis which results in "skidding" of the injector when it is operated with the result that a series of injections along an irregular path is produced, none of which are of the proper depth and much of the medicament is lost, that which is injected being improperly injected. The result is painful and produces an undesirable slit in the patient's skin and the attendant necessity of healing the slit. It is therefore important that the hydraulic seal referred to be produced prior to injection and in fact maintained for a second or so after injection in order to insure that all

5

the medicament of the follow-through jet will then be properly injected.

To accomplish injection, the latch plate 76 is pushed toward the left in Figure 3 which unlatches the shoulder 80 from the shoulder 74 and permits the spring 56 to expand. The primary cup 54 is propelled thereby until it strikes the secondary cup 60 and during this time the primary plunger 62 is acting on the follower F, causing its diaphragm portion 30 to be stretched and the follower partially turned "wrong-side out" as illustrated in Figure 4. Since the plunger 62 is relatively small in diameter it produces very high pressure in pounds per square inch (p. s. i.) in the ampule A and this pressure is sustained while the plunger moves from the Figure 1 position to the Figure 4 position. This results in displacing the medicament 18 through the jet orifice 16 and produces a true jet as shown at 84 in Figure 4 because the high pressure produces high velocity of the medicament due to its issue from an opening as small as the jet orifice 16.

The high velocity of the liquid tends to keep it in the form of a column but the column becomes pointed at the forward end because of the resistance offered to its flow by the body tissues which tend to peel off the periphery of the jet, tissues of greater resistance increasing this effect. Thus, the jet may be visualized as in the form of a pointed needle and the jet actually pierces a hole or channel which deepens as the jet continues to flow at a high pressure that causes jet penetration. The jet encounters its first resistance when it strikes the epidermis but with relatively high velocity it can readily pierce the epidermis and will then more easily open a channel through the layer of fat underlying the skin and accordingly reach down relatively easily to the next layer which is the fascia. The penetrating jet has the property of distending the surrounding tissues to form a hole 86 against the natural elastic tendency of the tissues to return to their original positions thus closing the hole.

The fascia layer is tissue that is more resistant than fat to the passage of the jet. If the high pressure is reduced to low pressure at the time the jet enters the fascia an intrafascia injection 18a takes place as shown in Figure 5 as the low pressure follow-through jet merely feeds the medicament into the distended hole 86 made by the high pressure penetrating jet, and the liquid then spreads laterally as at 18a producing an injection pattern the size of which increases with the quantity of liquid fed through the hole 86 by the low pressure follow-through jet.

Referring to Figure 8, the pressure-time curve *a, b, c, d, e, f*, represents an average jet injection. When the pull rod 70 is first released the spring 56 moves the cup 54 downwardly causing the primary plunger 64 to press against the follower F, the pressure rise *a, b*, being that resulting from taking up all play in the parts. Pressure then begins to build up quite rapidly as represented by the curve *b, c*, while the primary plunger 62 is traveling from the position of Figure 1 to the position of Figure 4 whereupon the cup 54 strikes the cup 60.

During this rise of pressure which is very rapid, the jet 84 is projected from the jet orifice 16 and somewhere along the curve *b, c*, for instance at the point indicated as *b'* the jet velocity is sufficiently built up to puncture the epidermis. From *b'* to *c* the jet continues to be projected and accomplishes the desired penetrating action and formation of the hole 86, for instance, to the depth of the fascia 26 in Figure 4. Due to the greater resistance of the fascia to the jet action the penetrating action is sharply reduced at this point and if the jet pressure is then reduced as from *c* to *d* no further penetration will take place. The remaining liquid can then be injected through the hole 86 and will follow the fibers of the fascia while a much lower follow-through pressure is in effect to introduce the remaining liquid from the ampule into the hole 86. I have found that the pressure may be reduced to 20 or 25 percent of the pressure required for the high pressure penetrating jet to reach the fascia layer.

The point *d* at which pressure reduces for the follow-through jet operation is represented in the injector itself by the lower end of the primary cup 54 striking the secondary cup 60 so that the spring 56 then moves the secondary plunger 64 in unison with the primary plunger 62. From *c* to *d* the follower is expanding and the ampule is contracting from the sizes they assumed as a result of the high pressure produced for the penetrating jet. This operation, the low pressure follow-through jet,

6

commences when the parts are in the position just described and which position is illustrated in Figure 4 and the low pressure is sustained while the plungers are moving from this position to the Figure 5 position.

