

DESCRIPTION

TITLE OF THE INVENTION:

INJECTION DEVICE

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TECHNICAL FIELD

The present invention relates to an injection device, and more specifically relates to a device suitable for injecting, supplying, or administering
10 various substances including cells, into tissue.

BACKGROUND ART

In cell therapy or the like, it is often desirable to precisely inject a predetermined substance,
15 such as cells, into a subject at the treatment spot in the skin by a desired amount in a predetermined depth.

Furthermore, when injecting a minute amount of a substance such as cells into a single layer or a single region, it may be necessary to divide a predetermined
20 amount, and to dispersively inject the divided amount for multiple times from multiple different directions.

In addition, in the case of dividing the predetermined amount to dispersively inject the divided amount for multiple times from multiple different
25 directions, it is desirable that the influence on a test object is equally divided, and in the divided multiple times, it may be desired to inject the divided amount at the same predetermined pace every time.

In order to solve such issues, an injection
30 device is proposed in Patent Document 1, which provides an injection needle housing for fixing an injection needle in the injection device; the injection needle is fixed in the housing; and an injection cylinder can be

readily attached to or detached from the fixed injection needle. In this injection device, an injection operation is performed at a predetermined pace by an internal drive system and a retraction system.

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PRIOR ART DOCUMENTS

PATENT DOCUMENTS

Patent Document 1: Published Japanese Translation of PCT International Application No. 2015-505487

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SUMMARY

However, in the technique of Patent Document 1, since the injection needle is fixed in the interior, in the case of performing injection using this device for multiple patients or subjects, there is a high risk of infection due to contagious diseases and infectious diseases, and of
15 needling pain due to abrasion or the like of the injection needle. Therefore, the injection device itself needs to be discarded once used.

Furthermore, the structure of the targeted
20 injection device, which is integrated with an injection needle for a syringe that is not attachable and detachable, may necessitate the device to be handled as a rather highly sophisticated medical device, and may impose strict cares in delivery and conveyance of the device.

25 In addition, when a substance having a highly viscous, gel-like structure is used as the contents to be injected by injection, high pressure is applied at the time of use, and in some cases, the injection cylinder is detached from the fixed injection needle.

30 Thereupon, in view of the above circumstances, embodiments of the present disclosure provide an

injection device that can prevent the injection needle from falling out of the injection cylinder when being used, and can have the syringe detached and attached.

- 5 According to an aspect, there is provided an injection device to inject a content into a test object by a syringe that includes a plunger, an injection cylinder into which the plunger is inserted, and an injection needle including a needle base connected to the injection cylinder and a
- 10 needle tube to be punctured into the test object, the injection device comprising:
- a contact head configured to contact the test object and to have an opening formed through which the needle tube passes;
 - 15 a movable holder configured to hold the injection cylinder and the injection needle;
 - a support mechanism configured to be fixed to the contact head; and
 - 20 a content injection control mechanism configured to push the plunger into the injection cylinder,
- wherein the movable holder moving along the support mechanism moves the injection cylinder and
 - 25 the injection needle with respect to the contact head,
 - wherein the syringe is attachable to and detachable from the injection device,
 - wherein the content injection control mechanism includes a pressing part configured to push the
 - 30 plunger into the injection cylinder,
 - wherein the movable holder moving in a forward direction approaching the contact head causes the needle tube to puncture the test object and to enter an inside of the test object,
 - 35 wherein the movable holder moving in a backward direction away from the contact head causes the needle tube to move backward with respect to the test object, and causes the movable holder to approach the pressing part and

to push the plunger into the injection cylinder to inject the content into the test object,

wherein the injection cylinder includes an outer cylinder part to contain the content, and a flange provided at a rear end of the outer cylinder part,

5 wherein at an upper part of the movable holder is provided with a flange fitting portion to hold the flange and to restrict a movement of the flange in the backward direction with respect to the movable holder, and
10 an outer cylinder part holding portion to restrict displacement of the outer cylinder part in a sideward direction with respect to the movable holder,

wherein the flange fitting portion holds, in a front-end direction and in a rear-end
15 direction, a part extending in the sideward direction from the outer cylinder part,

wherein the outer cylinder part holding portion has linear protrusions standing on an upper surface of the movable holder, to sandwich and hold the
20 outer cylinder part, and
wherein the outer cylinder part holding portion and the flange fitting portion are open upward, and a central part and a lower part of the flange fitting portion are open, the central part and the lower part corresponding to a part of
25 the outer cylinder part in the rear-end direction.

According to an embodiment, an injection device is provided to inject a content into a test object by a syringe that includes a plunger, an injection
30 cylinder into which the plunger is inserted, and an injection needle including a needle base connected to the injection cylinder and a needle tube to be punctured into the test object. The injection device includes a contact head configured to contact the test object and to have an
35 opening formed

through which the needle tube passes; a movable holder configured to hold the injection cylinder and the injection needle; a support mechanism configured to be fixed to the contact head; and a content injection
5 control mechanism configured to push the plunger into the injection cylinder. The movable holder moving along the support mechanism moves the injection cylinder and the injection needle with respect to the contact head. The syringe is attachable to and detachable from the
10 injection device.

According to embodiments of the present disclosure, the injection device can prevent the injection needle from falling out of the injection
15 cylinder when being used, and can have the syringe detached and attached.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 includes explanatory diagrams of an

injection device according to a first embodiment of the present invention;

FIG. 2 includes configuration diagrams of a syringe applied to the injection device of the present invention;

FIG. 3 includes explanatory diagrams of a movable holder in the injection device in FIG. 1;

FIG. 4 includes explanatory diagrams of a movable holder and a support mechanism in the injection device in FIG. 1;

FIG. 5 includes explanatory diagrams of a movement mechanism and rod-shaped members on the lower surface of the movable holder illustrated in FIG. 4;

FIG. 6 is an explanatory diagram of a ratchet mechanism in a pressing part in the injection device in FIG. 1;

FIG. 7 includes explanatory diagrams of a contact head in the injection device in FIG. 1;

FIG. 8 includes explanatory diagrams of operations of an injection device according to the first embodiment of the present invention;

FIG. 9 includes explanatory diagrams of an injection operation flow according to the first embodiment;

FIG. 10 illustrates an injection device according to a second embodiment of the present invention;

FIG. 11 includes enlarged views of a control mechanism of pulling out the needle tube of the injection device in FIG. 10;

FIG. 12 is a transparent perspective view of the injection device in FIG. 10;

FIG. 13 includes explanatory diagrams of

operations of an injection device according to the first embodiment of the present invention;

FIG. 14 includes explanatory diagrams of an injection operation flow according to the second
5 embodiment;

FIG. 15 includes explanatory diagrams of a case where marking is performed on a test object by using an injection template;

FIG. 16 includes explanatory diagrams of steps
10 of installing a syringe; and

FIG. 17 includes a view of an injection device having a syringe attached and a view of an injection device brought into contact with a test object.

