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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : A61M 5/30, 31/00	A1	(11) International Publication Number: **WO 99/10031**
		(43) International Publication Date: 4 March 1999 (04.03.99)

(21) International Application Number: PCT/US98/17726

(22) International Filing Date: 26 August 1998 (26.08.98)

(30) Priority Data:
60/056,852 27 August 1997 (27.08.97) US

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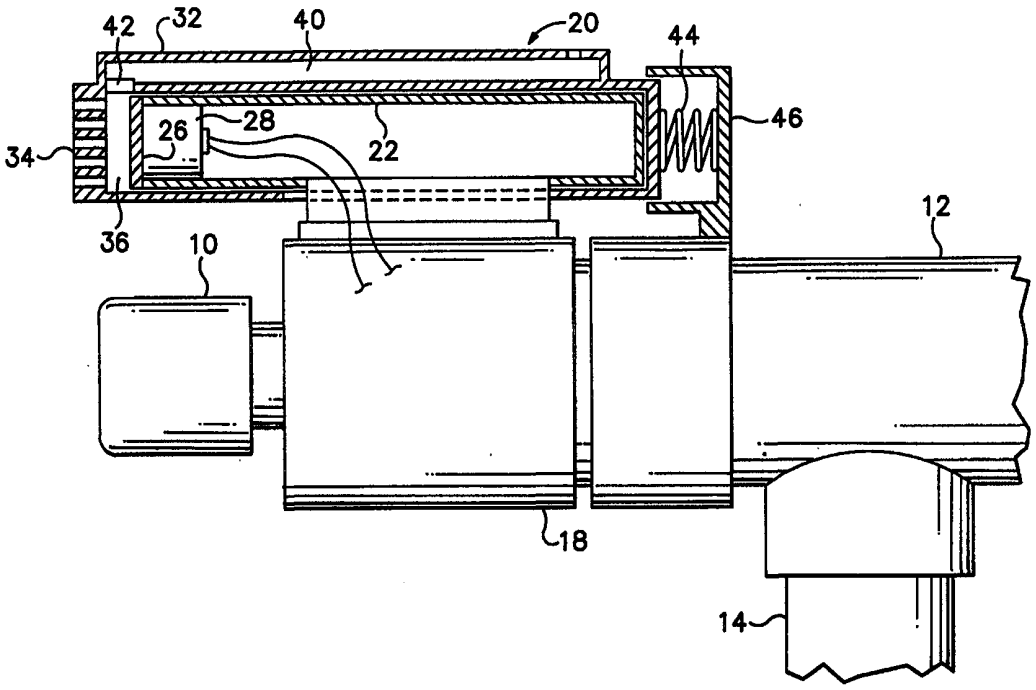
(81) Designated States: AU, BR, CA, CN, JP, US, European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Published
With international search report.

(54) Title: DEVICE FOR INJECTING MATERIAL BENEATH THE SKIN OF A HUMAN OR ANIMAL



(57) Abstract

An apparatus for injection of material into the body of an animal includes an injector for applying injectable material to a skin thickness detector (20) for providing a signal which depends on the thickness of the skin of the animal (Fig. 2), and a controller (50) for adjusting the injection force in dependence on the measured thickness of the skin of the animal.

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DEVICE FOR INJECTING MATERIAL BENEATH THE SKIN OF A HUMAN OR ANIMAL

Background of the Invention

This invention relates to a device for injecting material beneath the skin of a human or animal. For the sake of conciseness, the term "animal" as used in this specification includes a human unless the context indicates otherwise.

International Publication WO 92/1026, the disclosure of which is hereby incorporated by reference herein, discloses a needleless jet injector for mass inoculation. The jet injector shown in that publication includes a double piston which comprises a medication piston sliding in a medication cylinder and a drive piston sliding in a drive cylinder, the two pistons being coaxial and being rigidly coupled together. The drive cylinder can be connected selectively either to a source of CO_2 under pressure or to ambient pressure. The medication cylinder is connected through one check valve to a source of liquid medication and to another check valve to an ejection nozzle. When the drive cylinder is connected to the source of high pressure CO_2, the double piston is driven in a direction to eject medication from the medication cylinder by way of the nozzle. When the drive cylinder is thereafter connected to ambient pressure, the piston is forced in the opposite direction and a new dose of medication is drawn into the medication cylinder, for ejection on the next driving stroke. The stroke of the double piston is adjustable, for controlling the size of the dose of medication that is ejected. The force with which the medication is ejected depends upon the pressure of CO_2 supplied to the drive cylinder.

