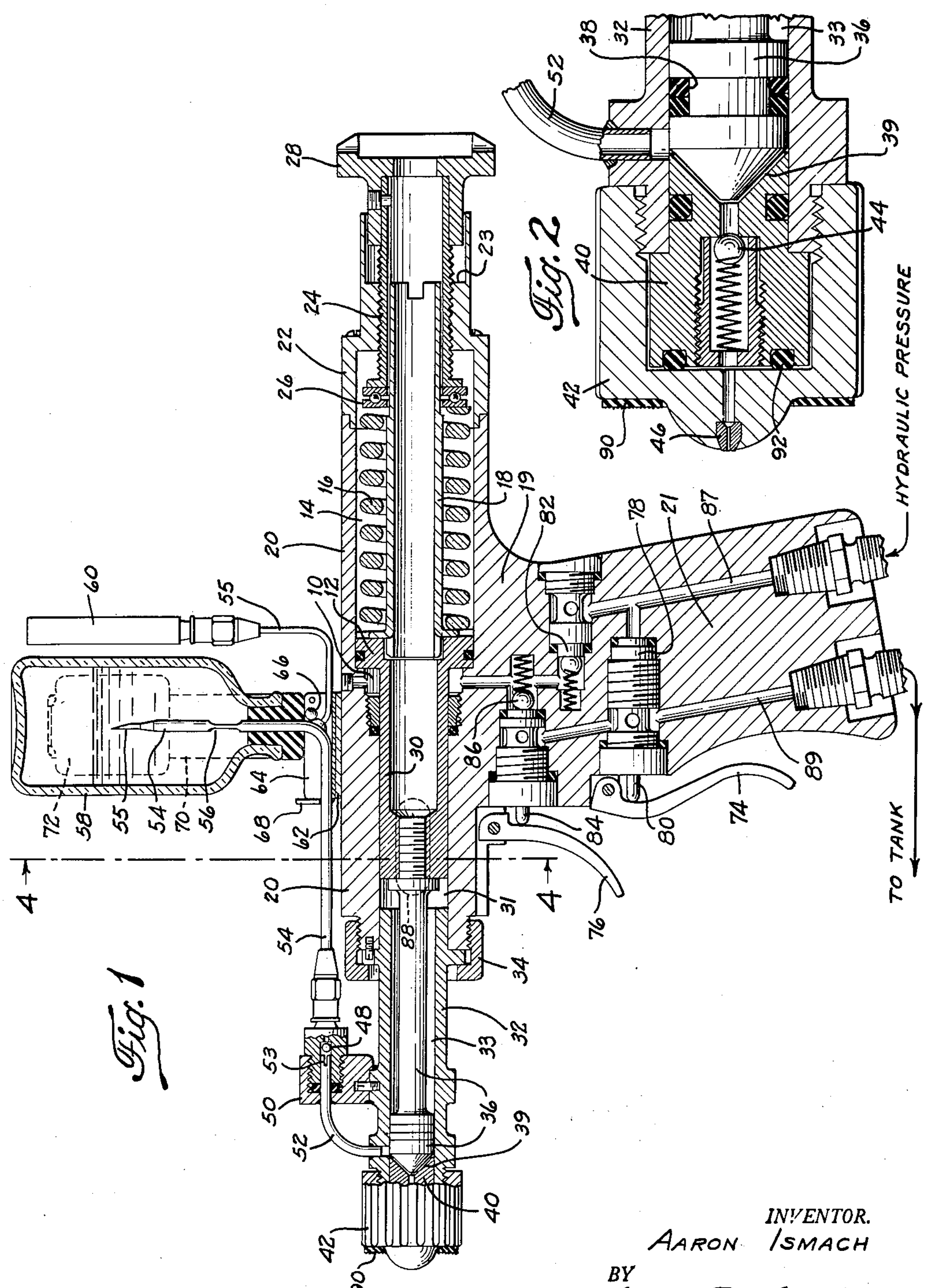
Oct. 9, 1962 A. ISMACH 3,057,349

MULTI-DOSE JET INJECTION DEVICE

Filed Dec. 14, 1959 3 Sheets-Sheet 1



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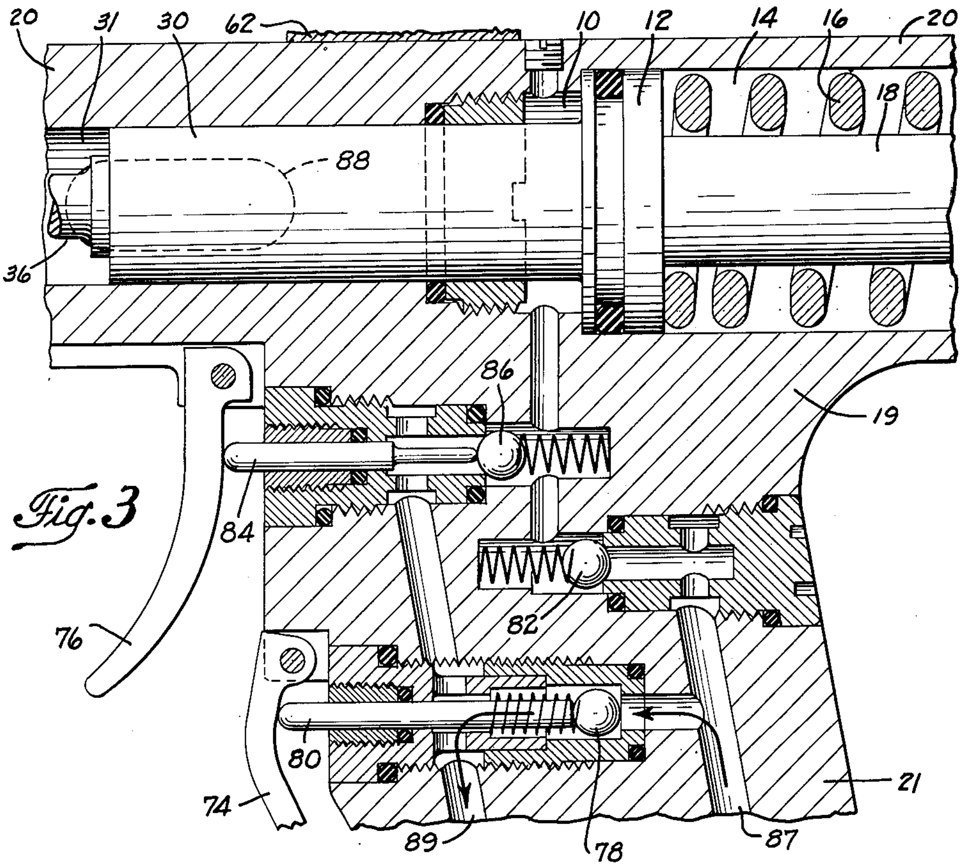

