Jan. 19, 1960 J. A. SADD 2,921,582

HYPODERMIC INJECTION APPARATUS

Filed Feb. 9, 1954 6 Sheets-Sheet 1

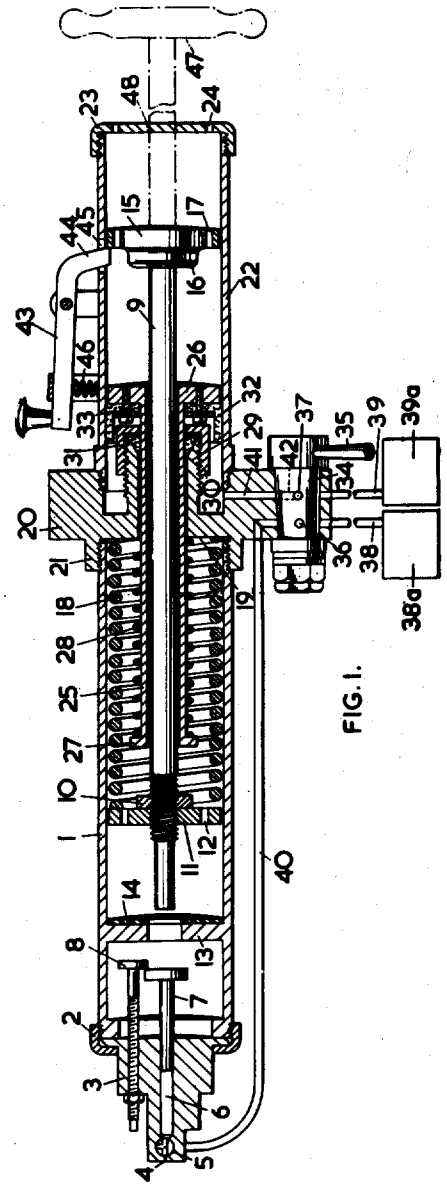



FIG. 1.

John Ambrose Sadd
Inventor

By Cushman, Darby & Cushman
Attorneys

Jan. 19, 1960 J. A. SADD 2,921,582

HYPODERMIC INJECTION APPARATUS

Filed Feb. 9, 1954 6 Sheets-Sheet 2

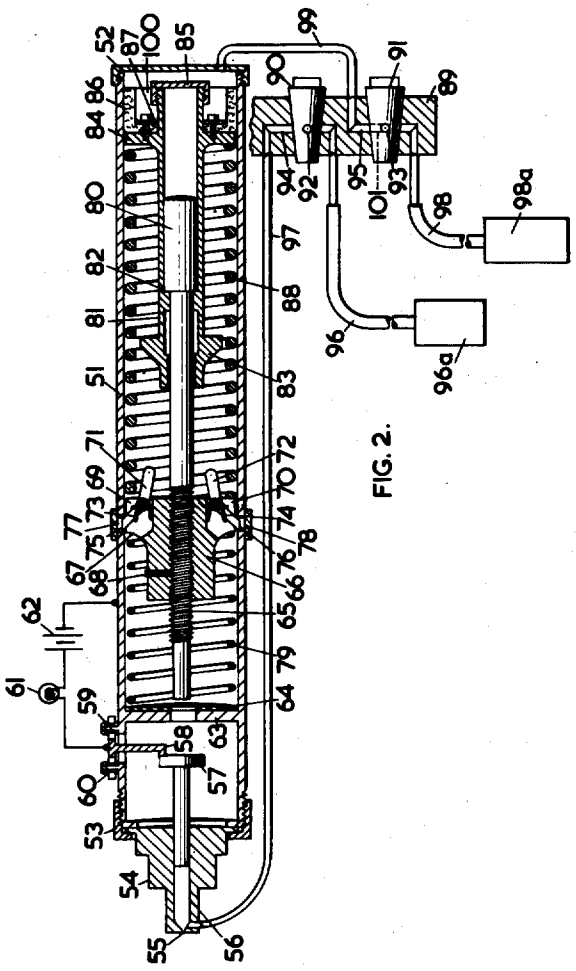



FIG. 2.