15 EMBODIMENTS FOR IMPLEMENTING THE INVENTION

FIG. 1 includes explanatory diagrams of an injection device according to a first embodiment of the present application. Here, (a) is a perspective view and (b) is a side view.

20 [Overall Description]

The injection device 1 is an injection device in which a syringe is installed for injecting contents such as a cell suspension or the like into a test object (human, animal, individual organs, skin, etc.). The
25 injection device 1 functions as an injection syringe holder (syringe holder) for injecting an appropriate amount of contents into a test object by using a syringe.

The injection device includes a contact head 10, a support mechanism 20, a movable holder 30, and a
30 content injection control mechanism 50.

The contact head 10 is capable of contacting a test object and has an opening formed. The contact head 10 is located at the front end of the injection device 1.

When a needling operation or a needle-pulling-out operation is performed on a test object with a needle tube 83, which will be described later, the needle tube 83 passes through this opening 11 (see FIG. 4(b)).

5 The support mechanism 20 is fixed to the contact head 10 at a predetermined angle. The coupling angle between the support mechanism 20 and the contact head 10 defines the injection angle with respect to a test object. The contact head 10 and the support
10 mechanism 20 may be manufactured as a unified part, or may be manufactured separately to be fixed afterward by welding or the like.

 The support mechanism 20 is a holder receiving member to define the stop position of movement of the
15 movable holder 30, and to receive and stop the movable holder 30.

 The movable holder 30 holds an injection cylinder 84 and an injection needle 81 (see FIG. 2(a)), and is movable along the support mechanism 20 with
20 respect to the contact head 10. The movable holder 30 moving with respect to the contact head 10 moves the injection cylinder 84 and the injection needle 81 held by the movable holder 30 with respect to the test object in contact with the contact head 10. This relative movement
25 causes the needle tube 83 of the syringe 80 to move in the forward direction, which is the needling direction, and in the backward direction, which is the direction of pulling out the needle, relative to the test object.

 The content injection control mechanism 50
30 pushes a plunger 88 into the injection cylinder 84. The content injection control mechanism includes a pressing part 40, a guide rod 51, an interlocking rod 52, a connecting rod 53, and elastic members 54 and 55 (see FIG.

5).

Here, in the injection device 1 of the present invention, the injection cylinder and the injection needle can be attached and detached as a syringe. FIG. 2 includes explanatory diagrams of a syringe where (a) illustrates an assembled syringe and (b) illustrates an exploded view of the syringe.

As illustrated in FIG. 2, the syringe 80 is constituted with the injection needle 81, the injection cylinder 84, and the plunger 88. The injection cylinder (cylinder) 84 holds contents and has a plunger 88 inserted and fitted. More specifically, the injection cylinder 84 includes an outer cylinder part 85 to hold contents, a flange 86 disposed at the rear end of the outer cylinder part 85, and a cylinder tip 87.

Here, in the injection device of the present invention, it is favorable to use a syringe having the capacity of 1 mL. Such a 1-mL syringe enables to perform 10 shots of 100- μ L injections or six shots of 166- μ L injections. Syringes with 2, 5, or 10 mL can also be used. Depending on a specific use form of the injection device, the syringe may have a larger or smaller capacity.

The injection needle 81 is connected with the injection cylinder 84. More specifically, the injection needle 81 includes a needle base 82 fitted over the cylinder tip 87 of the injection cylinder 84 and a needle tube 83 to be punctured into a test object. When setting the syringe 80, the cylinder tip 87 of the injection cylinder 84 is inserted into the needle base 82 of the injection needle 81 to be engaged with each other. A syringe may be used that has a structure to lock the needle base 82 of the injection needle 81 with the cylinder tip 87 of the injection cylinder 84 so as not to

easily come off.

Here, it is favorable that the diameter of the needle tube of the injection needle applied to the injection device of the present invention is in a range of 18 to 34G or 20 to 30G. Also, it is more favorable that the diameter is 26G, 27G, or 30G.

When a head portion (at the rear end) 88h is pushed, the plunger 88 (plunger) moves in the outer cylinder part 85 of the injection cylinder 84, and thereby, the contents are discharged from the syringe. The front end of the plunger 88 has a gasket 89 adhered, which is a thin plate-shaped packing (sealing element) made of rubber for preventing liquid leakage and preventing entry of foreign substances.

Here, in the present invention, since the injection cylinder 84 and the injection needle 81 as illustrated in FIG. 2(a) are integrated to be attached and detached together, contents contained in the injection cylinder 84 do not adhere or barely adhere to the inner side of the injection device 1, and hence, the injection device 1 can be reused. Here, the injection cylinder 84 and the injection needle 81 simply need to be integrated by coupling at least when to be attached to or detached from the injection device 1, and while being installed in the injection device 1; namely, the injection cylinder 84 and the injection needle 81 may be in a separated state when placed outside of the injection device 1.

[Movable Holder (Syringe Holder)]

FIG. 3 includes an enlarged cross-sectional view of the upper surface of the movable holder 30. Here, (a) is a perspective view, and (b) is a cross-sectional top view of (a) cut off by A-A'.

The movable holder 30 includes a syringe holder constituted with a front holder 310 and a rear holder 320, which are located at the top; and a movement support portion 330 in which two through holes (331 and 332, see FIG. 5) are formed to have rod members 51, 52, and 53 pass. In addition, coil springs 54 and 55 as first elastic members are provided inside the movement support portion 330.

The portions 310 and 320 located at the top of the movable holder have a flange fitting portion 31, an outer cylinder holding portion 32, a needle base stopper 33, and a circumferential surface holding portion 34.

The flange fitting portion 31 is engaged with the flange 86 of the injection cylinder 84. As illustrated in FIG. 3(b), the flange fitting portion 31 has a wing-like outer frame shape in a top view, to be engaged with the flange 86 by having the flange 86 fit into this outer frame shape. This engagement determines the position of the flange 86, and restricts a movement of the flange 86 in a separating direction (backward direction, the direction designated by the arrow B in FIG. 1(b)) with respect to the movable holder 30.