Fig. 3

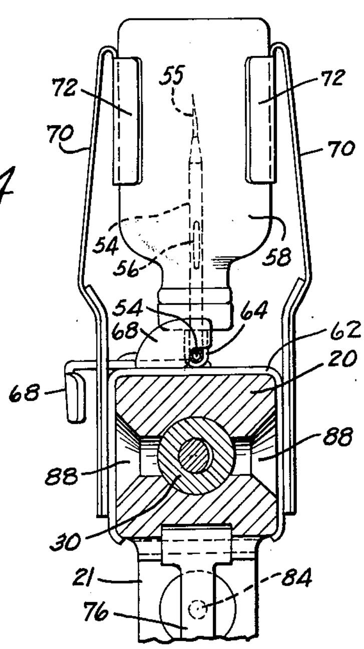

Fig. 4

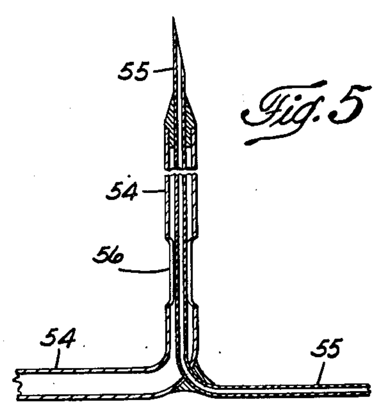

Fig. 5

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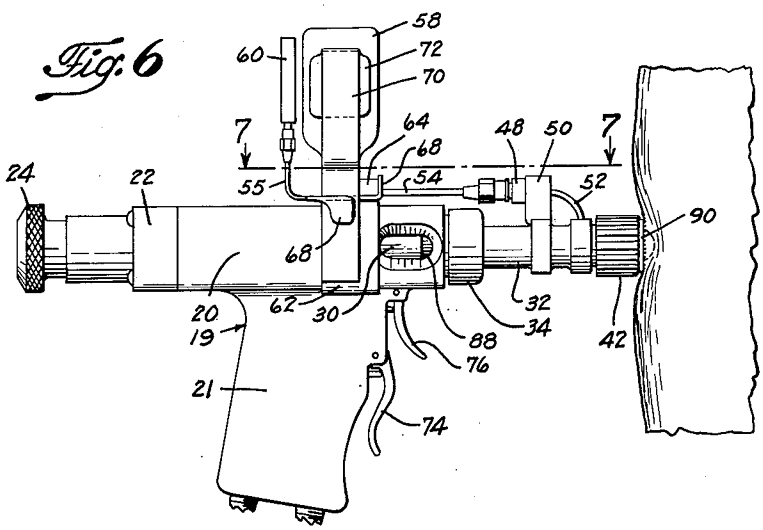
Fig. 6