John Ambrose Sadd
Inventor

By Cushman, Darby & Cushman
Attorneys

Jan. 19, 1960 J. A. SADD 2,921,582

HYPODERMIC INJECTION APPARATUS

Filed Feb. 9, 1954 6 Sheets-Sheet 3

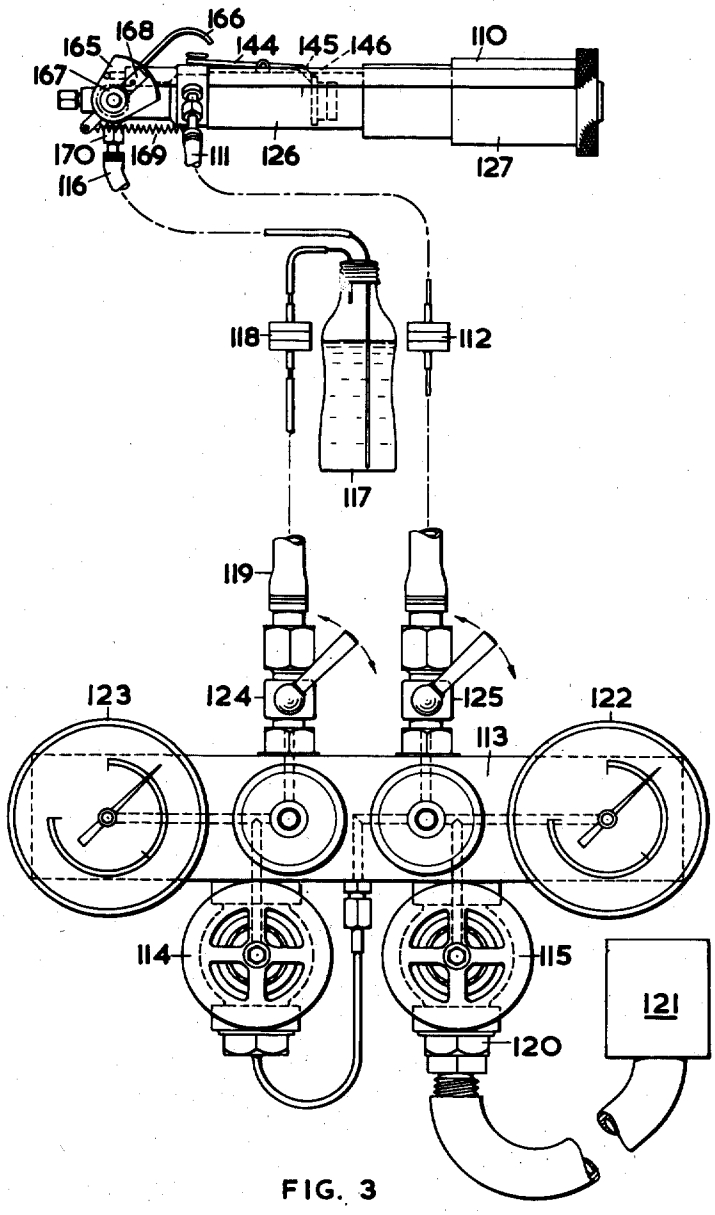



FIG. 3

John Ambrose Sadd
Inventor

By Cushman, Darby & Cushman
Attorneys

Jan. 19, 1960 J. A. SADD 2,921,582

HYPODERMIC INJECTION APPARATUS

Filed Feb. 9, 1954 6 Sheets-Sheet 4

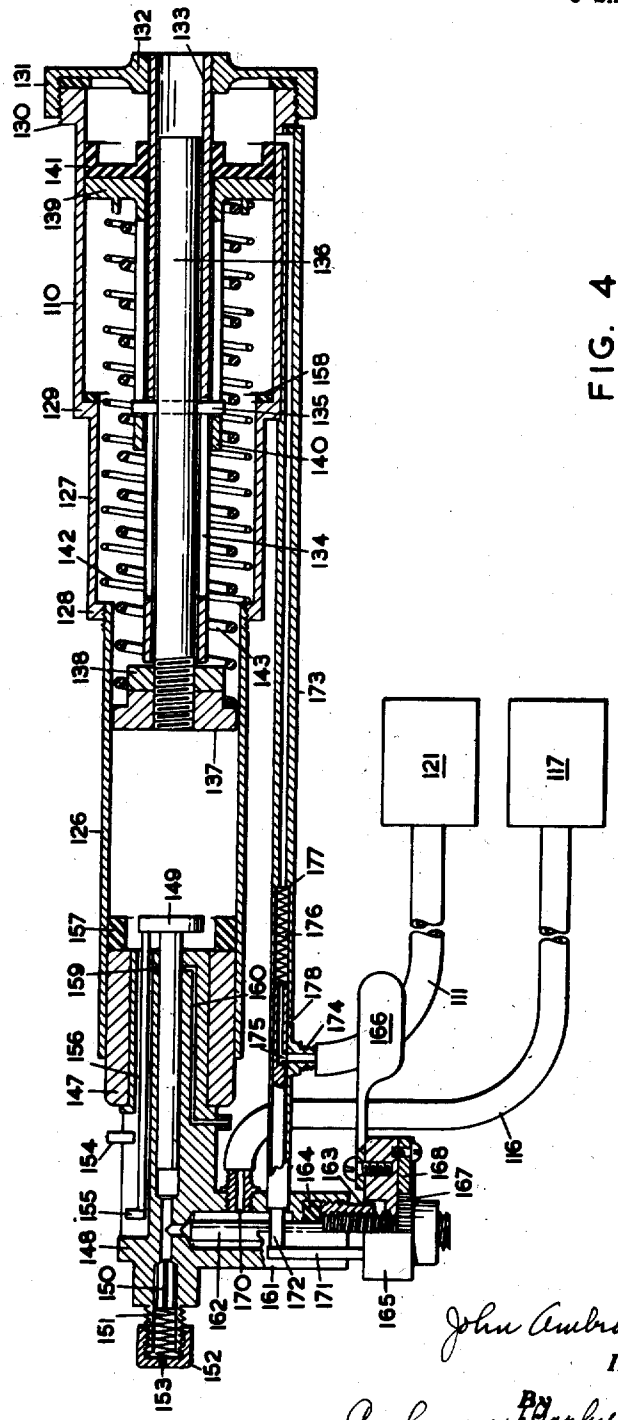



FIG. 4

John Ambrose Sadd
Inventor

By Darby & Cushman
Attorneys

Cushman, Darby & Cushman

Jan. 19, 1960 J. A. SADD 2,921,582

HYPODERMIC INJECTION APPARATUS

Filed Feb. 9, 1954 6 Sheets-Sheet 5

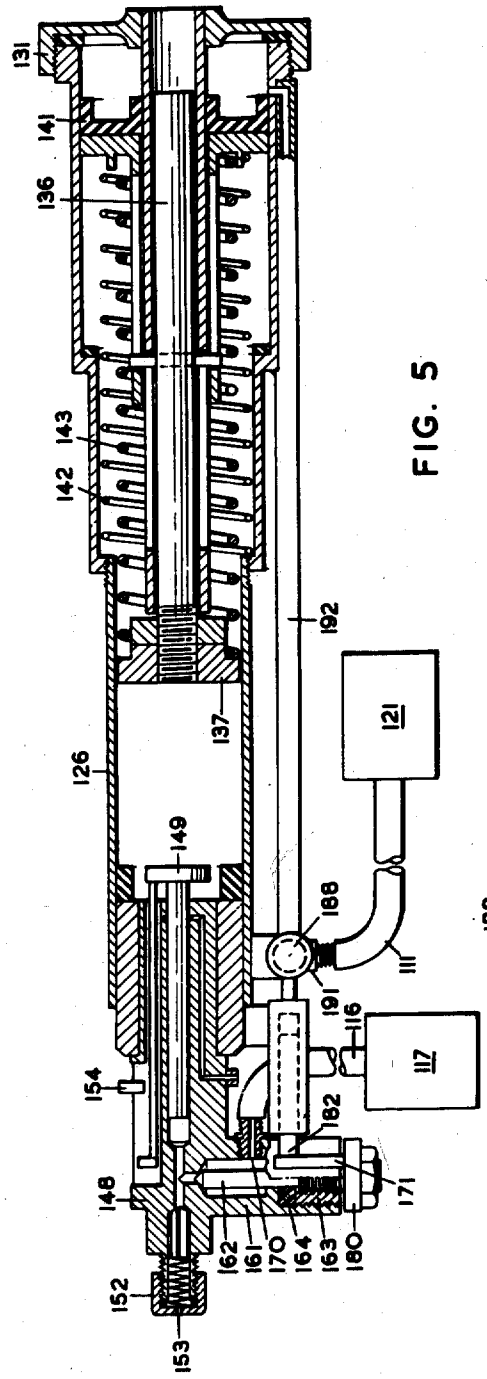
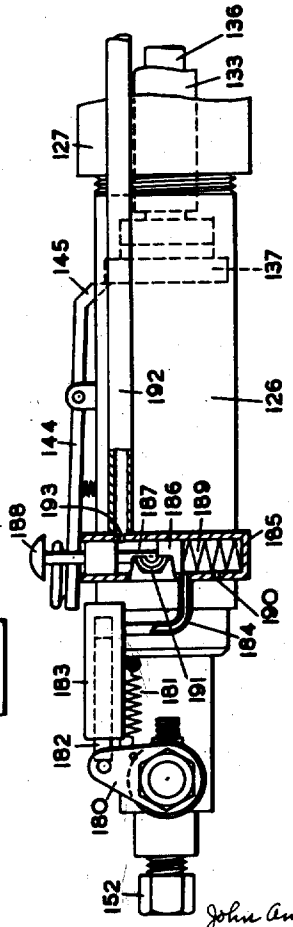