As the spring 56 continues to expand, its pressure will gradually drop which is represented by the decline of the curve from *d* to *e*. This decline will not be to zero because the spring is under some compression even in the position of Figure 5. However, when the secondary cup 60 reaches the upwardly projecting boss 65 around the opening 66 as in Figure 5 substantially all the medicament 18 has been injected to form the injection pattern 18a, and pressure then rapidly reduces to zero as the ampule contracts due to the relief of pressure therein and the follower F expands also due to the relief of pressure and strain is removed from all the operating parts. This is represented by the curve section *e, f*.

If it is desirable that the jet 84 penetrate only part way down to the fascia plane, less travel of the primary plunger before the secondary plunger starts to move will accomplish this result. The parts of course can be proportioned to secure this result or any desired variation of it. By way of example another pressure curve has a peak at *c'* indicating that after break-through of the jet with respect to the epidermis at *b'* the penetrating jet operates for a shorter period of time and therefore doesn't penetrate as deeply. The peak *c'* accordingly will reduce the high pressure build-up, and the low pressure follow-through jet will commence operating a little sooner as indicated at *d'*. The same follow-through action is then had with the injected liquid being dispersed laterally in the fat tissues 24.

Practical operation of Figure 7

By proportioning the parts as in Figure 7 impact in addition to the maximum force of the spring 56 is had because the primary plunger 62 must travel a short distance before striking the follower F and when it does strike it will quickly build up the pressure to a higher value as indicated at *c''* before the pressure drops down for the low pressure follow-through action beginning at *d*. This higher pressure for the penetrating jet will cause it to pass on through the fascia 26 and into the muscle 28 so that an intramuscular injection can be made. Obviously, a stronger spring used in the Figure 1 arrangement will accomplish a result similar to impact.

Practical operation of Figures 9, 10 and 11

This form of my injector is shown cocked in Figure 9, the initial pull on the rod 70 raising the cup 54 from the position of Figure 11 to the position of Figure 10 and in so doing further compressing the spring 56. Further movement of the pull rod 70 tends to flatten the discs 90 until they assume the shape shown in Figure 9 when the shoulder 74 is latched on the latch plate 76.

The ampule A may then be secured to the injector and when ready for the injection the latch plate 76 is released whereupon the initial movement of the plunger 63 is effected by the discs 90 expanding from the position of Figure 9 to the position of Figure 10. The relative stiffness of these discs produces the desired high pressure initial movement for causing the plunger 63 to expel the jet at penetrating pressure and velocity.

After the discs 90 have expanded so that their force is equal to the force in the compressed spring 56, the spring 56 will expand to produce the follow-through pressure desired for injecting the medicament laterally from the bottom of the channel 86 as in Figure 5.

The form of invention shown in Figures 12 and 13 operate substantially the same as the forms shown in Figures 9, 10 and 11, the initial penetrating jet pressure being produced by the spring 91 until the washer 92 strikes the flange 94. The shoulder 96 will then leave the washer 92 under continued expansion of the relatively weak spring 56, which spring then produces the follow-through jet at the desired reduced pressure.

In my discussion of jet injections thus far I have not taken into consideration the fact that age, site of the injection and other factors affect the depth of injection. Babies and children have tissues that are less resistant to the jet and accordingly lower spring pressures produce substantially the same result as higher pressures used in connection with the injection of adults. There is some difference also of course in the distance of the fascia and muscles from the skin surface at different loca-

tions on the body, all of which must be taken into consideration.

I have also found that people with highly pigmented skin have more resistant tissues than light complexioned people and that everything else being equal injections go deeper in the anterior surface of the body than into the posterior surface thereof. The toughness of the fascia compared to the fatty tissues and the greater toughness of the muscle fibres provide more or less definite obstructions so that pressures are not too critical and can vary over a reasonable range and yet insure any injection desired whether intradermal, intrafat, intrafascia or intramuscular.

The most important feature of my hypo jet injector over the prior art consists of providing for two-stage jet operation so that a relatively light spring can be used first on a primary plunger 62 to produce high pressure required for jet penetration during a fraction of the expansion of the spring when released, and the low pressure follow-through jet produced by simultaneous movement of the primary and secondary plungers to then utilize the remaining energy in the spring to accomplish follow-through introduction of liquid at only the necessary pressure to make an injection instead of continuing high pressure penetration. For instance, the dotted line c, e' represents the pressure curve resulting from the use of a single plunger and a spring 4 or 5 times as heavy as required at 56 in Figure 1 in order to secure the required initial high pressure for a penetrating jet. This pressure might necessarily be as high as 10,000 p. s. i. but for injection after penetrating only 2,000 p. s. i. would be required. If the 10,000 p. s. i. pressure is continued it would cause the jet to continue penetrating deeper and deeper and the necessary dispersion of the medicament at the desired subcutaneous level could not be controlled. It is obviously important therefore that after the penetrating jet has reached the desired level the pressure be reduced so that lateral injection then occurs as illustrated in Figure 5. In accordance with Figures 9 to 13 a single plunger and two springs of different strength can also accomplish the desired two-stage jet action.