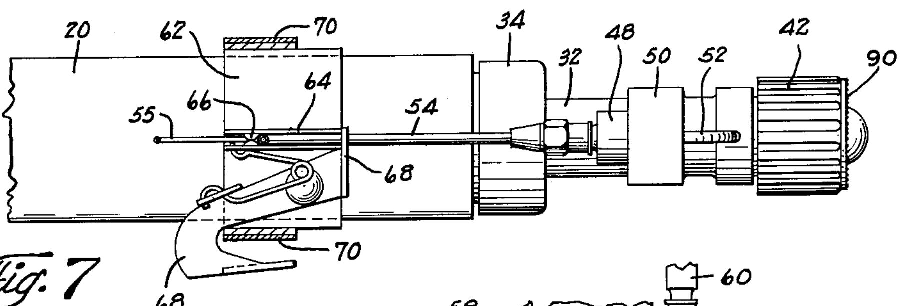


Fig. 7

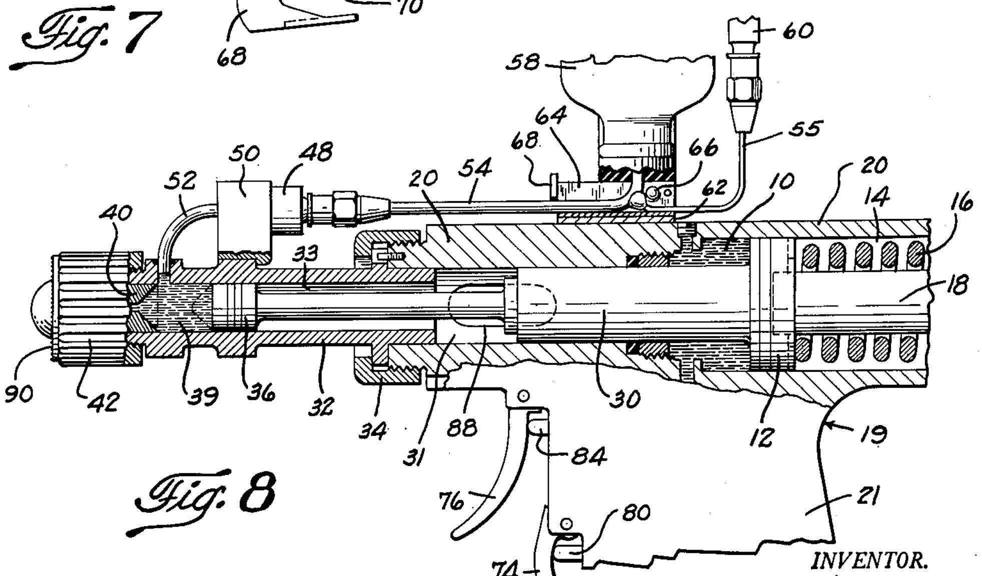


Fig. 8

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MULTI-DOSE JET INJECTION DEVICE

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12 Claims. (Cl. 128—173)

The present invention relates to medical inoculant injection instruments and more particularly to high speed multidose hypodermic jet injection instruments.

The present invention provides a novel combination of means for effecting a sterile inoculation of vaccine or other medicament by providing a fine jet of inoculating fluid which is impelled at high speed and with great pressure under the skin of the subject to whom the inoculant is administered. The invention makes possible the delivery of an exactly metered dose of a desired vaccine beneath the skin of a patient without the use of a needle and in a relatively painless manner without breaking the surface of the skin.

The instant invention provides improvements over prior methods of effecting inoculation by means of a thin high pressure stream or jet of vaccinating fluid, wherein multiple doses of vaccine are given to a number of patients without the need for reloading the injection instrument with a new reservoir of vaccine before each shot is administered. The present invention is particularly novel and useful in providing a jet injection instrument capable of administering inoculation shots to a very large number of patients within a very small interval of time, without any necessity for sterilization of the instrument between shots, without risk of injury or cross-infection to the patient, and with great accuracy in metering the required dosage of inoculating fluid. In use, rates as high as 4,000 patients per hour have been achieved in administering a ½ cc. dose of vaccine.

It is an object of the instant invention to provide a jet hypodermic injection device by which inoculations can be given to more patients in a shorter time, with much greater safety and much more economically than was formerly possible either with the conventional hypodermic needles and syringes or with other types of hypodermic injection devices.

It is another object of the instant invention to provide a hypodermic jet injection device which possesses an extremely high shooting rate, which permits the vaccine being administered to be changed from one type to another very easily, rapidly, and under sterile conditions, and which permits prescribed dosages of vaccine to be altered very rapidly and accurately.

Another object of the present invention is to provide a hypodermic jet injection gun which is well balanced with a centrally disposed load, which can be operated and comfortably held by the operator in one hand, leaving the operator's other hand free to swab or grasp the patient, which is relatively noiseless and free from recoil, and which lends itself to long periods of fatigue-free operation. The latter characteristic of this invention is extremely important when inoculations are being administered by a high speed jet injection, since if the gun is permitted to slip on the arm of a patient when it is fired, a nasty cut may result.

Another object of the present invention is to provide a hypodermic jet injection device which can be quickly and easily disassembled, which can be easily and efficiently sterilized by autoclaving or other means, and which can be readily serviced by using conventional hand tools without the need for specially adapted tools or devices.

Another object of the present invention is to provide a hydraulic jet injection gun so constructed that a failure in any one portion of the gun will be isolated to that portion and so constructed that there is a path to the exterior of the gun near each seal in the mechanism. The latter feature insures that if any one of the seals should fail, fluid (either inoculating fluid or hydraulic fluid) will appear at the surface of the gun adjacent to the seal and enable the operator to immediately discern which of the several seals has failed or is leaking.

Another object of the present invention is to provide a hypodermic jet injection device which is ideal for use in isolated areas where it is difficult to obtain spare or replacement parts, since the device uses standard components, and is relatively trouble-free, and is easy to keep in operating condition.

With the device of the instant invention only the inoculating fluid goes below the skin level of the patient, and it is relatively easy to insure sterile operating conditions; whereas with conventional hpyodermic injection devices part of the device itself penetrates beneath the skin and necessitates the most stringent requirements for sterility in the older devices.

The present invention provides a hypodermic jet injection device, which requires no sterilization either between shots or even when the type of vaccine is changed, which delivers accurately measured doses of vaccine once it is pre-set, which is not dependent upon the operator to control accuracy of the dose as conventional devices are, and which creates no danger of cross-infection, since nothing but the inoculating fluid itself penetrates beneath the skin of the patient. The latter characteristic is especially helpful in preventing the spread of infectious hepatitis, and the danger of spreading hepatitis infection is an outstanding disadvantage of the older method of administering inoculations by the use of syringes and hypodermic needles. It is possible for a patient to be a carrier of hepatitis and capable of seriously infecting another patient with the disease, although the carrier himself may show none of the symptoms associated with hepatitis. One of the outstanding benefits conferred by the invention in helping to prevent hepatitis or other cross-infection, is that if operation of the jet injection device is commenced with the device in a sterile condition, the gun will maintain its own sterility.