FIG. 5

FIG. 6




John Ambrose Sadd
Inventor

By Cushman, Darby & Cushman
Attorneys

Jan. 19, 1960 J. A. SADD 2,921,582

HYPODERMIC INJECTION APPARATUS

Filed Feb. 9, 1954 6 Sheets-Sheet 6

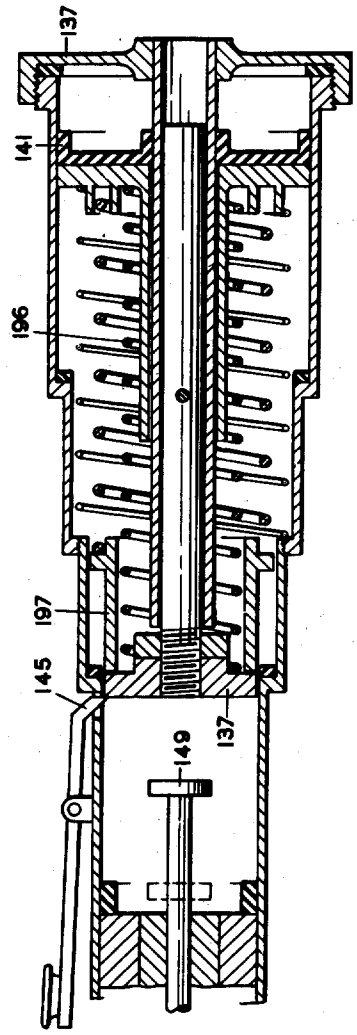



FIG. 7

John Ambrose Sadd
Inventor

By Cushman, Darby & Cushman
Attorneys

United States Patent Office 2,921,582 Patented Jan. 19, 1960



2,921,582

# HYPODERMIC INJECTION APPARATUS

John Ambrose Sadd, Harnham, Salisbury, England, assignor to National Research Development Corporation, London, England, a corporation of Great Britain

Application February 9, 1954, Serial No. 409,148

Claims priority, application Great Britain February 11, 1953

8 Claims. (Cl. 128—173)

This invention relates to apparatus for carrying out hypodermic injections and in particular it relates to apparatus which will enable inoculating injections to be administered without the use of a hypodermic needle.

A very fine jet of liquid projected at a high velocity can penetrate the human skin and it has been suggested that this effect might be used in carrying out hypodermic injections. The invention provides a means of effecting in a rapid and safe manner needleless injections and thus it avoids the disadvantages involved in continually having to change the injection needles and in needing a constant supply of sterile needles. In addition this injection apparatus eliminates the time normally incurred in withdrawing the correct amount of inoculating fluid into the ordinary syringe prior to each injection, and, consequently its use advantageously enables injections to be given at an extreme speed.

In accordance with the present invention the needleless injection apparatus comprises a chamber for receiving a predetermined quantity of liquid, a plunger for expelling such liquid at high velocity through a small orifice in the chamber and impact producing means for operating the liquid discharging plunger.

The impact producing means is desirably constituted by a hammer acting under the influence of a main spring, the hammer being adapted to be withdrawn from contact with the discharging plunger and held ready for its operation on the release of a manually operable retaining device or by the admission of compressed air. By withdrawing the hammer from contact with the liquid discharging plunger, the hammer is allowed to move forward to gather momentum and then to strike the plunger with a high velocity which produces a definite shock as opposed to a gradual pressure.

The liquid may be introduced into the apparatus under pressure and the hammer withdrawn ready for firing either by means of compressed air, by the action of a return spring or manually by means of a cocking handle. The supply of compressed air and liquid may be controlled through a single valve or a separate valve provided for each, and in addition a manually operated lever or an air operated plunger may be used for controlling the liquid supply to the apparatus. Further the main spring may be compressed prior to each impact of the hammer on the plunger by the use of compressed air.

The plunger is partly positioned in the chamber for receiving the liquid and the amount of liquid received in this chamber is controlled by regulating the outward travel of the plunger on the admission of liquid to the chamber.

An indicating device may be provided for ensuring that prior to each injection the chamber is correctly filled with liquid. The indicating device may be inter-connected with the releasable retaining device or with the compressed air control cock to prevent operation when the chamber is incorrectly filled, and an adjustable stop may be threaded through the nozzle cap of the apparatus to limit the backward extent of movement of the plunger.



After the initial impact of the hammer on the plunger the hammer may be caused to rebound and strike the plunger again with reduced force, this action being repeated until the initial energy of the hammer is finally dissipated and the liquid in the chamber expelled. In addition to the main spring a follower spring may be provided to thrust the hammer against the plunger, the arrangement being such that the main spring is prevented from exerting a continuous pressure on the hammer whilst the follower spring is allowed to exert a pressure on the hammer until the hammer is brought to rest. The main spring may be positioned to exert pressure on a collar which is allowed to move a limited distance under the action of this spring. The hammer may be returned to its cocking position by a piston which may be operated on by compressed air and which may be removed out of the path of action of the hammer by a coiled spring.

The invention may best be understood with reference to the accompanying drawings wherein illustrative embodiments are shown.