The outer cylinder holding portion 32 keeps the position of the outer cylinder part 85 of the syringe cylinder 84 by sandwiching it from both sides. The outer cylinder part holding portion 32 has a linear protrusion shape standing in a rib shape that extends along both sides of the side surface of the tubular-shaped outer cylinder part 85. This structure enables the outer cylinder part holding portion 32 to restrict displacement in the sideward direction, namely, a sideward shift, of the outer cylinder part 85 within the movable holder 30. Even when the movable holder 30 moves, the holding state

can be stably maintained.

The needle base stopper 33 restricts a movement of the needle base 82 of the injection needle 81. In the example of the syringe illustrated in FIG. 2, the front end of the needle base 82 has a predetermined surface shape, and the needle base stopper 33 illustrated in FIG. 3 having a reducing inside diameter (having a step) makes it possible to come into contact with the front end surface of the needle base 82.

In FIG. 3(a), the needle base stopper 33 extends in a direction perpendicular to the moving direction of the syringe 80 to stop the syringe 80, and has a configuration in which the needle tube 83 can pass through, but the front end of the needle base 82 (the surface perpendicular to the moving direction) comes into contact with the needle base stopper 33, so as to restrict a movement of the syringe 80 with respect to the movable holder 30. Note that the needle base stopper 33 is not required to extend in a direction perpendicular to the moving direction of the syringe 80 to stop the syringe 80, and may have a gradually reducing circular shape to stop the needle base 82. Alternatively, in the case where the perpendicular surface at the front end of the needle base 82 does not exist and the shape of the needle base 82 gradually becomes thicker toward the portion connected with the injection cylinder 84, the needle base stopper 33 may contact the side surface of the needle base 82 to restrict a movement of the syringe 80 with respect to the movable holder 30.

This configuration enables, when attaching the syringe 80 to the injection device 1, and during the course of an injection operation, to restrict a movement of the needle base 82 in the approaching direction toward

the side of the opening 11 within the movable holder 30 (forward direction, the direction designated by the arrow A in FIG. 1(b)).

The circumferential surface holding portion
5 (needle base circumferential surface holding portion) 34 holds the circumferential surface of the needle base 82 of the injection needle 81 in a circumferential surface shape. Note that the circumferential surface holding portion 34 may further hold the front end of the outer
10 cylinder part 85 of the syringe cylinder 84 in a circumferential shape. The circumferential surface holding portion 34 illustrated in FIG. 3 has a tubular shape that covers the entire circumferential surface along the circumferential direction of the needle base 82
15 and the front end of the outer cylinder part 85. Note that the circumferential surface holding portion 34 does not necessarily need to cover the entire circumference, and may have, for example, a shape that semi-circularly fits the shape of the needle base 82 and the front end of
20 the outer cylinder part 85. The circumferential surface holding portion 34 restricts a sideward displacement of the needle base 82 and the outer cylinder part with respect to the movable holder 30. This configuration enables, when the movable holder 30 moves, to prevent a
25 movement (shift) of the holding state in the sideward direction (short direction).

As described above, in the movable holder 30, the flange fitting portion 31 restricts a movement of the syringe cylinder 84 in the separating direction (backward
30 direction designated by the arrow B in FIG. 1(b)), the needle base stopper 33 restricts a movement of the injection needle 81 in the approaching direction (forward direction designated by the arrow A in FIG. 1(b)), and

thereby, the coupled state of the syringe cylinder 84 and the injection needle 81 is maintained in the moving direction.

Therefore, even when the injection cylinder 84 and the injection needle 81 move together with the movable holder 30, it is possible to prevent the injection needle 81 from coming off the injection cylinder 84 and to prevent the contents from leaking into the injection device 1.

Note that the outer cylinder holding portion 32 of the movable holder 30 does not necessarily need to stand on all portions along the outer cylinder part 85 of the syringe 80. As illustrated in FIG. 3(a), by providing a plane portion 35 where the protrusion of the outer cylinder holding portion 32 is partially discontinuous, it becomes easier to fit the syringe 80 into the movable holder 30, and the operability is improved when attaching or detaching the syringe 80.

[Support mechanism]

The support mechanism 20 will be described by using FIG. 4 and FIG. 1(b). In FIG. 4, (a) illustrates a perspective view of the contact head 10 and the support mechanism 20; (b) illustrates a perspective view viewed from another direction; and (c) illustrates an arrow view of the contact head 10 and the support mechanism 20 viewed from the injection direction. The contact head 10 and the support mechanism 20 function as a stationary member (main body) that is immovable with respect to the movable holder 30 that can move.

The support mechanism 20 is fixed to the contact head 10. The connection angle between the contact head 10 and the support mechanism 20 sets the contact angle of the needle tube 83 of the syringe 80

with respect to a test object.

The angle between the support mechanism 20 and the contact head 10, which defines the injection angle, may be favorably any angle between 10 degrees and 90
5 degrees, and is more favorably within a range between 15 degrees and 25 degrees.

The support mechanism 20 includes a top cover 24 and a side wall 23, and has a tubular holder guide path (insertion through hole) 21 formed inside the
10 support mechanism 20 for guiding the movement of the movable holder 30. Here, on the side wall 23 located at the rear end of the support mechanism 20, an opening 230 is formed as the entrance of the insertion hole of the holder guide path 21 into which the movable holder 30 is
15 inserted.

In the holder guide path 21 that allows the movable holder 30 to move along the support mechanism 20, the lower portion functions as a movement guide rail 22 to guide the movement of the movable holder 30.

20 The lower part of the support mechanism 20 provides a cut (opening) 25 extending in the sideward direction (injection direction). Having such an opening at the lower part enables to prevent the tip of the needle tube 83 from contacting the inside of the
25 injection device 1 when performing an attaching or detaching operation of the syringe 80.

In the embodiment, the holder guide path 21, which is a tubular insertion through hole for inserting the front end of the movable holder 30 (at least a
30 portion for holding the injection needle 81), has a shape in accordance with the shape of the front end of the movable holder 30 (the circumferential surface holding portion 34) except for the lower surface part of the

inner circumferential surface as the movement guide rail 22.