It is another object of the present invention to provide a hypodermic jet injection gun comprising two separate but interrelated pump mechanisms: a vaccine pump and a hydraulic pump. Both pumps are self-priming and exceptionally smooth working in operation.

It is a further object of the instant invention to provide a hypodermic jet injection gun which is of an inestimable value for use under emergency or epidemic conditions when it is essential that a great many shots be administered in the shortest possible time with a maximum amount of safety. The efficiency of design and simplicity of operation of the invention obviate the need for a skillful operator. Almost any intelligent person can satisfactorily operate the gun after a rudimentary amount of training.

Unlike most earlier hypodermic jet injection guns, the instant invention is free from danger of sucking fluid back from a patient either during or after the firing cycle is completed so that the danger of cross-infection is almost completely avoided; this is obviously an important advantage at all times, but is particularly apparent when the gun is used under emergency conditions. The characteristic of the gun which permits it to be preset to deliver an exceptionally accurate dose of vaccine and repeatedly deliver this same dose each time it is fired is of great value when the gun is used under any circumstances, but is particularly important when the gun is to be used under emergency, disaster or epidemic conditions by a relatively untrained operator.

Broadly described, the present invention comprises a hypodermic jet injection device including vaccine pump means capable of metering an exact amount of inoculating fluid into a vaccine pump chamber, outlet valve means providing a small outlet orifice for vaccine from the vaccine pump means, a piston forming part of the vaccine pump means, combined hydraulic pump and spring means for driving the vaccine pump piston very rapidly but smoothly into the vaccine pump chamber to expel a metered amount of vaccine through the outlet valve orifice in a thin stream under tremendous force and pressure, and valve means for storing and selectively releasing the force of the hydraulic pump and spring means to drive the vaccine pump piston.

Additional objects and advantages of the invention will be set forth in part in the description which follows and in part will be obvious from the description, or may be learned by practice of the invention, the objects and advantages being realized and attained by means of the instrumentalities and combinations particularly pointed out in the appended claims.

The invention consists in the novel parts, constructions, arrangements, combinations, and improvements shown and described.

The accompanying drawings, which are incorporated in and constitute a part of this specification, illustrate one embodiment of the invention and together with the description, serve to explain the principles of the invention.

Of the drawings:

FIG. 1 is a central vertical section of the device;

FIG. 2 is a fragmentary enlarged section of the nozzle portion of FIG. 1;

FIG. 3 is a fragmentary enlarged section of the actuating valves and hydraulic piston portions of the device;

FIG. 4 is a section taken on the line 4—4 of FIG. 1;

FIG. 5 is a cross-section of the vaccine extracting tube;

FIG. 6 is a side elevation of the device in use and showing the sight port;

FIG. 7 is a plan section taken on the line 7—7 of FIG. 6;

FIG. 8 is a fragmentary section of the comparable portion of FIG. 1, but showing the device cocked and ready to eject vaccine.

It is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory, but are not restrictive of the invention.

In accordance with the invention, a hypodermic jet injection device is provided having means to meter a prescribed dose of vaccine, means to accumulate and apply force to eject vaccine under pressure, and means to control the accumulation and release of the force. In the present preferred embodiment the means to meter the dose of vaccine comprises a vaccine pump having an intake valve and an outlet valve, the means to accumulate and apply force comprises a hydraulic cylinder and spring, and the means to control the accumulation and release of force comprises a series of hydraulic valves.

Reference will now be made in detail to the present preferred embodiment of the invention, an example of which is illustrated in the accompanying drawings, and in which the means for accumulating and applying force and pressure on the metered amount of vaccine comprises (FIG. 1) a hydraulic chamber **10**, a hydraulic piston **12**, a spring chamber **14**, a compression spring **16**, and spring guide **18**. The device includes a main body **19** which in turn comprises a barrel **20** and grip **21** and the hydraulic chamber **10** and the spring chamber **14** are formed in the barrel **20**. The spring chamber **14** of the barrel **20** is closed with a square cap **22** to which a dosage adjusting screw **24** is threadedly engaged. At its interior end the dosage adjusting screw **24** is provided with a thrust ball bearing **26** which bears against one end of the spring **16**. The dosage adjusting screw **24** has an adjusting knob **28** secured to its exterior end to permit hand operation of the screw. At one end the spring **16** bears against the thrust ball bearing **26** and at the other end bears against the hydraulic piston **12** so that the spring may be adjustably

compressed between these two bearing surfaces (thrust bearing **26** and hydraulic piston **12**) by turning the dosage adjusting screw **24**.

As embodied, the hydraulic piston **12** includes a plunger **30** which reciprocates in a cylinder **31** formed in the forward end of the barrel **20**. Also as embodied, the means to meter vaccine comprises a vaccine pump cylinder **33** formed by a barrel extension **32** which is attached to the barrel **20** by a threaded barrel extension cap **34**. A vaccine pump piston **36** is secured to the hydraulic piston plunger **30** at the forward end of the plunger and the vaccine piston **36** reciprocates in the vaccine pump cylinder **33** responsive to movement of the hydraulic piston **12**. Included in the vaccine pump piston **36** is a sealing ring groove **38** in which appropriate sealing rings may be mounted to seal the forward portion, or vaccine chamber **39**, of the vaccine pump cylinder **33** from the rear of the cylinder.