In the drawings:

Figure 1 is a vertical sectional view illustrating one form of an apparatus embodying the principles of the present invention;

Figure 2 is a view similar to Figure 1 illustrating another embodiment of the present invention;

Figure 3 is a front elevational view illustrating still another embodiment of the present invention;

Figure 4 is a horizontal sectional view of the apparatus shown in Figure 3;

Figure 5 is a view similar to Figure 4 showing a still further modification of the present invention;

Figure 6 is a front elevational view partly in section of the apparatus shown in Figure 5; and

Figure 7 is a fragmentary vertical sectional view of a still further modification of the apparatus.

A forward body tube **1** is externally threaded at one end to engage a locking ring **2** adapted to receive a nozzle cap **3** having a very fine central orifice **4**. This orifice **4** communicates through a control cock **5** with a cylindrical chamber **6** which is closed at its other end by a plunger **7** adapted to move forward into the chamber **6** and to have its backward travel regulated by an adjustable stop **8**. A hammer **9** is threaded partly along its mid-portion where it is locked by the nut **10** to a circular plate **11** which has in it a number of symmetrically placed air release holes **12** and which is free to slide within the tube **1**. The hammer **9** is in alignment with a stop **13** faced on one side with a rubber cushion **14** and secured within the tube **1**. At its other end the hammer **9** is fixed to a circular plate **15** having a shouldered bearing surface **16** and having through it a number of symmetrically placed air release holes **17**. A powerful coiled main spring **18** is positioned longitudinally within and around the inner surface of the body tube **1** and is held between the plate **11** and a recessed central surface **19** of a connecting ring **20** which has an internally threaded flange **21** screwed over the end of the body tube **1**. A rear body tube **22** threaded externally at its ends, is screwed at one end into the rear of the connecting ring **20** and screwed at the other end into an end cap **23** which has in it symmetrically placed holes **24**. The connecting ring **20** has a central opening through which passes a tubular air piston **25** wherein slides the hammer **9**. This air piston **25** has a piston head **26** on one end thereof and at its other end there is provided a shoulder plate **27**. An air piston return spring **28** is positioned between the shoulder plate **27** and the central surface **19** of the connecting ring **20** which has an externally threaded boss **29** screwed into a sleeved tightening gland **30** enclosing a quantity of packing material **31** between it and the piston **25**. A flanged rubber seal **32** is held against the forward side

of the piston head **26** and against the inner surface of the rear body tube **22** by a plate **33** which is screwed to the piston head **26**. A tapered control cock **34** having an operating handle **35** protrudes through the connecting ring **20** and has bored transversely through it two ports **36** and **37** which connect respectively with a tube **38** connected to a supply of inoculating liquid maintained under pressure in a cylinder **38A** and with a tube **39** connected to a source of compressed air **39A**. The tubes **38** and **39** pass through the outer edge of the connecting ring **20** and are positioned in alignment with a delivery tube **40** leading to the control cock **5** and with a narrow channel **41** which connects with the air space between the seal **32** and the connecting ring **20**. The control cock **34** has also a port **42** (shown dotted) which is bored half way into it and which is drilled at right angles to the line of direction of the ports **36** and **37** and the connecting ring **20** has a port (not shown) communicating with the channel **41** and drilled at 90° to the axis of this channel. A pivoted operating lever **43**, attached to the rear body tube, has a sear **44** which protrudes through a hole **45** into the rear body tube. A compressed spring **46** is positioned between the underside of the operating lever **43** and the surface of the body tube **22** whilst a cocking handle **47** (shown chain dotted) is fixed to the plate **15** and passes through a central hole **48** (shown chain dotted) in the end cap **23**.

In using the apparatus in accordance with the invention the control cock **5** is rotated through 90° in a clockwise direction so that the chamber **6** and the tube **40** are in communication while the orifice is closed. When the operating handle **35** and thus the control cock **34** are rotated, the ports **36** and **37** are brought into alignment with the delivery tube **40** and with the channel **41** respectively so that liquid immediately flows under pressure to fill up both the delivery tube **40** and the chamber **6** and in so doing the liquid pushes the plunger **7** to the rear until the plunger abuts against the adjustable stop **8**. At the same time compressed air entering the rear body tube **22** through the channel **41** exerts a rearward pressure on the rubber seal **32** and thus causes the air piston **25** to move in that direction. This air piston contacts the shouldered surface **16** of the hammer **9** and whilst the hammer is forced rearward the plate **11** compresses the main spring so that the plate **15** is pushed beyond and hence retained by the protruding sear **44** with the result that the forward end of the hammer is held away from the plunger **7**. When the operating handle **35** is given a clockwise rotation of 90° both the liquid and compressed air supplies are cut off from the apparatus and the compressed air remaining in the rear body tube is allowed to leak out to the atmosphere through the port **42**. When this air pressure is sufficiently reduced the air piston return spring **28** is able to exert an effective force powerful enough to force the air piston **25** forward and away from the hammer plate **15** which is held behind the sear **44**. With the hammer **9** in this position and the main spring **18** in a compressed state the control cock **5** is rotated through 90° in a counter clockwise direction and the apparatus held with the orifice **4** firmly pressed against the skin of the subject to be inoculated so that on depressing the operating lever **43** the sear is withdrawn and the hammer allowed to move forward quite freely at high velocity under the action of the main spring until after gaining momentum it is caused to strike the plunger **7** and thus to eject a high velocity jet of liquid out of the orifice **4**. The mechanism may now be returned to the "ready for injection" position by again giving the operating handle **35** an anti-clockwise rotation of 90° and by giving the control cock **5** a clockwise rotation of 90° and so simultaneously admitting liquid to refill the chamber **6** and compressed air to the rear body tube to return the hammer to its operating position.

When the air supply to the piston **25** is insufficient for automatic operation of the apparatus the handle **47** may be used to recock the mechanism by pulling it rearward and hence withdrawing the hammer **9** to its operating position after each injection is made; thus in the event of any failure of the air supply the hammer spring can be repeatedly cocked by hand and the injections continued at a reduced speed.