As illustrated in FIGs. 4(a) and 4(c), in the support mechanism 20, the upper side and both lateral sides of the holder guide path 21 are covered in a semicircular shape (semi-cylinder shape). More specifically, the support mechanism 20 includes the top cover 24 that covers at least the injection needle 81 and a portion of the movable holder 30 to hold the injection needle 81 (the needle base stopper 33 and the circumferential surface holding portion 34) in the circumferential direction on the upper side and both lateral sides. Therefore, in the embodiment, the support mechanism 20 has a housing shape in which the lower part is open, and the holder guide path 21 is provided as a tubular insertion hole extending in the movement direction for guiding the movable holder 30.

In the embodiment, the side wall 23 of the support mechanism 20 stops a movement (forward movement) of the movable holder 30 in the approaching direction toward the contact head 10. In other words, the side wall 23 defines the end point of the sliding movement. Also, the front end of the guide rod 51 and the front end of the connecting rod 53 are fixed (coupled) on the side wall 23 of the support mechanism 20. More specifically, the side wall 23 is provided with a side wall fixing portion 23G for fixing the guide rod 51 and a side wall fixing portion 23J for fixing the connecting rod 53 (see FIG. 5). As illustrated in FIG. 5, the side wall fixing portions 23G and 23J may include fastening members for fastening the guide rod 51 and the connecting rod 53, adhesive members for bonding, and the like.

The tubular housing that forms the holder

guide path may be open upward (the top cover 24 may not be provided). For example, in the embodiment, it is sufficient for the support mechanism 20 to have, at a minimum, the movement guide rail 22 for moving and
5 guiding a portion of the movable holder 30 (a portion holding the needle portion) toward the contact head 10, and the side wall 23 as the stopper that defines the end of the movement.

However, as illustrated in FIG. 4(a) and FIG.
10 4(c) in the embodiment, providing the top cover 24 enables to guide the front end of the movable holder 30 on the circumferential surface, and thereby, has an effect of stabilizing the movement. Furthermore, or alternatively, safety aspects and hygiene aspects of the
15 operator can be taken into consideration.

[Content injection control mechanism]

In FIG. 5, (a) is an exploded view illustrating the content injection control mechanism 50 of the present invention, and (b) is a cross-sectional
20 view illustrating the content injection control mechanism 50 and the movement support portion 330 on the lower surface of the movable holder 30. Note that FIG. 5(b) corresponds to a cross-sectional view of FIG. 1(a) cut off by a plane B-B'.

25 The injection device 1 in the embodiment of the present invention includes, as the content injection control mechanism 50, the pressing part 40, the guide rod 51, the interlocking rod 52, the connecting rod 53, the coil springs (first elastic members) 54 and 55.

30 The pressing part 40 pushes the plunger 88 into the inside of the injection cylinder 84 held by the movable holder 30.

The guide rod 51, the interlocking rod 52, and

the connecting rod 53 are rod-shaped members to control the relative movement of the movable holder 30. The guide rod 51 is engaged with the movable holder 30 and the pressing part 40, to be relatively movable.

5 The interlocking rod 52 is fastened to the movable holder 30 and is movably engaged with the pressing part 40. The connecting rod 53 extends on the same straight line as the interlocking rod 52, and has the end portion (rear end) facing the end portion (front
10 end) of the interlocking rod 52, where the rear end and the front end are capable of coming into contact with or being separated from each other. Also, the front end of the connecting rod 53 is positioned inside the movable holder 30.

15 Also, as illustrated in FIG. 5(b), the first elastic members (coil springs) 54 and 55 are provided inside the movable holder 30.

 The lower part of the movable holder 30 illustrated in FIG. 5(b) illustrates the movement support
20 portion 330 provided at a lower part of the portion to hold the injection cylinder 84.

 In the movement support portion 330, a first through hole 331 through which the guide rod 51 is slidably inserted is formed. Also, a second through-hole
25 332 through which the connecting rod 53 is slidably inserted at the front end is formed, and at the rear end on the same straight line, the interlocking rod 52 is fastened.

 The guide rod 51 and the connecting rod 53 are
30 movable with respect to the through holes 331 and 332 of the movable holder 30, respectively.

 Also, the interlocking rod 52 is fixed to the through hole 332 of the movable holder 30 at a

predetermined position by an adhesive member 38.

When the movable holder 30 moves in the approaching direction toward the contact head 10, the guide rod 51 and the connecting rod 53 apply compressive
5 forces to the coil springs (first elastic members) 54 and 55 provided inside the movable holder 30.

The pressing part 40 is engaged with the guide rod 51 and the interlocking rod 52. The pressing part 40 is a plunger-pushing part that comes into contact with
10 the head (rear end) 88h of the plunger 88 and pushes the plunger 88 by a relative movement. Restoring forces of the coil springs 54 and 55 provided in the movable holder 30 change the distance between the movable holder 30 and the contact head 10, and the distance between the movable
15 holder 30 and the pressing part 40. The details of the change in the distance will be described later by using FIGs. 8 and 9.

Here, when the distance to move the movable holder 30 is constant, the compressive forces applied to
20 the coil springs 54 and 55 are constant. Therefore, in the case where a predetermined amount of contents is divided to be injected for multiple times and the injection amount is the same for each of the times, the movement amount of the movable holder 30 being constant
25 makes the compression forces and the following restoring forces of the coil springs 54 and 55 constant, and hence, enables the injection operation to be performed at the same injection pace for each of the times.

On the inner walls of the through holes 331
30 and 332, which are provided in the lower part of the movable holder 30 for passing the rod-shaped members 51, 52, and 53, protrusions 36 and 37 (namely, portions having smaller diameters in the through holes 331 and

332) are provided as spring holding members.

Each of the guide rod 51 and the connecting rod 53 provides a small diameter portion and a large diameter portion. The small diameter portions 51S and 53S are located around the center of the movable holder 30 in the extending direction of the guide rod 51 and the connecting rod 53; and the large diameter portions 51F and 53F are located on the side of the movable holder 30 close to the support mechanism 20 (the front end side).

The coil springs 54 and 55 are externally fitted to the small diameter portions 51S and 53S of the guide rods 51 and 53, respectively. The guide rod 51 to which the coil spring 54 is externally fitted is internally fitted to the through hole 331. The connecting rod 53 to which the coil spring 55 is externally fitted and the fixed interlocking rod 52 are internally fitted to the through hole 332.

The coil springs (first elastic members) have their front ends held by the side surfaces (step portions) of the guide rod 51 and the connecting rod 53 located where the diameter is reduced from the large diameter portions 51F and 53F to the small diameter portions 51S and 53S; and have their rear ends held by protrusion side surfaces 36S and 37S of the protrusions 36 and 37 as spring holding members, respectively.