The needleless jet injector shown in International Publication WO 92/1026 may be used for injecting medication into humans or into animals having a tough but flexible and relatively impermeable outer skin, hereinafter referred to collectively as bodies. In use, the nozzle is placed against the skin of a body and a valve is operated to connect the

drive cylinder to the source of high pressure CO_2. The medication is ejected from the nozzle and penetrates the skin of the body. The depth to which the medication penetrates depends on the force with which the medication is ejected from the nozzle. The skins of different animals can vary quite substantially in thickness. In an agricultural or veterinary application of the needleless injector, if the CO_2 pressure is optimum for the thinner skinned animals, it may be insufficient to inject into an animal having a thick and tough skin or hide, whereas if the pressure is optimized for thicker hided animals, there is a possibility of injury to a thinner skinned animal or of the medication being injected too deeply into the animal. Similarly, the skin of a young child is generally thinner than the skin of an adult human.

Summary of the Invention

In accordance with the present invention there is provided apparatus for injection of material into the body of an animal, comprising an injector means for applying injectable material to the skin of the animal with an adjustable injection force, a measurement means for providing a signal which depends on the thickness of the skin of the animal, and a control means for adjusting the injection force in dependence on the measured thickness of the skin of the animal.

Brief Description of the Drawings

For a better understanding of the invention, and to show how the same may be carried into effect, reference will now be made, by way of example, to the accompanying drawings, in which

FIG. 1 is a partial sectional view of an injection apparatus comprising a needleless jet injector and a device for measuring skin thickness,

FIG. 2 is a side view of the apparatus when positioned against a body for injection,

FIG. 3 is a block diagram illustrating a control circuit for controlling the apparatus, and

FIG. 4 is a partial illustration of a modification of the injection apparatus shown in FIGS. 1-3.

Detailed Description

FIG. 1 illustrates the nozzle 10 of a needleless jet injector having a medication cylinder 12 to which medication is supplied through a tube 14. A mounting collar 18 carrying a skin thickness detector 20 is fitted over the forward end of the medication cylinder 12. The skin thickness detector 20 comprises a cylindrical inner housing 22 which is attached to the mounting collar 18 and is closed at one end (the left end in FIG. 1) by an acoustic standoff or coupling member 26. The inner housing 22 contains an ultrasonic transducer 28 which is attached to the acoustic standoff 26. The transducer is connected to a control circuit (FIG. 3) through wires extending from the inner housing. The control circuit controls the pressure of CO_2 supplied to the driving cylinder of the jet injector.

An outer housing 32 defines a cylindrical inner chamber which contains the inner housing. The outer housing is slidable longitudinally with respect to the inner housing while remaining mounted thereon. The outer housing is partially closed at its forward end by a perforated acoustic standoff 34 which is aligned with and confronts the acoustic standoff 26 across a pump chamber 36. The outer housing also defines a reservoir 40 which is connected to the pump chamber 36 by a check valve 42. A spring 44 is effective between the outer housing 32 and an abutment member 46 which is stationary relative to the inner housing 22 for pushing the outer housing to the left of FIG. 1 so that it projects axially beyond the tip of the nozzle 1. The inner housing and the outer housing together form a lift pump, in which fluid can be drawn into the pump chamber through the check valve and forced from the pump chamber through the perforations in the acoustic standoff 34.

In use of the apparatus shown in FIGS. 1 and 2, a quantity of vegetable oil or other suitable acoustic couplant is placed in the reservoir 40 and fills the pump chamber 36

and the perforations in the acoustic standoff 34. The operator positions the apparatus so that the standoff 34 is in contact with the skin of a body to be treated and then presses the apparatus to bring the tip of the nozzle 10 into contact with the skin, as shown in FIG. 2. In this manner, the inner housing 22 is pushed to the left relative to the outer housing 32 and couplant is forced from the pump chamber though the pores of the standoff 34. The couplant provides an effective acoustic coupling between the transducer 28 and the skin of the animal. When the forward end of the acoustic standoff 34 is aligned with the forward end of the nozzle 10, as shown in FIG. 2, the skin thickness detector supplies a signal to a controller 50 (FIG. 3), e.g. by closing a limit switch. The controller 50 responds to this signal by supplying a signal to the transducer 28 and the transducer emits a pulse of ultrasonic acoustic energy. The pulse of ultrasonic energy is propagated through the standoff 26, the standoff 34 and the couplant and penetrates the skin of the animal. Some acoustic energy is reflected toward the transducer, which detects the level of reflected power and provides a signal to the controller 50, which measures the variation in reflected power level as a function of time after emission of the pulse. The level of the reflected acoustic power depends on changes in density of the animal. Since there is a change in density at the inner margin of the skin, there is a peak in the level of reflected acoustic power corresponding to the inner margin of the skin. The time of occurrence of this peak relative to the time of emission of the acoustic pulse is calculated by the controller and this delay allows the controller to calculate the skin thickness. The controller calculates an appropriate pressure value for the pressure of CO_2 to be applied to the driving cylinder based on the calculated skin thickness. The controller provides an output signal to a pressure adjustment device 54 to adjust the pressure of CO_2, and at this point the injector apparatus is enabled. The controller supplies a signal to illuminate a READY lamp 52, which informs the operator that the apparatus is ready for use, provided that