The reduction of the jet pressure from high for penetration to low for follow-through is also of great importance when a considerable quantity of material is to be injected. The two-stage operation of my injector is therefore a necessity in the making of successful, accurately controlled jet injections of maximum dosage required for practical purposes.

When reference is made hereinafter in the claims to "plunger means", such recitation is intended to read both upon the single plunger 63 shown in the species of Figures 9 to 13, and upon the plurality of plungers 62 and 64 operating individually or collectively, shown in the species of Figures 1 to 6.

Some changes may be made in the construction and arrangement of the parts of my injector without departing from the real spirit and purpose of my invention, and it is my intention to cover by my claims any modified forms of structure or use of mechanical equivalents which may be reasonably included within their scope.

I claim as my invention:

1. In a hypo jet injector, a holder, a container for a predetermined volume of liquid to be hypodermically injected by jet action mounted in said holder, liquid in said container, said container having a jet orifice adapted to be placed tightly against the surface tissue into which an injection is to be made, plunger means fitting in the container to displace the liquid therefrom by movement axially thereof, and a first force transmitting operating means operatively associated with said plunger means one force-to-area relationship between the plunger means and the liquid in the container for effecting initial discharge of liquid from said jet orifice at a high pressure which is sustained by travel of said plunger means to penetrate the tissues and open a channel therein, a second force transmitting operating means for secondarily changing to a lower pressure by a reduction in the force-to-area relationship between the plunger means and the liquid in the container which substantially terminates further penetration, for tertiarily substantially maintaining such lower pressure which also maintains flow through the established channel by further travel of said plunger means until said predetermined volume of the liquid has been injected, and then terminating the applied pres-

sure, and a force producing means capable of expanding when released in said holder for exerting force on said force transmitting operating means.

2. In a hypo jet injector, a holder, a container for medicament to be hypodermically injected by jet action mounted in said holder, medicament in said container, said container having a jet orifice from which the medicament is discharged, plunger means entering said container and movable therein to displace the liquid through said jet orifice, and first and second force transmitting mechanical means operatively associated with said plunger means to move said plunger means to effect projection of a two-stage jet of medicament from said jet orifice in which each stage is definitely delineated, means within said holder for exerting force on said force transmitting mechanical means to move the same, the first stage being at a higher medicament discharge pressure and velocity than the second stage and being sustained by and during travel of said plunger means when in operative association with said first mechanical means, the second stage being at a pressure sharply below the pressure of the first stage, and the second stage being continued sufficiently by and during further travel of said plunger means when in operative association with said second mechanical means to effect injection of substantially all of the medicament from said container, the pressure being then sharply terminated.

3. A jet injector comprising a holder, an ampule in the holder, means for holding said ampule with respect to said holder, said ampule having a jet orifice adapted to be placed at the desired location in relatively tight contact with surface tissue into which an injection is to be made, plunger means entering said container to effect expulsion of liquid from said ampule, and first and second force transmitting means operatively associated with said plunger means, means within said holder for exerting force on said force transmitting means to move the same, said force transmitting means cooperating with said plunger means to effect movement of said plunger means, first substantially instantaneously in a manner to apply a predetermined high pressure to cause penetration of the tissues and then continuing at such high pressure by plunger means movement, when said plunger means is in operative association with said first force transmitting means, to open a channel of desired depth, and then at a sharply reduced pressure which substantially terminates further penetration and effects continued flow, by further plunger means movement when said plunger means is in operative association with said second force transmitting means, through the established channel of the remaining medicament at a gradually reducing pressure which is sharply terminated when all the medicament has been injected.