Note that the guide rod 51 and the connecting rod 53 are configured to be splittable so that the coil springs 54 and 55 can be fitted over the small diameter portions 51S and 53S, respectively.

In the movable holder 30, the rear end of the connecting rod 53 has a larger diameter, and a large-diameter end portion 53T at the rear end can be separated from the other part, and can be engaged, for example, by

fitting a screw groove to a screw groove. Here, the position at which the large-diameter end portion 53T at the rear end of the connecting rod 53 comes into contact with the small-diameter portion 53S, to be caught on a surface of the protrusion 37 on the side of the pressing part 40, is a position where the distance between the movable holder 30 and the support mechanism 20 becomes the most distant.

Also, it is favorable to design the guide rod 51 such that a portion on the side of the pressing part 40 has a diameter that is close to the diameter of the through hole 331 and is greater than the diameter of the small diameter portion 51S (to provide a medium diameter portion 51M). This is because when compression forces are applied to the coil springs 54 and 55 so as to move the needle tube 83 and when the springs are restored, even if the engagement manner of the ratchet mechanism (which will be described later) changes, the intermediate diameter portion 51M can move along the through hole 332, and thereby, enables a smoother relative movement of the support mechanism 20 with respect to the guide rod 51.

Here, a distance D2 (distance Dm, which will be described later) by which the movable holder 30 is separated from the support mechanism 20 corresponds to a distance D1 between the interlocking rod 52 and the connecting rod 53 before start of needling. This distance sets the injection depth of the injection needle.

Here, it is favorable that the injection depth of the needle tube 83 of the injection needle 81 is in a range of 0.5 to 5.5 mm, and is more favorable in a range of 2.0 to 3.5 mm.

[Pressing portion]

FIG. 6 is an explanatory diagram of the

ratchet mechanism in the pressing part 40. More specifically, an exploded view of the pressing part 40 is illustrated.

Engagement racks 51r and 52r having an
5 inclination are formed on the circumferential surface of the guide rod 51 and the interlocking rod 52 along a portion to face the pressing part 40.

The pressing part 40 is provided with pawls (leaf springs) 41 that mesh with the engaging racks of
10 the guide rod 51 and the interlocking rod 52. Note that in addition to the ratchets, the pressing part 40 is provided with a leaf spring support rod 42 to which the pawls 41 are fixed and a case part 44 for covering the pawls 41. The leaf spring support rod 42 is movably
15 attached to a support plate 45 fixed to the pressing part 40. Also, on the side opposite to the side where the pawls 41 are fixed, a button 42h is provided, and a compression coil spring 43 is externally fitted between the button 42h and the support plate.

20 Here, the engaging configuration between the pawls 41 in the pressing part 40 and the engaging racks 51r and 52r of the guide rod 51 and the interlocking rod 52 constitute a ratchet mechanism. In other words, the pressing part 40 can relatively move to the guide rod 51
25 and the interlocking rod 52 in a direction approaching the movable holder 30, whereas a movement is locked in a direction away from the movable holder 30, namely, in a relatively separating direction (backward direction).

In the case of releasing the lock of a
30 position of the pressing part 40 such as occasions of attaching and detaching the syringe 80, pushing the button 42h against the coil spring 43 releases the engagement between the pawls 41 and the engagement racks

51r and 52r. Details will be described later by using FIGs. 8 and 9.

[Contact Head]

FIG. 7 includes enlarged views of the contact head 10. As illustrated in FIG. 7, the contact head 10 has an upper surface 13, a side surface 14, and a lower surface 12. The shapes of the upper surface 13 and the lower surface 12 of the contact head 10 may be circular, horseshoe-shaped, or polygonal.

Referring to FIGs. 7(a) to 7(c), the opening 11 penetrates the upper surface 13 and the lower surface 12 of the contact head 10. Also, a needle can pass through the opening 11. In other words, with respect to the lower surface 12 of the contact head 10, the opening 11 of the contact head 10 penetrates in bifurcating directions, namely a direction in which the needle tube 83 passes along with the movement of the movable holder 30, and the vertical direction of the contact head 10.

Referring to the side sectional view in FIG. 7(a), the lower surface 12 of the contact head 10 is configured such that a surface 12c around the opening 11 is positioned inward with respect to the other part of the lower surface (for example, a lower surface protrusion 12e). Having the lower surface 12 configured in this way, when contents are injected into a test object, the lower surface 12 partially comes into contact with the test object, and the surroundings of the opening 11 do not contact the test object.

For example, as a non-contact case, in the embodiment illustrated in FIG. 7(c), in the circumferential portion, which is the edge of the lower surface of the circular contact head 10, a lower surface protrusion 12e is formed to protrude continuously in the

surface direction of the lower surface. The top of the lower surface protrusion 12e having a circular shape contacts the test object as if to surround the opening 11. Note that the lower surface protrusion 12e is not limited to have a continuous shape, and may have a discontinuous shape such as a shape of legs.

Configuring the lower surface 12 of the contact head 10 in this way provides a predetermined space between the surroundings of the opening 11 and the test object. Therefore, when a liquid such as a leakage liquid or blood flows out from a test object with an injection operation, the liquid contacting the lower surface around the opening 11 of the contact head 10 prevents the liquid from spreading on and adhering to the lower surface 12.

Furthermore, before a needling operation and after a pulling-out-needle operation, it is configured such that the tip of the needle tube 83 is positioned above a portion of the lower surface 12 of the contact head 10 contacting a test object.

More specifically, when to be used, the needle tube 83 of the syringe applied to the injection device of the present invention is selected in terms of the length of the needle tube 83 such that, before performing the needling, the tip of the needle tube 83 is located above the portion of the lower face of the contact head 10 contacting the test object.

For example, the injection capacity may differ depending on individual injection spots and individual injection depths. The range of the injection length determines the length of the injection path during a backward operation of the injection needle. It is therefore foreseen that the total injection length is

determined by the length of the injection needle. The total injection length of the injection needle is favorably 2.0 mm to 50 mm, more favorably 5.0 mm to 40 mm.

In this way, before a needling operation and
5 after a needle-pulling-out operation, the tip of the needle tube 83 of the injection needle 81 not contacting a test object enables to prevent the injection device from moving in an unexpected direction in a state where the needle tube 83 is stuck into the test object when
10 separating the injection device from the test object. Therefore, the safety of the injection device is improved.