the signal provided by the limit switch indicates that the standoff 34 is still in contact with the skin of the animal. The operator actuates the apparatus, e.g. by pulling a trigger or pressing a button, and pressurized CO_2 is supplied to the driving cylinder and as a result the medication is forced from the nozzle with an ejection force that depends on the pressure of CO_2 and hence on the skin thickness measured by the measurement device. The trigger or button is locked out, preventing actuation of the apparatus, until the controller illuminates the READY lamp.

When the dose of medication has been ejected from the nozzle 10, the operator moves the nozzle away from the skin of the body. The force of the spring 44 pushes the outer housing 32 to the left relative to the inner housing 22. Since the pores in the standoff are narrow, the couplant in the pores is not drawn back into the pump chamber but additional material is instead drawn into the pump chamber through the check valve.

It will be understood that in an agricultural application, where many animals of the same species and age are treated, it may not be necessary to measure the skin thickness of each animal prior to injection, and that instead it might be acceptable to operate the measurement device on the first animal and to reset the skin thickness measurement periodically thereafter. On the other hand, in other applications, particularly for injection to humans, it may be desirable to operate the measurement device for each injection.

In a modification shown in FIG. 4, the standoff 34 includes a skirt 56 surrounding the perforated area so that a film of couplant is trapped between the forward face of the standoff and the skin of the animal.

It will be appreciated that the invention is not restricted to the particular embodiment that has been described, and that variations may be made therein without departing from the scope of the invention as defined in the appended claims and equivalents thereof. For example, the invention is not restricted to use in conjunction with a jet

injector of the kind shown in International Publication WO 92/10226, in which CO_2 is used to supply the motive force for ejecting the medication from the nozzle, and there are many other possible ways of applying the necessary motive force. Specifically, the medication piston may be spring-loaded, in which event the control signal provided by the controller is used to adjust the spring force, for example by displacing a backup member against which the spring bears. Another possibility is to use an electromagnetic solenoid to displace the medication piston, in which case the control signal is used to control the magnetic force generated by the solenoid. The invention is not restricted to a mass inoculation apparatus, in which there is a reservoir for successively injecting the same medication into numerous animals, and is also applicable to a single injection apparatus, in which potentially a different medication is injected each time the apparatus is used. In this case the medication may be in the form of capsules.

Claims

1. Apparatus for injection of material into the body of an animal, comprising:

an injector means for applying injectable material to the skin of the animal with an adjustable injection force,

a measurement means for providing a signal which depends on the thickness of the skin of the animal, and

a control means for adjusting the injection force in dependence on the measured thickness of the skin of the animal.

2. Apparatus according to claim 1, wherein the measurement means comprises an ultrasonic transducer for emitting acoustic energy into the body of the animal and receiving return acoustic energy from the body of the animal.

3. Apparatus according to claim 1, wherein the measurement means is mounted on the injector means for contacting the skin of the animal immediately prior to injecting material into the animal.

4. Apparatus according to claim 3, wherein the measurement means comprises an ultrasonic transducer and a dispensing means for dispensing acoustic coupling material automatically onto the skin of the animal for coupling the transducer to the animal.

5. Apparatus according to claim 4, wherein the dispensing means comprises a piston member attached to the injector means, a cylinder member in which the piston member is fitted and slidable relative thereto, a perforated element closing the cylinder and confronting the piston member, and a means for introducing a flowable acoustic coupling material into a pump chamber between the piston element and the perforated element, so that movement of the perforated element toward the piston element causes the flowable acoustic coupling material to be forced from the pump chamber through the perforations of the perforated element.