It is to be noted that to obtain an efficient injection operation it is necessary that the energy imparted to the plunger should be of a constant value and that the energy stored in the main spring **18** and hammer **9** on their release by the tripping action of the sear **44** should be maintained constant and that their movements should be arranged to be as frictionless as possible. Consequently the air piston which indirectly compresses the spring **18** has been provided with the separate return spring **28** to move the air piston forward out of the path of the hammer so that it is able to move forward quite freely when released. The relative masses of the hammer and plunger are so proportioned that on impacting the plunger the hammer rebounds after imparting a portion of its kinetic energy to the plunger and is then caused by the action of the spring **18** to return forward and restrike the plunger several times before its kinetic energy is finally dissipated and the plunger driven home. The primary impact of the hammer on the plunger produces a sufficient shock effect for the liquid to burst through the skin of the subject being injected and to make in the skin a very small entry orifice, whilst the succeeding impacts complete the injection at a much reduced velocity so that any harmful effect of suddenly injecting a mass of liquid into the body tissues is minimised since a large part of the inoculating liquid is injected into the body under reduced pressure.

The above described embodiment of the invention shows the location and action of two liquid control cocks **5** and **34** respectively although for satisfactory operation of the apparatus only one such control cock is necessary and which cock is, in fact used at any time, depends on the particular inoculating liquid used and the precautionary measures needed to prevent contamination. The control cock **5** may be omitted so that each time the control cock **34** is rotated to align the port **36** with the liquid supply tube **38** a fine jet of inoculating liquid will be forced out of the orifice **4**. When using the apparatus this liquid loss per injection is small and advantageously washes out the orifice **4** after each injection is made and so minimises the risk of incorporating harmful organisms into the inoculating liquid. This loss of liquid may, however, be avoided by pressing the orifice against a suitable pad, which may be medicated if desired, whilst the liquid chamber is filling. Alternatively the loss may be avoided by holding the orifice against the skin of the person to be inoculated.

Another embodiment of the invention will now be described with reference to Figure 2 which shows an alternative arrangement of the hypodermic injection apparatus.

A body tube **51**, threaded to engage an end cap **52**, is screwed at its forward end into a locking ring **53** adapted to receive a nozzle cap **54** having a very fine central orifice **55**. This orifice **55** communicates with a cylindrical chamber **56** which is closed at its other end by a plunger **57** adapted to move forward into the chamber **56** and to have its backward travel regulated by an adjustable stop **58**. This stop **58**, held by screws **59** to the body tube **51**, is maintained out of contact with it by insulated bushes **60** and is electrically connected through an indicating lamp **61** and battery **62** to the body tube **51**. A stop **63** is faced on one side with a rubber cushion **64** and is secured within the tube **51**. A hammer **65** is threaded partly along its mid-portion where it is screwed into and supported by a collar **66** located in position along the hammer **65** by a grub screw **68**. The collar **66** has a flange **67** having recessed portions **69** and **70** in which pivoted levers **71** and **72** are acted on by coiled springs **73** and **74** respectively. These pivoted levers have

protruding sears 75 and 76 which are positioned to engage in two elongated slots 77 and 78 respectively, which slots are made diametrically in the surface of the body tube 51. A coiled return spring 79 is held longitudinally within and around the inner surface of the body tube 51 between the rubber cushion 64 and the forward face of the collar flange 67. The hammer 65 has an enlarged cylindrical end portion 80 which is adapted to slide within a hollowed piston 81 and to abut against an interior shoulder 82 of the piston 81. This piston 81 has a bevelled head 83 and a circular flange 84 and is threaded to receive an end cap 85. A rubber seal 86 is held against the rearside of the flange 84 and against the inner surface of the body tube 51 by a plate 87 which is screwed to the piston flange 84. A powerful main spring 88 is longitudinally positioned around the inner surface of the body tube 51 between the rear surface of the collar 66 and the forward face of the flange 84. An arm 89, positioned below the body tube 51, is drilled to receive two tapered control cocks 90 and 91 which protrude through the arm 89 and which have ports 92 and 93 drilled transversely in them so that the ports 92 and 93 can be rotated and brought into corresponding alignment with narrow passages 94 and 95 drilled in the arm 89. The passage 94 is connected to a tube 96 connected to a supply of inoculating liquid maintained under pressure in a cylinder 96A and leads to a delivery tube 97 which is connected to the forward end of the chamber 56. The passage 95 is connected to a tube 98 connected to a source of compressed air 98A and leads to a tube 99 which is connected to the air chamber 100 formed between the rear end of the piston 81 and the end cap 52. The control cock 91 has a port 101 (shown dotted) which is bored half way into it and which is drilled at right angles to the axis of the port 93 and the arm 89 has a port (not shown) communicating with the passage 95 and drilled at 90° to the axis of this passage.

In using the apparatus in accordance with the invention, the control cock 90 is rotated so as to momentarily place the liquid supply tube 96 in alignment with the delivery tube 97. During this period vaccine flows through the delivery tube 97 to fill up the chamber 56 and so to rearwardly push the plunger 57 until it contacts the adjustable stop 58 and thus completes the electrical circuit and lights the indicating lamp 61. When the control cock 91 is rotated in a clockwise direction so to allow the air supply tube 98 to communicate with the tube 99 an increased air pressure produced within the air chamber 100 acts on the seal 86 and pushes forward the piston 81 and compresses the main spring 88. During this forward motion of the piston 81, the bevelled piston head 83 dislodges the pivoted levers 71 and 72 and cause their corresponding sears 75 and 76 to disengage with the slots 77 and 78 respectively so that the hammer 65, thrust forward under the action of the main spring 88, is caused to strike the plunger 57 and thus to eject an initial high velocity jet of liquid out of the orifice 55. The hammer 65 is finally brought to rest against the cushioned surface 64 and the liquid chamber is then empty. When the control cock is rotated through 90° in an anticlockwise direction the air supply to the air chamber 100 is cut off and the compressed air within the chamber is allowed to escape to atmosphere through the port 101. The reduced air pressure, thus caused in the air chamber 100, allows the light return spring 79 to force the hammer 65 to the rear of the body tube. During this movement of the hammer the sears 75 and 76, which press on the inner surface of the body tube 51, are caused by the action of their corresponding coil springs 73 and 74 to re-engage in the slots 77 and 78 respectively. The hammer 65 is now in its locked position and is ready to move forward and restrike the plunger 57 when a further supply of compressed air is admitted to the air chamber by giving the control cock 91 a clockwise rotation of 90°.