Furthermore, in an operation, in order to improve the stability of contact with the test object during the operation, and in order to enlarge the non-
15 contact space between the opening 11 and the test object, a flange portion 16 may be provided in the contact head 10, which protrudes from the side surface 14 on the lower surface 12.

Referring to FIG. 7(b), on the upper surface,
20 the opening 11 has an elongated hole shape that is open and elongated from a position corresponding to the injection point toward the support mechanism 20.

In this way, forming the shape of the opening portion 11 as an elongated hole when viewed from the top
25 enables to clarify the injection direction when performing an injection operation, and enables to lengthen the time to visually recognize the needle tube for the operator performing the injection operation. By clarifying the injection direction, it becomes possible
30 to perform an injection operation at the correct position with respect to a targeted injection point more precisely. In addition, a longer time to visually recognize the needle tube enables to find an abnormality, such as

bending or cutting in the needle tube 83 if there is any, before transiting to the injection operation. Therefore, it is possible to prevent in advance an abnormal injection operation from being performed on a test object.

5 Furthermore, in the lower surface 12 of the contact head 10, as the opening 11, in the passing direction of the needle tube 83 along with the movement of the injection needle, a cut shape is provided to reach the edge of the lower surface 12 of the contact head 10
10 from a portion penetrating in the vertical direction toward the support mechanism 20. Also, at the lower portion of the support mechanism 20, the space between two portions of the movement guide rail 22 is open to provide a cut shape. The support mechanism 20 and the
15 contact head 10 opening downward in this way enable to prevent the needle tube 83 from coming into contact with any part when attaching and detaching the syringe 80.

 Also, in the embodiment, it is favorable for the upper surface 13 of the contact head 10 to have a
20 shape such as a mortar shape or a semicircular shape recessed inward so that a magnifying glass can be formed. Forming the upper surface with a magnifying glass makes it easier to visualize the injection spot. For example, even in the case where it is difficult to directly and
25 visually recognize the injection spot due to an influence of a light source or the like, using a magnifying glass enables to perform an injection operation while visually recognizing the opening 11 and the needle tube 83 passing through the opening 11.

30 In order to obtain a better effect of the magnifying glass, it is favorable that the position corresponding to the injection point in the opening 11 on the upper surface is located at the center of the lower

surface (upper surface). Also, in order to make the injection point easily recognizable even though the opening 11 is an elongated hole, a mark 17 may be provided around the center.

5 Also, on the side surface 14 of the contact head 10, linear cuts are formed to serve as positioning grooves 15. These linear cuts are used for visually recognizing a mark put on a test object in a preparation stage of an injection, which will be described later. As
10 being linear, the positioning grooves 15 formed on the side surface 14 for visually recognizing a mark, enable easier positional alignment between the mark and the contact head 10, as will be described later in operational steps. In addition, the cuts having a linear
15 shape have an advantage in that the surface treatment becomes easier.

[Injection Operations]

FIG. 8 includes explanatory diagrams of operations in the injection device 1 according to the
20 first embodiment. FIG. 9 includes explanatory diagrams of an injection operation flow according to the first embodiment. In the following, injection operations according to the first embodiment will be described by using FIGs. 8 and 9.

25 In the embodiment, the content injection control mechanism 50 injects contents into a test object, and simultaneously, controls backward movement of the needle tube 83 to be pulled out from a desired depth to the surface of the test object. The flow will be
30 described as follows.

START: Set an infusion-filled syringe to the injection device. At this time, the syringe is set at the start position so that the plunger 88 and the

pressing part 40 come into contact with each other (see operational steps as will be described later). As a premise, when starting the operations, the contact head 10 of the injection device 1 is brought into contact with a test object S. Before the needling operation, assume that the components of the injection device 1 are in a state as illustrated in FIG. 8(a). Note that before the needling, the shape of the lower surface of the contact head 10 illustrated in FIG. 7(a) causes the tip of the needle tube 83 to be located above the portion of the lower surface of the contact head 10 contacting the test object, such that the tip of the needle tube 83 does not contact the test object.

S1: The operator manually brings the movable holder 30 closer to the contact head 10 (needling operation). At this time, the movable holder 30 moving in the direction approaching the contact head 10 (the direction designated by an arrow) causes the needle tube 83 of the injection needle 81 to approach the test object, to puncture the test object, and to move forward (enter) the inside of the test object. Here, the coil springs (first elastic members) 54 and 55 provided in the movable holder 30 are compressed.

More specifically, along with the interlocking rod 52 fastened to the movable holder 30, the pressing part 40 moves in the direction approaching the contact head 10 while keeping a predetermined distance D_p to the movable holder 30, and the distance D_m becomes shorter (reaching zero (FIG. 8(a) $\rightarrow$ FIG. 8(b))). Here, since the interlocking rod 52 fastened to the movable holder 30 moves together with the movable holder 30, the pressing part 40 and the rear end of the interlocking rod 52 also move together.

Also, since the pressing part 40 moves relative to the non-moving guide rod 51, the fitting portion between the guide rod 51 and the pressing part 40 relatively slides in the forward direction (toward the
5 side of the movable holder 30).

Due to this relative movement of the pressing part 40, the distance between the movable holder 30 and the pressing part 40 does not change during the needling operation. Therefore, it is possible to prevent mixture
10 of air bubbles that would be generated due to depressurization caused by the plunger 88 if solely moving backward with increasing the distance between the movable holder 30 and the pressing part 40. In addition, it is possible to prevent an injection operation from
15 being performed concurrently with the needling operation that would be caused by the plunger 88 if solely moving forward with decreasing the distance between the movable holder 30 and the pressing part 40.

At Step S2, when the movable holder 30 moves
20 in the direction away from the contact head 10 in response to an operation of the operator detaching his/her hand from the movable holder 30, the needle tube moves backward from the inside of the test object, and the needle tube is pulled out of the test object to be
25 separated from the test object.

More specifically, when the force in the forward direction applied to the movable holder 30 is released, the restoring force of the coil spring (first elastic member) 54 provided in the movable holder 30
30 moves the movable holder 30 away from the support mechanism 20.