6. Apparatus according to claim 5, wherein the transducer is part of the piston member.

7. Apparatus according to claim 5, comprising a spring urging the perforated element away from the piston element.

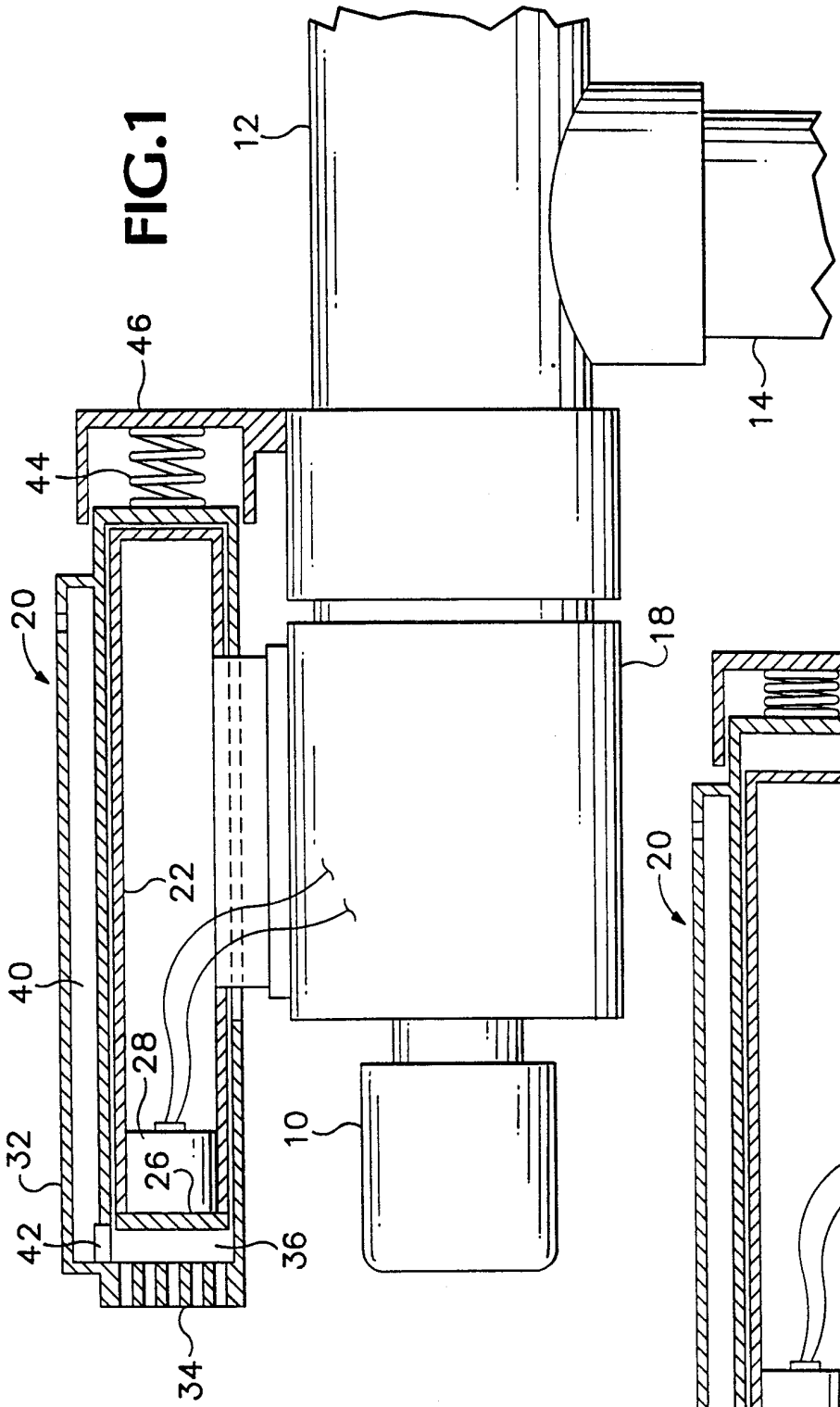


FIG.1

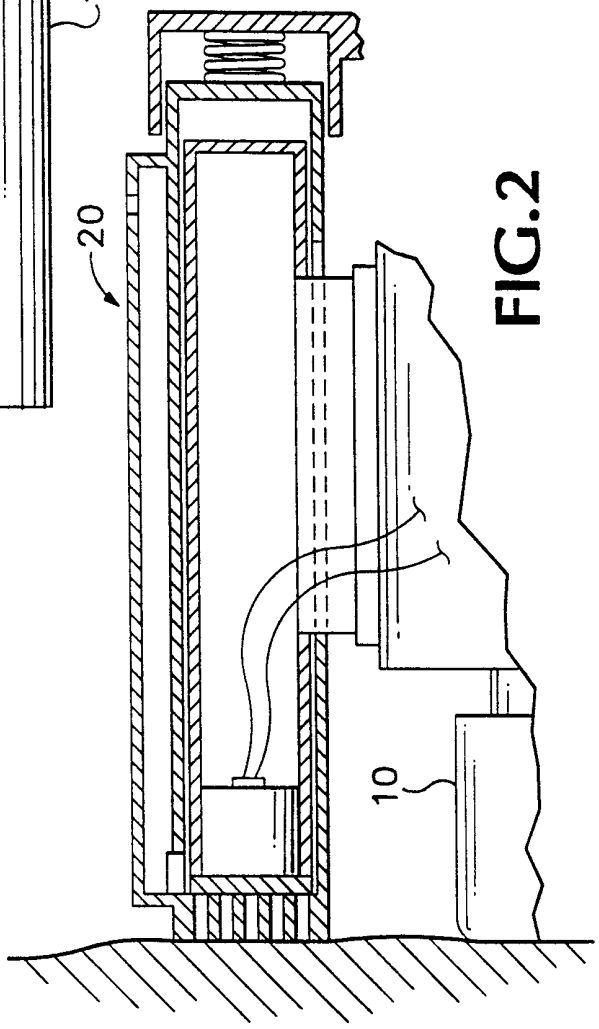
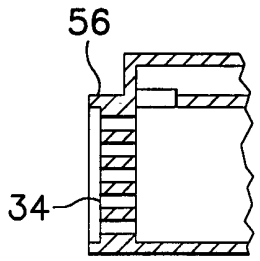


FIG.2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34

FIG.3

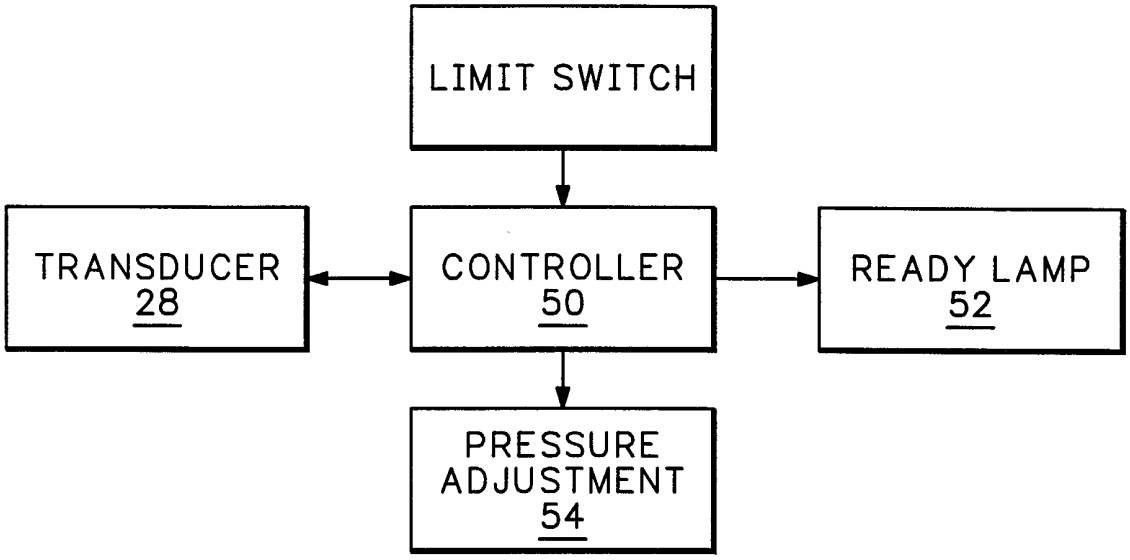
LIMIT SWITCH
TRANSDUCER
28
CONTROLLER
50
READY LAMP
52
PRESSURE
ADJUSTMENT
54

FIG.4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US98/17726

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :A61M 5/30, 31/00
US CL :604/68, 66

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 128/DIG. 1; 222/389; 604/22, 65-72, 151, 152, 228, 232

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C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 5,569,190 A (D'ANTONIO) 29 October 1996, Fig. 3, and col. 5 lines 1-33.	1
Y	US 4,767,402 A (KOST et al.) 30 August 1988, col. 4 lines 12-24, and col. 5 lines 5-11.	1
A	US 5,660,528 A (TSUNENARI) 26 August 1997, Figs. 1 and 2.	2, 4
A, P	US 5,728,130 A (ISHIKAWA et al.) 17 March 1998, Fig. 1.	1

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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Date of the actual completion of the international search
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Date of mailing of the international search report
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