A third embodiment of the invention will now be described with reference to Figures 3 and 4. Figure 3 is a diagrammatic view of the injection apparatus connected to a vaccine supply and an air pressure regulator and Figure 4 is a diagrammatic view showing a section through the main body of the injection apparatus and showing the mechanism thereof when not subject to the action of any vaccine or air pressure.

The injection apparatus 110 is shown connected by a length of tubing 111 to a filter 112 and then to an air pressure regulator 113 having pressure regulating controls 114 and 115. A second length of tubing 116 connects the forward portion of the apparatus to a supply of vaccine 117 which is connected to a filter 118 communicating by means of the tubing 119 with the air pressure regulator 113. This regulator is connected by means of a union 120 to a source of compressed air 121. Air pressure gauges 122 and 123 for indicating the air pressures applied to the injection apparatus and to the vaccine supply are fitted to the regulator 113, and associated control cocks 124 and 125 are connected in the circuits leading to the vaccine supply and to the injection apparatus respectively.

The body portion of the injection apparatus 110, as shown in Figure 4, comprises two aligned tubular portions 126 and 127 which are screwed together. The rear body portion 127 is provided with stepped shoulders 128 and 129 and with an enlarged end flange 130 which is screwed into an end cap 131 having a central boss 132 into which is firmly secured a guide sleeve 133. This sleeve has vertically aligned slots 134 which locate a vertical pin 135 passing through a hammer shaft 136 which slides within the guide sleeve itself and to which is fitted at its forward end within the body portion 126 a hammer head 137 and lock nut 138. A piston 139 having an extended sleeve portion 140 and fitted with a piston seal 141 slides over the fixed guide sleeve 133 in contact with the inner polished walls of the rear portion of the body tube 127. A coiled return spring 142 and a stronger main spring 143 are held in position between the forward end of the piston and the shoulder 128 and rear face of the hammer 137 respectively.

A pivoted operating lever 144 (Fig. 3), attached to the forward body tube 126 has a sear 145 which protrudes through a hole 146 into the interior of the body tube and the forward end of this tube 126 is fitted over a sleeve 147 (Fig. 4) which encloses a nosepiece 148. This nosepiece is drilled centrally to receive a plunger 149 which projects rearwardly into the hollow interior of the body tube 126 and to accommodate a fluted non return valve 150 which is held under the action of a spring 151 in the forward threaded portion of the nosepiece by an end cap 152 having a fine central orifice 153. The upper portion of the nosepiece 148 is slotted to receive an adjustable stop 154 and a telltale rod 155 which passes through a passage 156 drilled in the nosepiece, and is connected to the rear enlarged portion of the plunger 149. Buffers 157 and 158 are positioned adjacent the rear portion of the sleeve 147 and against the shoulder 129 respectively. A circular groove 159 made in the rear end of the interior of the nosepiece 148 is connected by a drilled passage to a drain tube 160. A side portion 161 of the nose piece 148 is drilled to communicate with the interior of the nose piece and is threaded to receive a needle valve 162 which is shown in its closed position in Figure 4 and which passes through a hexagonal gland nut 163 and associated packing 164. The needle valve 162 has a left hand threaded portion which is screwed into the side portion 161 of the nosepiece and it carries a crank shaped arm 165 to which is secured an operating lever 166. The outer end of the needle valve has a toothed adjusting wheel 167 which is held in position relative to the lever 166 by a sliding adjustable pawl 168 which locks into one of the teeth on the wheel 167. The lower end of the arm 165 is connected to a spring 169 having its other end secured to

the body tube **126** of the apparatus. A union **170** communicating with the interior of the side portion **161** is connected to the length of tubing **116** leading to the pressurised vaccine supply **117**. A rod **171** supported by the arm **165** contacts an extended portion of a plunger **172** protruding from a hollow length of tubing **173** which communicates with the space in the apparatus between the piston seal **141** and the end cap **131**. The end of the plunger **172** within the tubing **173** is drilled to communicate with a union **174** connected to a length of tubing **111** leading to the supply of compressed air **121**, and an orifice **175** passing through the wall of the drilled end of the rod **172** communicates with the drilled interior of the rod. A spring **176** is held under compression between the inner end of the rod **172** and a shoulder **177** within the tubing **173** and an air vent **178** is positioned in the wall of the tubing **173** between the union **174** and the forward end of the spring **176**.

When operating the apparatus, the control cocks **124** and **125** are turned on and the regulating controls **114** and **115** are adjusted to give the required working pressure for both the vaccine and air which are supplied to the apparatus. These working pressures may be, for example, about 10 and 50 lbs. per sq. in. respectively. On depressing the operating lever **166** the needle valve **162** is rotated and simultaneously withdrawn from its seating so that vaccine under pressure in the tubing **116** is allowed to flow into the interior of the nosepiece **148** and to force the plunger **149** to the rear until the tell-tale rod **155** comes to rest against the adjustable stop **154**. Any vaccine which flows past the plunger **149** and which tends to leak away is collected in the circular groove **159** and drained away through the connection **160**. The pressure exerted by the spring **151** on the fluted valve **150** is sufficient to prevent the vaccine leaking under its own pressure out of the orifice **153**. Simultaneously with the flow of vaccine into the nosepiece the movement of the rod **171** pushes the plunger **172** further into the tube **173** until the orifice **175** in the plunger **172** is brought into alignment with the air vent **178** so as to release any air pressure which may exist in the body of the apparatus between the piston seal **141** and the end cap **131**.

The operating lever **166** is then released and is brought back by the spring **169** to its original position, as shown in Figure 4, with the needle valve closed. Meanwhile the movement of the rod **171** which is attached to the needle valve, has allowed the spring **176** to return the plunger **172** to the position shown in Figure 4 in which the orifice **175** is brought into alignment with the axis of the union **174** and the source of compressed air **121** is brought into communication with the interior of the injection apparatus between the piston seal **141** and the end cap **131**. Under the action of the air pressure exerted on it the piston seal **141** and the piston **139** are forced forward until the piston is brought to rest against the buffer **158**. The coiled springs **142** and **143** are thus compressed between the face of the piston **139** and the shoulder **128** and the rear of the hammer head **137** respectively. This hammer head is retained in position by the sear **145** which projects into the interior of the body casing **126**. The apparatus is now ready for making an injection by depressing the operating lever **144** and so withdrawing the sear **145** out of the path of the hammer head **137**. The hammer head moves rapidly forward under the action of the compressed spring **143**. After a period of free movement during which it acquires momentum it strikes the plunger **149** which thus exerts enough pressure on the liquid to dislodge the fluted valve **150** from its seating and to cause the liquid to issue from the orifice **153** with sufficient velocity to penetrate the skin of the subject and to penetrate liquid into the underlying tissues.