Here, a movement of the pressing part 40 in the relatively separating direction (backward direction)

with respect to the rod-shaped members 51 and 52 is locked by the ratchet mechanism (FIG. 6). In other words, when the movable holder 30 moves away from the contact head 10, since the pressing part 40 is stopped together
 5 with the non-fastened guide rod 51 that does not move, the interlocking rod 52 fastened to the movable holder 30 moves its position with respect to the pressing part 40 that does not move. In other words, the fitting portion of the pressing part 40 slides toward the movable holder
 10 30 (forward direction) with respect to the interlocking rod 52.

This operation lengthening the distance D_m and shortening the distance D_p enables to perform pulling out the needle tube and injecting the liquid together (FIG.
 15 8(b) $\rightarrow$ (c)). The movable holder 30 moving its position with respect to the guide rod 51 along with the backward movement of the movable holder 30 shortens the distance between the movable holder 30 and the pressing part 40. When the distance between the pressing part 40 and the
 20 movable holder 30 becomes short ($D_p \rightarrow D_p'$), the plunger 88 is pushed into the syringe cylinder 84, and the capacity of the syringe cylinder 84 becomes narrower to inject the internal liquid into the test object. Accordingly, the injection operation can be carried out appropriately with
 25 an appropriate amount.

END: the injection device 1 is separated from the test object. At this time, thanks to the shape of the lower surface of the contact head 10 in FIG. 7(a), the tip of the needle tube 83 is separated from the test
 30 object.

According to the above configuration and flow, when an injection operation of the injection device 1 of the present invention is performed, the injection

cylinder 84 and the injection needle 81 are appropriately held in the movable holder 30. In particular, a movement of the injection cylinder 84 and the injection needle 81 in the content injection direction is restricted by the
5 flange fitting portion 31 and the needle base stopper 33.

Therefore, even in the case of using a substance having a highly viscous, gel-like structure as the content to be injected by injection, and a high pressure is applied to the injection cylinder during the
10 use, the connected state between the injection needle and the injection cylinder is not eliminated. Therefore, a precise injection operation can be realized by the injection device 1.

<Second Embodiment>

15 Next, a second embodiment will be described. An injection device in the second embodiment is favorably applied in the case where an injection operation is performed in a very shallow spot in a test object.

With the injection device in the second
20 embodiment, after a needling operation, the backward movement of the needle (needle-pulling-out operation) is performed in two stages. More specifically, in conjunction with an injection operation (content injection operation) by an operation pushing the plunger
25 into the injection cylinder, the needle is moved backward by a predetermined distance (needle release operation), and then, the needle at the predetermined distance is further moved backward until pulled out of the surface of the test object without injecting the contents.

30 FIG. 10 includes explanatory diagrams of the injection device 2 according to the second embodiment of the present invention; (a) illustrates a perspective view and (b) illustrates a side view. FIG. 11 illustrates

enlarged views of a control mechanism of pulling out the needle tube of the injection device in FIG. 10. FIG. 12 illustrates a transparent perspective view of the injection device in FIG. 10.

5 As illustrated in FIGs. 10 to 12, the injection device 2 of the embodiment includes a control mechanism 60 of pulling out the needle. In the embodiment, a content injection control mechanism 50 injects contents into a test object, and simultaneously,
10 controls the first stage of a needle-tube backing operation to move the needle tube backward from a desired depth to a predetermined position. The control mechanism 60 of pulling out the needle controls the second stage of the needle-tube backing operation to move the needle tube
15 backward, by moving the needle tube backward from the predetermined position to at least the surface of the test object, without injecting the contents into the test object.

Referring to FIG. 11, the control mechanism 60
20 of pulling out the needle includes a control plate 61, two position adjustment pins 62 and 63, two coil springs (second elastic members) 64 and 65, and lock pins 66 and 67.

The control plate 61 includes an upper surface
25 plate 61T and a side surface plate 61S that cover at least a part of an upper surface portion 24-1 of a support mechanism 20-1, and a side wall 23-1 on the rear end side away from the contact head 10.

The two position adjustment pins (dowels) 62
30 and 63 have large-diameter head portions, and are fitted in the side plate 61S of the control plate 61.

The coil springs 64 and 65 as second elastic members are provided (externally fitted) on the outer

circumference of the position adjustment pins, and are held by the side plate 61S of the control plate 61 and the support mechanism 20-1.

5 The two lock pins (elastic pins) 66 and 67 are provided on the upper surface of the support mechanism 20-1, and have respective one ends held on the side surfaces (guide surfaces) of a circumferential surface holding portion 34-1 of the movable holder 30-1. Also, the lock pins 66 and 67 are provided extending in a
10 direction substantially perpendicular to the moving direction of the syringe 80 (the short direction of the injection cylinder).

Also, in the embodiment, an engagement protrusion 39 is provided on the upper surface of the
15 circumferential surface holding portion 34-1 of the movable holder 30-1. The front end portion of the engagement protrusion 39 is tapered, and the lock pins 66 and 67 slidably come in contact with vertical surfaces (holder side guide surfaces) 39L and 39M at the front end
20 of the protrusion.

The support mechanism 20-1 includes the upper surface portion 24-1 and the side wall 23-1, and has a guide path for guiding the movement of the movable holder 30-1 formed inside. As in the first embodiment, the side
25 wall 23-1 of the support mechanism 20-1 has an opening (opening 230) into which a part of the movable holder 30-1 is inserted.

Here, the shape of the support mechanism 20-1 is different from that of the first embodiment; a cut
30 portion 26 is provided on the upper surface part 24-1 of the support mechanism 20-1, which has a depressed shape for fitting the upper surface plate 61T of the control plate 61. The lock pins 66 and 67 are slidably in

contact with vertical surfaces (support side guide surfaces) 27L and 27M in the movement direction of the cut portion 26.

Furthermore, grooves 28L and 28M are formed as depressed portions with respect to the vertical surfaces 27L and 27M, which expand the cut space.

The lock pins 66 and 67 are elastic pins that can be extended and contracted, and are slidably movable along the holder side guide surfaces 39L and 39M of the movable holder 30-1, and along grooves 61TL and 61TM engraved on the top plate 61T, respectively.

When performing an injection operation, in a state of FIG. 13(a), which will be described later, the holder side guide surfaces 39L and 39M have not yet come into contact with the lock pins 66 and 67, respectively. In this state, when the movable holder 30-1 is moved, the lock pins 66 and 67 start contacting the front ends of the holder side guide surfaces 39L and 39M, and then, move along the holder side guide surfaces 39L and 39M (leftward in FIG. 11), respectively.