The forward portion of the barrel extension **32** is adapted to receive a closure member **40**, and the closure member **40** is held firmly in place at the end of the barrel extension **32** by a nozzle cap **42** which is threadedly engaged to the exterior of the barrel extension **32**. The closure member **40** is provided with a ball check outlet valve **44** and carries appropriate sealing rings. At its forward extremity the nozzle cap **42** carries a sapphire orifice insert **46** which is bored to a very close tolerance and which determines the diameter of the jet stream of inoculating fluid.

A vaccine inlet valve **48** is carried by a member **50** which is secured to the top of the barrel extension **32**, and a vaccine inlet tube **52** leads from the vaccine inlet valve **48** to the vaccine chamber **39** in the barrel extension **32**. A vaccine extracting tube **54** is wedged on the tapered nose of the vaccine inlet valve **48** and secured thereto by conventional means. The tube **54** includes a right angle bend so that its rear portion extends in a vertical direction when the device or gun is in firing position.

Within the upright portion of the vaccine extracting tube **54** is an air vent tube **55** of smaller diameter but concentric with the vaccine extracting tube **54**. The vaccine extracting tube **54** includes a longitudinal port **56** by means of which vaccine is withdrawn from a conventional vaccine bottle **58** and into the tube **54**.

The air vent tube **55** is provided with an air filter **60** which in use would be filled with sterile cotton to trap any impurities which might otherwise be drawn into the vaccine bottle **58** along with outside air as vaccine is withdrawn from the bottle.

A clip **62** (FIGS. 4 and 7) is secured to the barrel **20**. On top and centrally disposed on the clip **62** is a U-shaped tube support **64** which is welded or otherwise secured to the clip **62**. The vaccine extracting tube **54** is held by the U-shaped tube support **64** and the support **64** is provided with two small stops **66** which come to rest against the upright portion of the tube **54** and determine the position of the clip **62** on the barrel of the gun stock **20**. The U-shaped tube support **64** also acts as a positive stop for the vaccine bottle **58** when the bottle is pushed onto the upright portion of the tube **54** to provide the vaccine supply for operation of the gun.

The U-shaped tube support **64** secures the vaccine extracting tube **54** against horizontal movement and a spring loaded retractable vaccine extracting lock **68** secures the needle tube **54** against vertical movement. The lock **68** and the tube support **64** thus cooperate to hold the tube **54** in a rigid, upright, and easily accessible position and at the same time prevent the relatively delicate vaccine extracting tube **54** from being easily dislodged and bent or otherwise damaged. The tube support **64** also acts as a channel to secure the air vent tube **55** against horizontal movement and the stops **66** in the support **64** help to secure the air vent tube from vertical movement. In use, the air vent tube **55** acts to admit air to the vaccine bottle **58** as vaccine is withdrawn and prevents the formation of a vacuum within the bottle.

A pair of bottle jaws **70** are secured to the clip **62**, one jaw being attached to each side of the clip, and secured to each bottle jaw 70 is a bottle gripper 72. The bottle jaws and grippers are of a spring type to accommodate automatically any standard size vaccine bottle and lock it in a secure upright position on the center of the gun. By having the bottle of vaccine centrally disposed over the grip or handle portion of the gun, the weight of the bottle is carried at the horizontal center of gravity of the gun and directly above the hand of the operator. This characteristic tends to preserve dynamic balance and reduce operator fatigue.

As embodied, the means to control the accumulation and release of force comprises the cocking mechanism, the firing mechanism, and the conduits and valves which control the application of hydraulic power to the gun; these elements are contained in the grip 21 (FIGS. 1 and 3). The gun is provided with a cocking trigger 74 and a firing trigger 76. The conduits and valves contained in the grip portion of the gun control the flow of hydraulic fluid depending on the condition of the valves. In FIG. 3, the valves are shown in the static condition. The lowest valve is an unloading valve 78 and is lightly spring loaded. When the gun is not being cocked hydraulic fluid from a hydraulic pump (not shown) takes the path shown in FIG. 3, since very little pressure is required to overcome the light spring resistance of the unloading valve 78.

When the cocking trigger 74 is depressed, it moves a cocking pin 80 toward the rear of the gun and closes the unloading valve 78. With the unloading valve 78 closed by the joint action of the cocking trigger and cocking pin, the hydraulic fluid overcomes the resistance of a check valve 82 and enters the hydraulic chamber 10 where it acts on the forward face of the piston 12 and causes the piston 12 to be moved to the rear of the gun fully compressing the spring 16.

The hydraulic pump mechanism (not shown) is provided with a pressure relief valve which acts to prevent further displacement of the piston when a certain predetermined pressure is reached in the hydraulic system. In the present embodiment the hydraulic pump (not shown) is provided with a pressure actuated switch which causes an electrical counter to advance one digit just prior to the time when the pump pressure relief valve opens. The electrical counter makes a distinctly audible click at this stage of the cycle permitting the operator to know that the gun is in the fully cocked position and obviating the need for his visual observation of any other signal that the gun is cocked and ready to fire. This use of an audible signal to indicate that the gun is in a firing condition has been helpful in permitting an operator to achieve a high shooting rate.

The trigger 76 when depressed actuates a trigger pin 84 which in turn opens a spring loaded ball check valve 86 permitting rapid escape of the hydraulic fluid from the hydraulic chamber 10. The release of the hydraulic fluid from the chamber 10 permits the spring 16 acting through intermediate parts to drive the piston 36 of the vaccine pump forward into the vaccine chamber 39 with great speed and force.