In order to prepare the apparatus for the next injection the lever **166** is again depressed whereupon, as described above, the needle valve **162** is opened and liquid is allowed to flow within the nosepiece. Simultaneously, the space between the piston seal **141** and the end cap **131** is cut off from the air supply and connected to atmosphere through the vent **178** so that the pressure in it is reduced to atmospheric. The return spring **142** is then able to force the piston **139** to the rear of the body **127**. The pin **135** projecting through the slots **134** in the guide sleeve **140** causes a simultaneous return motion of the hammer shaft until the hammer head **137** is again positioned behind the sear **145**. On releasing the lever **166** air pressure is again applied behind the piston and the apparatus is again ready for an injection.

In this third embodiment of the invention the vaccine needle valve, has an unlubricated needle seat and its spindle is connected to the adjusting wheel **167** so that as the valve seat wears the pawl **168** may be released and fitted into another tooth on the wheel to correct the linkage of the vaccine and air controls and the position of the operating lever **166**.

The simple non return valve **150**, which is positioned behind the orifice **153** and which is spring loaded, is set so that it will not open under the normal vaccine supply pressure but it will allow the vaccine to reach the orifice when an injection is made.

The guide sleeve, piston, hammer shaft and hammer may be withdrawn completely from the rear of the apparatus by unscrewing the end cap **131** without interfering with the forward vaccine portion of the apparatus.

The quantity of vaccine supplied to the apparatus for each injection operation may be regulated by adjusting the position of the stop **154** and so limiting the rearward movement of the plunger **149**. The tell-tale rod **155** which is visible in a slot cut in the top of the nosepiece **148** indicates the plunger movement as vaccine is being supplied to the apparatus.

If injections are to be administered at a high rate the effect of fatigue on the person carrying out the injections is a major factor and to reduce the fatigue which would be incurred using the third embodiment of the invention a further arrangement of the apparatus has been designed.

In this fourth embodiment of the invention a compressed air cylinder has been provided to operate the vaccine needle valve and the only actions required of the operator consist in depressing a button to supply vaccine to the apparatus and then pressing an operating lever to make the injection.

The fourth embodiment of the invention differs from the apparatus shown in Figures 3 and 4 solely by way of utilising the compressed air supply to rotate the needle valve and to compress the main hammer spring in readiness for an injection operation instead of using a manually operated lever which must be rotated to effect the opening of the needle valve and the subsequent filling of the vaccine chamber. By this means the thumb of the person carrying out the injection operations is brought to a more comfortable position for a single hand operation of the apparatus.

The modified form of construction will now be described with reference to Figures 5 and 6. Figure 5 is a diagrammatic view showing a section through the main body of the apparatus and showing the mechanism thereof when not subject to the action of any vaccine or air pressure and Figure 6 is an elevation of the forward part of the apparatus.

An extended side portion **161** of the nosepiece **148** is drilled to communicate with the nosepiece and is threaded to receive a needle valve **162** which is shown in its closed position and which passes through a gland nut **163** and associated packing **164**. This needle valve **162** has a right hand threaded portion which is screwed into the side portion **161** of the nosepiece and it is fitted to a crank **180** which is connected to a spring **181** anchored to the exterior surface of the nosepiece **148**. A rod **171** fixed to the crank **180** is in contact with a plunger **182** which projects from an air cylinder **183** mounted on the outside of the apparatus. The interior of the cylinder

183 communicates by means of the tube 184 with the lower portion of a main air distribution cylinder 185 which is fixed to the body of the apparatus and which is provided with a piston 186 having a cut away portion 187 and surmounted by an air control button 188. A spring 189 is positioned at the bottom of the cylinder 185 where is situated a vent 190 and a main air supply union 191 connected by a length of tubing 111 with a supply of compressed air 121. A tube 192 connects a port 193 in the upper portion of the cylinder 185 with the interior of the apparatus between the rear of the piston seal 141 and the end cap 131. A length of tubing 116 is connected between the union 170 and a supply of vaccine 117 which is maintained under pressure.

The operation of this modified form of the apparatus is as follows: When the compressed air supply is admitted to the apparatus it fills the chamber between the end cap 131 and the rear of the piston seal 141 and forces the piston 139 forward against the forces exerted by the coiled springs 142 and 143 until the piston is brought to rest up against the buffer 158. Now on depressing the air control button 188 against the action of the spring 189 the lower enlarged portion of the piston 186 is lowered until it uncovers the orifice leading to the tube 184 so that the main air supply is cut off from port 193 and placed in direct communication with the cylinder 183. Simultaneously the port 193 is connected to the atmosphere so that any air pressure in the chamber between the piston seal 141 and the end cap 131 is vented. The air pressure thus supplied to the air distribution cylinder 183 pushes the plunger 182 further out of the cylinder and causes an anti-clockwise rotation of the crank 180 and consequently a withdrawal of the needle valve 162 from its seating with the result that the pressurised vaccine in the side portion 161 of the nosepiece 148 is allowed to flow into the nosepiece and to force the plunger 149 rearwardly until its movement is limited by the adjustable stop 154. On releasing the control button 188 air supply to the air distribution cylinder is cut off and the air therein is allowed to escape through the vent 190 while simultaneously the restoring force of the spring 181 causes the crank 180 to rotate in a clockwise direction to effect a closing action of the needle valve.

The air supply, now connected by way of the port 193 to the space between the piston seal 141 and the end cap 131, forces the piston forward and compresses the springs 142 and 143 until the piston is brought to rest against the buffer 158.

The apparatus is now ready for use and on depressing the lever 144 an injection is made in the manner already described.

On releasing the lever 144 and depressing the control button 188 the cycle of operations described above is repeated, the air distribution cylinder is again connected to the air supply and the needle valve is opened whilst the space between the piston seal 141 and the end cap 131 is vented to the atmosphere so that the return spring 142 forces the piston 137 to the rear of the apparatus until it engages with and is held by the sear 145.