4. A jet injector comprising a holder, an ampule in the holder, means for holding said ampule with respect to said holder, said ampule having a jet orifice adapted to be held in relation to epidermis or the like, liquid in said ampule to be jet injected through said epidermis to a subcutaneous position therebeneath, a follower in said ampule behind the liquid, said holder having follower actuating means to move said follower, and a first force transmitting mechanism operatively associated with said follower actuating means for operating said actuating means initially to produce a high pressure penetrating jet, then by movement of said actuating means to produce a channel inwardly of the point of penetration, then to stop the high pressure and then by a second force transmitting mechanism operatively associated with said follower actuating means to produce a low pressure follow-through jet by further movement of said actuating means to complete the injection terminated by a cessation of movement of the actuating means and thereby the follower resulting in, while still at a substantial pressure, terminating the applied pressure on the liquid, and means within said holder for exerting force to be transmitted upon said force transmitting mechanisms.

5. In a hypodermic jet injector, a holder, a container for liquid to be hypodermically injected by jet action mounted in said holder, liquid in said container, said container having a jet orifice from which liquid is discharged into body tissue or the like, plunger means entering said container to displace the liquid therefrom through said jet orifice and into such tissue, a first force transmitting operating means operatively associated with said plunger means for moving said plunger means to thereby pro-

duce an initial high pressure in the liquid by said plunger means to produce a penetrating jet and a channel digging jet into the body tissues by movement of said plunger means, followed by a sharp drop in pressure, a second force transmitting operating means operatively associated with said plunger means for operating said plunger means to produce a low pressure in said liquid to produce a follow-through jet by further movement of said plunger means after termination of further penetration by said sharp drop in pressure, and means within said holder for exerting force to be transmitted upon said force transmitting means.

6. A hypo jet injector comprising a container for liquid, said container having a jet orifice adapted to have its peripheral edge sealed relative to the epidermis of a patient, a follower in said container opposite said jet orifice, a primary plunger of relatively small size operatively associated with said container and positioned to engage and thereby move said follower to displace liquid from said jet orifice at a high pressure for penetrating through the epidermis and underlying tissues, a secondary plunger of greater area than said primary plunger operative to engage and thereby move said follower for expelling a follow-through jet at less pressure from said jet orifice into the jet-formed opening, and means operatively engageable first with said primary plunger to move it and then with said secondary plunger to move it after travel of said primary plunger for thereafter moving both plungers in unison with each other.

7. A jet injector comprising a holder, an ampule, means for holding said ampule with respect to said holder, said ampule having a jet orifice, liquid in said ampule to be jet injected, said holder having a pair of plungers to displace the liquid from said ampule through said jet orifice, and means to move said plungers to produce first a high pressure penetrating jet and then a low pressure follow-through jet issuing from said jet orifice.

8. In a hypo jet injector, a container for liquid to be hypodermically injected by jet action, liquid therein, said container having a jet orifice from which the liquid is discharged, a pair of plungers operatively associated with said container and positioned to enter said container and thereby displace the liquid therefrom, and means operatively associated with said plungers to move one of said plungers till it engages the second plunger whereupon said means moves both of said plungers to effect projection of a two-stage jet from said jet orifice, the first stage being at higher velocity than the second stage.

9. A hypo jet injector comprising a container provided with a jet orifice, a follower in said container between which and said jet orifice liquid to be jet injected is contained, a tubular plunger operatively associated with said container and positioned to engage and thereby displace said follower along the container, a second plunger within said tubular plunger, and common means operatively associated with said plungers for initially moving said second plunger when spaced from said follower to a position of contact therewith, thereby providing impact, then further moving said second plunger for producing a high pressure penetrating jet projected from said jet orifice, and thereafter moving said second plunger to engage and move said tubular plunger in unison with said second plunger to produce a low pressure follow-through jet.

10. A jet injector comprising a holder for an ampule, an ampule, means for holding said ampule in said holder, said ampule having a jet orifice, liquid in said ampule and a follower in said ampule behind the liquid, said holder having a primary plunger and a secondary plunger operatively associated with said ampule and positioned for contacting said follower, means operatively associated with said primary plunger to effect movement of said primary plunger to produce a high pressure penetrating jet when it moves said follower, and means operatively associated with said secondary plunger to effect movement of said secondary plunger to produce a low pressure follow-through jet when it moves said follower.

11. A hypo jet injector comprising a container having a discharge end provided with a jet orifice, the edge of which is adapted to be sealed relative to epidermis, a follower in said container between which and said jet orifice liquid to be jet injected is contained, a tubular plunger operatively associated with said container and positioned to enter said container to displace said fol-

lower, a second plunger within said tubular plunger and also to enter said container to displace said follower, and means operatively associated with said plungers for initially moving said second plunger when spaced from said follower to a position of contact therewith, thereby providing impact, then moving said second plunger while said tubular plunger remains stationary for producing a high pressure penetrating jet projected from said jet orifice, and thereafter moving both plungers in unison to produce a low pressure follow-through jet projected from said jet orifice.