The valves and conduits necessary for proper functioning of the hydraulic system are appropriately mounted in the grip portion of the gun by conventional means and with sealing rings as required and as shown in FIGS. 1 and 3. The exterior ends of the inlet conduit 87 and outlet conduit 89 are provided with conventional connectors for hydraulic hose (not shown).

Both sides of the forward end of the barrel 20 are provided with a sight port 88 (FIGS. 4 and 6) through which the forward end of the plunger 30 may be viewed in the present embodiment. The sight port 88 is graduated from 0.1 cc. to 1.0 cc. in tenths of cubic centimeters.

In operation, a conventional vaccine bottle is pressed onto the combined vaccine extracting tube 54 and air vent tube 55 and firmly secured by the bottle jaws 70 and fingers 72. The U-shaped tube support 64 acts as a positive stop to insure that the needle is inserted to the correct vertical depth in the bottle.

When the operator depresses the cocking trigger 74 the cocking pin 80 closes the unloading valve 78 causing pressurized hydraulic fluid to enter the chamber 10 and push the piston 12 to the rear against the force of the spring 16. When the spring 16 is fully compressed, the pressure relief valve on the hydraulic pump (not shown) opens to prevent further flow of fluid into the chamber 10. As previously described, a pressure actuated switch causes the electrical counter means (not shown) to advance one digit with an audible click. When the operator hears the click, he knows that the gun is fully cocked and releases pressure from the cocking trigger 74. The hydraulic fluid is trapped in the chamber 10 by the ball check valve 82 and continues to hold the spring 16 in a compressed condition.

An important and distinctive feature of the instant invention is its cocking system. During each firing cycle, the unloading valve 78 remains open except when the cocking trigger 74 is depressed. The hydraulic system is thus under load only for a brief period in each cycle when the hydraulic piston 12 is displaced against the energy of the spring 16 by hydraulic fluid pressure. When the unloading valve is in its normal position, the hydraulic system is unloaded, hence the nomenclature "unloading valve." Since the hydraulic system is under load only when the gun is actually being cocked, regardless of how long the operator waits between shots, the wear and strain on the parts of the hydraulic system during each cycle are almost negligible. This important characteristic, in practice, has permitted the gun to be fired hundreds of thousands of times without the need for overhaul or maintenance.

When the piston 12 is pushed to the rear of the gun by hydraulic fluid during the cocking operation, it acts through intermediate parts to move the vaccine pump piston 36 toward the rear an equal distance. The movement of the vaccine piston 36 to the rear tends to create a vacuum within the vaccine chamber 39 and causes vaccine to be drawn into the chamber 39 in an amount pre-determined by the distance through which the vaccine piston 12 is set to move. The vaccine is withdrawn from the bottle 58 through the port 56 into and through the vaccine extracting tube 54 past the vaccine inlet valve 48 and through the vaccine inlet tube 52 into the vaccine chamber 39. The ball check valve 44 serves to prevent the entry of any air or suckback of any fluid during the loading cycle of the vaccine pump, but the spring pressure on this valve 44 is light enough to be easily overcome during the firing or ejection cycle of the vaccine pump.

Side port 56 is employed in the vaccine extracting tube 54 to prevent rubber from the vaccine stopper from entering the needle tube when the stopper is pierced. The side port 56 also provides a change in direction in the vaccine flow path which aids in preventing foreign particles from being entrained with the vaccine entering the pump and clogging the outlet valve 44, the inlet valve 48, or the jet nozzle orifice 46. The concentric air vent tube 55 yields a stronger structure for the needle assembly and minimizes the size of the hole which must be made in the vaccine stopper thereby effecting a better seal between stopper and tube and minimizing the tearing off of particles of rubber. This characteristic is important in helping to insure trouble-free operation, since it is not uncommon for pieces of rubber stopper to be broken off when the needle end of the tube assembly is inserted into the vaccine bottle.

With the gun cocked, when the operator depresses the trigger 76, it acts through the firing pin 84 to open the check valve 86, and the hydraulic fluid locked in the chamber 10 is given a free path back to the hydraulic reservoir. The release of hydraulic fluid pressure from the piston 12 permits the spring 16, acting through intermediate parts, to drive the vaccine pump piston **36** forward with tremendous force and speed. The forward movement of the vaccine pump piston **36** causes the vaccine or inoculating fluid in the chamber **39** to pass through the check valve **44** and be ejected from the front of the gun through the jeweled orifice **46** in a small diameter jet.

The conduits and passageway in the gun are constructed so as to offer a sufficient resistance to provide hydraulic damping to the forward movement of the piston **12**. This damping is in addition to the damping normally attained due to the resistance encountered by the vaccine as it is forced through the jet orifice. This additional damping permits the unit to be dry fired (no vaccine in the vaccine pump) with no mechanical damage occurring to any portion of the injection unit. This feature assures that there will be no break in service if the operator accidentally does not renew the vaccine supply after the vaccine bottle in use has been emptied. Even if air does enter into the vaccine pump, under these conditions an injection would be impossible because there is not enough pressure generated in the pump to administer an injection.

The use of a jeweled orifice as the ejection port has been found particularly advantageous, since it permits the machining of the opening to very close tolerances; and since the finished jeweled tip is semi-transparent, it is very easy to determine under examination with optical instruments whether or not the completed tip provides a smooth and uniform orifice. If a metal tip were used, it would be almost impossible to test its suitability directly by optical tests. In the present preferred embodiment, the diameter of the jeweled orifice **46** which has been found to be most advantageous in achieving the results of the invention in practice is .005 inch with a tolerance of plus .0002 inch minus zero.