On releasing the button 188 and depressing the lever 144 an injection is given; the process may thus be repeated as desired at a high rate of operation and with minimum fatigue to the operator.

In the embodiments previously described the injection has been arranged to take place in two or more stages. In the first stage a liquid jet of sufficiently high velocity penetrates the skin of the subject and prepares the way for the subsequent injection stage or stages which are carried out at lower velocity so as to minimise tissue damage and to afford a measure of control over the route taken by the injected liquid.

This desired effect is attained in the following manner: When the hammer head 137 (Fig. 4) is released by the sear 145 it moves forward freely for a predetermined distance which may conveniently be about half its total travel. It then strikes the end of the plunger 149 and rebounds from it while the plunger moves forward for a short distance only. The energy thus imparted to the plunger forms the first stage which involves the ejection of only a small quantity of liquid which possesses a sufficiently high velocity for it to penetrate the skin. Thereafter the hammer head is again driven forward by the main spring 143 on to the plunger from which it again rebounds. This action is repeated until the plunger is driven home and the whole of the liquid dose ejected. These subsequent stages take advantage of the previous penetration of the skin and complete the injection at a comparatively low rate.

The rebounding action of the hammer head is controlled by the strength of the spring and the relative masses of the hammer and plunger. This means of control is, however, limited and circumstances may arise in which it is insufficient. A fifth embodiment has therefore been designed in which two springs namely a main spring and a follower spring are used to control the rebounding action and this arrangement of the apparatus is shown in Figure 7.

This re-arrangement of the apparatus may be applied to either the lever operated type (Figure 4) or to the air plunger operated type (Figs. 5 and 6) and it differs from the arrangements of the apparatus already described only in respect of the use of an additional follower spring 196 and a 197 collar to limit the travel of the main spring. When compressed air is admitted to the space between the piston seal 141 and end cap 131 the piston moves forward and compresses both main and follower springs. When the sear 145 releases the hammer head 137 the two springs act in conjunction and force the hammer head forward until it meets the plunger 149 and then drives it forward for a small distance sufficient to penetrate the skin, and thereby to carry out the first stage of the injection. The limiting collar 197 comes to rest against a buffer and limits the travel of the main spring. The hammer then moves forward under the action of the follower spring, usually in two or more stages as the hammer rebounds, and completes the injection.

It is to be understood that any convenient means of adjusting the spring pressures and any method or means for dividing the injection into a skin penetrating stage or stages and one or more subsequent stages may be used. Also if even more effective control of the rate of injection is desired a plurality of follower springs may be used with limiting collars or like devices as required.

I claim:

1. A needle-less hypodermic injection apparatus comprising means defining a chamber for receiving a predetermined quantity of liquid, said chamber having an exit orifice, a plunger slidably mounted in said chamber for expelling the said liquid at skin penetrating velocity through the orifice, a hammer mounted for movement toward and away from said plunger for striking the latter, means for placing the hammer in a cocked position in which the hammer is spaced from the plunger, and a spring system operatively connected with the hammer for driving the latter toward the plunger to impact the same, the strength of the spring system and the relative masses of the plunger and hammer being such that when the hammer is driven toward the plunger by the spring system repeated rapid impacts of diminishing strength are delivered to the plunger as a result of recoil movements of the hammer following successive impacts on said plunger.

2. A needle-less hypodermic injection apparatus as claimed in claim 1 including an adjustable collar carried by the said hammer and bearing against the spring system, the position of the said collar being adjustable along the length of the hammer to alter the compression of the spring system when placed in the cocked position.

3. A needle-less hypodermic injection apparatus as

claimed in claim 1 including a reservoir for the liquid, a liquid supply line connected between the reservoir and the said chamber, and an adjustable stop arranged to limit the extent of movement of the plunger when the liquid is caused to flow from the reservoir to the said chamber whereby a predetermined quantity of liquid may be supplied to the chamber.

4. A needle-less hypodermic injection apparatus as claimed in claim 3 including an electrical circuit, an indicating device in said circuit and means for closing the electrical circuit to operate said indicating device when the plunger is forced by the entry of liquid to the chamber to its limiting position out of the chamber.

5. A needle-less hypodermic injection apparatus comprising a body having a liquid receiving chamber in the forward end thereof and an outlet orifice leading from said chamber, a plunger reciprocable in said chamber, a hammer mounted in said body rearwardly of said plunger for sliding movement toward and away from the latter, a collar on said hammer intermediate its ends, releasable means acting between said body and said collar for retaining said hammer in a cocked position away from said plunger, a piston slidably mounted in the rear end of said body and having a lost motion connection with said hammer, spring means between said collar and said piston, fluid pressure means operable to move said piston forwardly with respect to said hammer to stress said spring means, and means on said piston for releasing said releasable means after a predetermined movement of said piston with respect to said hammer whereby the latter is driven forward by said spring means to strike the plunger.

6. A needle-less hypodermic injection apparatus as claimed in claim 5 including second spring means carried by said body and being operable to move said hammer into its cocked position when said fluid pressure means is rendered inoperative.



7. A needle-less hypodermic injection apparatus as claimed in claim 3 having a tell-tale rod attached to the plunger and which is visible outside the apparatus.

8. A needle-less hypodermic injection apparatus as claimed in claim 1 wherein said means for placing the hammer in a cocked position comprises a piston operatively connected with said hammer for driving the latter away from said plunger to said cocked position, means for applying compressed air to the piston to drive said piston away from said plunger, and a return spring for returning the piston to a forward position out of the path of the hammer when the pressure of the compressed air is removed.

**References Cited** in the file of this patent

UNITED STATES PATENTS

| | | |
|---|---|---|
| 2,380,534 | Lockhart | July 31, 1945 |
| 2,687,724 | Ziherl et al. | Aug. 31, 1954 |

FOREIGN PATENTS

| | | |
|---|---|---|
| 681,098 | Great Britain | Oct. 15, 1952 |

OTHER REFERENCES

"Local Infiltration of Tissues from a Machine Designed to Deliver High Pressure, High Velocity Jets of Fluid," by John F. Roberts Catalog #R747.C7/C73/1935 Medical Library of Columbia University, New York.

College of Physicians & Surgeons, 630 W. 168th Street, New York, N.Y. Presented in manuscript form and is bound. Open to inspection by persons granted the privilege of use of the Library. Available on interlibrary loan. (Fig. 3, Fig. 7 cited.)