12. In a hypo jet injector, a container for liquid to be hypodermically injected by jet action, liquid therein, said container having a jet orifice from which the liquid is discharged, a pair of plungers operatively associated with said container and positioned to enter said container to displace the liquid from said container, one of said plungers being within the other and moved in advance of it for producing an initial high pressure penetrating jet followed by movement of the other to produce a low pressure follow-through jet, and common means operatively associated with said plungers for moving said plungers in the order named.

13. In a hypodermic jet injector, a container for liquid to be hypodermically injected by jet action, liquid therein, said container having a jet orifice from which the liquid is discharged, a pair of plungers operatively associated with said container and positioned to enter said container to displace the liquid therefrom, one of said plungers being smaller than the other and moved in advance of the other for producing an initial high pressure penetrating jet followed by operation of the other to produce a low pressure follow-through jet.

14. In a hypodermic jet injector, a container for liquid to be hypodermically injected by jet action, liquid therein, said container having a jet orifice from which the liquid is discharged, a pair of plungers operatively associated with said container and positioned to enter said container to displace the liquid therefrom, one of said plungers being moved in advance of the other for producing an initial high pressure penetrating jet followed by operation of both plungers to produce a lower pressure follow-through jet.

15. A hypo jet injector comprising a container for medicament, said container having a jet orifice, a follower in said container opposite said jet orifice, a plunger of less size than the area of said container operatively associated with said container and positioned to engage and move said follower to displace liquid from said jet orifice at epidermis and tissue penetrating velocity, a secondary plunger operatively associated with said container and spanning the remainder of the area of said container and operative to engage and move said follower for expelling a follow-through jet at less pressure from said jet orifice, and means operatively associated with said plungers to first move said primary plunger and then said secondary plunger during an injection operation.

16. A hypo jet injector comprising a container for fluid medicament, said container having a jet orifice, a follower in said container opposite said jet orifice, a primary plunger of relatively small size operatively associated with said container and positioned to engage and move a portion of said follower to displace liquid from said jet orifice at a velocity sufficiently high for penetrating through the epidermis and underlying tissues, means operatively associated with said primary plunger for moving said primary plunger to place the contents of said container under high pressure, and a secondary plunger of greater area than said primary plunger moved by said means to move said follower for expelling a follow-through jet at less pressure from said jet orifice, said means being engageable with said secondary plunger after predetermined travel of said primary plunger for thereafter moving both plungers in unison with each other.

17. A hypo jet injector comprising a container for fluid medicament, said container having a jet orifice, a follower in said container opposite said jet orifice, a plunger of less size than the area of said container operatively associated with said container and positioned to engage and move said follower to displace liquid from said jet orifice at epidermis and tissue penetrating velocity, means engaging and moving said primary plunger to place the contents of said container under

11

high pressure to produce such velocity, and a secondary plunger operatively associated with said container spanning the remainder of the area of said container and operative to move said follower for expelling a follow-through jet at less pressure from said jet orifice, said means being engageable with said secondary plunger after predetermined travel of said primary plunger for thereafter moving both plungers in unison with each other.

18. A hypo jet injector comprising a container in which liquid to be jet injected is contained, said container having a discharge end provided with a jet orifice, a tubular plunger operatively associated with said container and positioned to enter said container and displace the liquid, a second plunger within said tubular plunger to also enter said container, and means operatively associated with said plungers for initially moving said second plunger while said tubular plunger remains stationary for producing a high pressure penetrating jet projected from said jet orifice and thereafter moving both plungers in unison to produce a low pressure follow-through jet projected from said orifice.

12

19. A jet injector comprising a holder, an ampule, means for holding said ampule with respect to said holder, said ampule having a jet orifice, liquid in said ampule to be jet injected, a follower behind the liquid, said holder having a primary plunger and a secondary plunger for contacting said follower, and means to initially move said primary plunger to produce a high pressure penetrating jet issuing from said jet orifice and then simultaneously moving both plungers to produce a low pressure follow-through jet issuing therefrom.

References Cited in the file of this patent

UNITED STATES PATENTS

15	2,322,244	Lockhart	June 22, 1943
	2,322,245	Lockhart	June 22, 1943
	2,380,534	Lockhart	July 31, 1945
	2,390,246	Folkman	Dec. 4, 1945
	2,398,544	Lockhart	Apr. 16, 1946
20	2,413,303	Folkman	Dec. 31, 1946