A protective cap is provided to protect the jeweled tip and sterile gauze may be inserted in the cap to keep the vaccine pump section of the gun sterile during brief interruptions in use.

A sandpaper or abrasive disc **90** is provided on the flat front surface of the nozzle **42**. This disc has been found of great help in practice to prevent the ejection tip of the gun from slipping or sliding on the skin surface of a patient when an ejection is being made. Without such means to prevent slippage, perspiration on the skin surface makes the gun particularly susceptible to slippage, and if the gun slips when it is being fired a severe cut can result from the knife-like action of the high pressure jet of fluid.

In the present embodiment (FIG. 2), sealing ring **92** is mounted in the closure member **40**. Preferably, this is made of a plastic, such as Teflon, which, unlike a rubber sealing ring, is not susceptible to breaking off in small particles. This assembly provides a particularly effective seal since the closure member **40** is of a floating type. This floating feature provides that if the nozzle is loosely screwed onto the vaccine pump cylinder **32** by the operator, or if the plastic sealing ring flattens in use, as is normal, no loss of sealing efficiency between the jet nozzle and the pump cylinder occurs. When an injection is fired, the thrust of the vaccine propels the floating closure member forward with sufficient force to automatically maintain an excellent hydraulic seal between these members. This feature is of prime importance in insuring that all vaccine is ejected through the orifice, with proper pressure and velocity, and that none leaks past the threaded joint between nozzle and cylinder to reduce the effective dose and depth of penetration of the vaccine.

The vaccine inlet valve **48** and its supporting member **50** are mounted somewhat toward the rear of the gun. This arrangement keeps the shooting end of the gun clear and uncluttered so that the operator has an unobstructed view of the shooting end as it is placed in contact with the skin of the patient.

The vaccine pump is self-priming, which is an advantageous feature of the invention in practice. After loading a new bottle of vaccine onto the device, the operator may purge the vaccine pump of air and place it in condition to fire an injection by merely shooting it into the air twice.

Another advantageous feature of the present embodiment is that the ball of the vaccine inlet valve **48** floats in the valve chamber and is free to rotate. On the feed or inlet cycle of the vaccine pump, the ball permits the free flow of vaccine into the vaccine feed tube through a series of slots **53** at the rear end of the tube. When the gun is fired, however, the pressure created in the vaccine chamber **39** transmitted through the feed tube **52** forces the ball of the inlet valve **48** tightly against its seat in the valve chamber and prevents any backflow of fluid through the vaccine extracting tube **54**. The seat of the valve **48** is designed so that a substantial surface of the ball is in contact with the seat when the valve is acting as a check; this reduces wear on the ball itself to a minimum. Accordingly, the latter feature and the design which permits the ball to rotate freely between cycles of the vaccine pump insure a long life for the valve in spite of its small size valve and subjection to tremendous pressure every time the gun is fired.

In operation, the operator controls the dosage of vaccine to be administered by turning the dosage adjusting screw **24** through the knob **23**. When a larger dose is desired the adjusting screw **24** is moved towards the rear of the gun, and when a smaller dose is desired, the screw is moved toward the front of the gun. As the screw **24** is moved toward the front of the gun, it places the spring **16** under partial compression. The pressure relief valve on the hydraulic pump is set to operate when the spring **16** is fully compressed. If the dosage adjusting screw has already partially compressed the spring **16**, it is obvious that the vaccine pump piston **36** will only move as far to the rear of the gun under hydraulic fluid pressure as is necessary to complete compression of the spring **16**. Accordingly, the degree to which the vacuum pump piston **36** moves to the rear can be directly controlled by the dosage adjusting screw **24**, and the degree to which the piston moves to the rear obviously determines the amount of vaccine drawn into the vaccine pump chamber **39** and the amount which is ejected upon firing.

In practice, the extent to which the spring **16** is finally compressed is determined by the magnitude of the hydraulic fluid pressure, which, in turn, is controlled by the pressure relief valve on the hydraulic fluid pump (not shown). Regardless of dosage to be administered, the spring **16** is compressed to the same degree each time the gun is cocked. This characteristic insures that the vaccine ejection force will always be the same at the instant the firing trigger is depressed, no matter what volume dose is being administered. Screwing in the dosage adjusting screw **24** merely pre-compresses the firing spring **16** mechanically so that the hydraulic fluid will only be required to further compress the spring a short distance before the gun is fully cocked. If the dosage adjusting screw is turned in all the way, only a very slight further compression of the spring is possible, and in the present embodiment, the vaccine piston **36** can only move back the equivalent of 0.1 cc. of vaccine dose. Conversely, if the dosage adjusting screw is turned out all the way, the spring must be compressed through its full acting distance by the hydraulic system, and in the present embodiment, a 1.0 cc. dose will be administered. An interior shoulder **23** of hub of the cap **22** acts as a positive stop to prevent the dosage adjusting screw **24** from being turned in too far.

Of course, the characteristic last described is an important advantage of the present embodiment, since it guarantees that regardless of the size of the dose, the injection force at the start of the firing stroke is always the same and imparts to the jet of inoculating fluid the correct speed and pressure for insuring an effective hypodermic injection.

The invention in its broader aspects is not limited to the specific mechanisms shown and described, but also includes within the scope of the accompanying claims any departures made from such mechanisms which do not depart from the principles of the invention and which do not sacrifice its chief advantages.

I claim:

1. A hydraulic-powered hypodermic jet injection instrument having a body with a hydraulic chamber and an inoculating fluid chamber, a hydraulic piston reciprocally mounted in the hydraulic chamber, means for biasing the hydraulic piston into a forward position in the hydraulic chamber, an inoculating fluid plunger reciprocally mounted in the inoculating fluid chamber, means connecting the inoculating fluid piston to the hydraulic piston so that the inoculating fluid piston moves in response to movement of the hydraulic piston, a source of hydraulic fluid under pressure, means normally providing a path for continual flow of fluid through a portion of the instrument, means for diverting the fluid to the hydraulic chamber, whereby pressure on the fluid is raised sufficiently to overcome the forward bias on the hydraulic piston, and means for releasing the fluid from the hydraulic chamber.

2. The invention as defined in claim 1, which includes means for variably and continuously controlling the volume of the inoculating fluid chamber.

3. The invention as defined in claim 1, which includes an inoculating fluid reservoir, a passageway leading from the reservoir to the inoculating fluid chamber, and valve means to prevent back flow of inoculating fluid from the inoculating fluid chamber to the reservoir through the passageway.

4. The invention as defined in claim 1, which also includes means visible from the exterior of the body to indicate the position of the inoculating fluid piston in the inoculating fluid chamber.

5. The invention as defined in claim 1, in which the inoculating fluid chamber and the inoculating fluid piston include means by which they may be readily detached from the body for sterilization.

6. The invention as defined in claim 1, in which the inoculating fluid chamber has an outlet orifice formed from a jewel.

7. The invention as defined in claim 1, in which the inoculating fluid chamber has an outlet orifice of greatly reduced cross-sectional area from the cross-sectional area of the inoculating fluid chamber, and which also includes valve means for preventing entry of air into the inoculating fluid chamber through the orifice upon rearward movement of the inoculating fluid piston, the valve means readily opening under inoculating fluid pressure upon forward movement of the inoculating fluid piston to permit inoculating fluid to be ejected through the outlet orifice.

8. The invention as defined in claim 1, in which the inoculating fluid chamber has an outlet orifice, and which also includes a sealing member in the forward chamber between the inoculating fluid piston and the orifice, the sealing member being axially-movable under inoculating fluid pressure exerted by the action of the inoculating fluid piston against inoculating fluid in the inoculating fluid chamber, a resilient seal carried in the forward end of the sealing member, whereby when the sealing member moves axially forward under inoculating fluid pressure, the resilient seal abuts against the forward inner wall of the inoculating fluid chamber and effects a fluid tight seal in the inoculating fluid chamber around the orifice.

9. The invention as defined in claim 1, in which the inoculating fluid chamber has an outlet orifice, and which also includes an abrasive surface on the front of the body adjacent to the outlet portion of the outlet orifice.

10. The invention as defined in claim 1, in which the means for releasing the fluid from the hydraulic chamber includes a conduit having a restricted portion which provides hydraulic damping of the forward movement of the hydraulic piston.

11. A hydraulic-powered hypodermic jet injection instrument having a body with a hydraulic chamber and an inoculating fluid chamber, a hydraulic piston reciprocally mounted in the hydraulic chamber, means for biasing the hydraulic piston into a forward position in the hydraulic chamber, an inoculating fluid piston reciprocally mounted in the inoculating fluid chamber, means connecting the inoculating fluid piston to the hydraulic piston so that the inoculating fluid piston moves in response to movement of the hydraulic piston, a source of hydraulic fluid, an inlet conduit from the source of fluid into the instrument, an outlet conduit for returning the fluid to the source from the instrument a by-pass interconnecting the inlet conduit and the outlet conduit within the instrument, the source of fluid being under pressure whereby there is continual flow of fluid from the source through the inlet conduit into the instrument, through the by-pass, and then through the outlet conduit back to the source, both the inlet conduit and the outlet conduit being connected to the hydraulic chamber, the by-pass being located closer to the source than the hydraulic chamber, means for diverting the fluid from the by-pass through the inlet conduit to the hydraulic chamber whereby the pressure on the fluid is raised sufficiently to overcome the forward bias of the hydraulic piston, check valve means for trapping the fluid in the hydraulic chamber, and means for releasing the check valve means to permit the fluid to flow back to the source through the outlet conduit.

12. A hydraulic-powered hypodermic jet injection instrument having a body with a hydraulic chamber an inoculating fluid chamber, a hydraulic piston reciprocally mounted in the hydraulic chamber, a spring biasing the hydraulic piston into a forward position in the hydraulic chamber, an inoculating fluid piston reciprocally mounted in the inoculating fluid chamber, means connecting the inoculating fluid piston to the hydraulic piston so that the inoculating fluid piston moves in response to movement of the hydraulic piston, a source of hydraulic fluid under pressure, an inlet conduit in the instrument for directing fluid from the source to the hydraulic chamber, an outlet conduit in the instrument for relasing fluid from the hydraulic chamber and returning it to the source, a by-pass interconnecting the inlet and outlet conduits, a normally-open valve means permitting continual flow of the fluid through the by-pass, means for selectively closing the normally-open valve means to divert fluid flowing through the by-pass and cause it to flow through the inlet conduit into the hydraulic chamber to act against the hydraulic piston causing compression of the spring and storage of energy within the spring, check valve means in the inlet conduit to trap fluid within the hydraulic chamber and lock the hydraulic piston in a retracted position, normally-closed valve means in the outlet conduit, and means for selectively opening the normally-closed valve means to release fluid from the hydraulic chamber and permit it to flow through the outlet conduit releasing energy stored in the spring and allowing the spring to drive the hydraulic piston forward in the hydraulic chamber.

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