Then, immediately before transitioning to a state of FIG. 13(b), the locking pins 66 and 67 are pushed outward owing to the shape of the engagement protrusion 39 as a bump on the movable holder 30, to be engaged with the grooves 28L and 28M (FIG. 11(a) -> FIG. 11(b)). After engaging with the grooves 28L and 28M, the control plate 61 and the movable holder 30-1 further move, and the grooves 61TL and 61TM of the upper plate 61T of the control plate 61 move their positions with respect to the lock pins 66 and 67, respectively (FIG. 13(b) -> FIG. 13(c)).

When the operator releases his/her hand, the movable holder 30-1 first moves in the state where the

lock pins 66 and 67 are engaged with the grooves 28L and 28M (FIG. 13(c) -> FIG. 13(d)). Once having reached a predetermined position, the outward extrusion force applied to the lock pins 66 and 67 owing to the shapes of the holder side guide surfaces 39L and 39M of the engagement protrusion 39, which is the projecting part of the movable holder 30-1, disappears, and thereby, the engagement between the lock pins 66 and 67 and the grooves 28L and 28M is released (FIG. 11(b)).

Then, the restoring forces of the coil springs 64 and 65 as second elastic members act on the control plate 61 and the movable holder 30-1 to move together (FIG. 11(b) -> FIG. 11(a) and FIG. 13(d) -> 13(e)), and the backward movement is completed. At this time, the lock pins 66 and 67 released from the engagement slide along the vertical surfaces (support side guide surfaces) 27L and 27M, respectively.

Also, in the embodiment, unlike the first embodiment, on the side wall 23-1 of the support mechanism 20-1, the side wall fixing portions 23G and 23J for fixing the guide rod 51 and the connecting rod 53 are not provided. Instead, pin insertion holes 23P and 23Q are perforated, into which the position adjustment pins 62 and 63 having the second elastic members 64 and 65 fitted on the outside are movably inserted.

The side plate 61S of the control plate 61 has an opening into which a part of the movable holder 30-1 is inserted. In the embodiment, the front end of a guide rod 51-1 and the front end of a connecting rod 53-2 are fixed to the side plate 61S of the control plate 61. The side surface plate 61S is provided with a side surface fixing portion 61SG for fixing a guide rod 51 and a side surface fixing portion 61SJ for fixing an interlocking

rod 52 (see FIG. 12).

Also, on the side plate 61S of the control plate 61, side plate pin insertion holes 61SP and 61SQ are perforated, into which the position adjustment pins 62 and 63 having the second elastic members 64 and 65 fitted on the outside are movably inserted.

A needling operation causes the side plate 61S of the control plate 61 to come into contact with the side wall 23-1 of the support mechanism 20-1. In the first stage of a needle-tube backing operation, the movable holder 30-1 moves backward while the side plate 61S of the control plate 61 is in a state of contacting the side wall 23-1 of the support mechanism 20-1. In the second stage of the needle-tube backing operation, the side plate 61S of the control plate 61 moves away from the side wall 23-1 of the support mechanism 20-1, and the movable holder 30-1 moves backward.

[Injection Operation]

FIG. 13 includes explanatory diagrams of operations of an injection according to the second embodiment. FIG. 15 includes explanatory diagrams of an injection operation flow according to the second embodiment. In the following, an injection operation in the second embodiment will be described by using FIGs. 13 and 14.

START: As a premise, an injection point and marks are marked on a test object by using an injection template 100 (see FIG. 16); and then, a syringe 80 (see FIG. 3) is set in the injection device 2, to bring the contact head 10-1 of the injection device 2 into contact with the test object.

<Needle-tube forwarding operation>

At S11 in FIG. 14, the operator manually

brings the movable holder 30-1 closer to the contact head 10 (needling operation). When the movable holder 30-1 moves by a predetermined distance in the approaching direction toward the contact head 10-1, compressive
 5 forces are applied to the first elastic members 54 and 55 from the guide rod 51-1 and the connecting rod 53-2 with respect to the first elastic members 54 and 55, respectively, and the position adjustment pins 62 and 63 move together with the movable holder 30-1 in the
 10 approaching direction toward the contact head 10-1. In other words, in FIG. 13, the distance DM becomes shorter (reaching zero) while the distance DP and the distance DL remain unchanged, and the compressive forces are applied to the first elastic members 54 and 55, respectively (FIG.
 15 13(a) -> (b)).

Once having reached the predetermined position, the lock pins 66 and 67 are engaged with the grooves 28L and 28M of the support mechanism 20, respectively.

Thereafter, in a state in which the lock pins
 20 66 and 67 are fitted in the grooves of the support mechanism 20-1, the position adjustment pins 62 and 63 and the control plate 61 move in the direction toward the contact head 10-1 (forward direction). In other words, the distance DL becomes shorter (reaching zero) while the
 25 distance DM remains unchanged to be zero and the distance DP also remains unchanged, and the compressive forces are applied to the second elastic members 64 and 65 (FIG.
 13(b) -> (c)).

<Needle-tube backing operation>

30 As S12 in FIG. 14, the operator releases his/her hand from the movable holder 30-1. Once the force applied to the movable holder 30-1 in the direction toward the contact head 10-1 has been released, as the

first stage, the restoring forces of the first elastic members 54 and 55 cause the movable holder 30-1 to move in the direction away from the support mechanism 20-1, which is also the direction approaching the pressing part 40, while the positions of the position adjustment pins 62 and 63 and the lock pins 66 and 67 remain unchanged. This movement causes the contents to be injected into the test object, and moves the needle tube 83 backward from the desired depth to the predetermined position. In other words, while the distance DL remains unchanged, the distance DM becoming longer and the distance DP becoming shorter (DP') enables to move backward by a predetermined distance and to perform the injection operation (FIG. 13(c) $\rightarrow$ (d)).

As the second stage of the backing operation at S13 in FIG. 14, once the lock pins 66 and 67 have been disengaged (released from the fitting state), and the positions of the position adjustment pins 62 and 63 and the control plate 61 have moved, the restoring forces of the elastic members 64 and 65 move the movable holder 30-1 and the pressing part 40 that is fitted to the guide rod 51 and the interlocking rod 52 contacting the connecting rod 53. In other words, while the distance DM remains unchanged and the distance DP' remains unchanged, the distance DL becoming longer moves the needle tube 83 backward from the predetermined position until the needle tube is pulled out of the test object without injecting the contents (FIG. 13(d) $\rightarrow$ (e)).

According to the above configuration and flow, when an injection operation is performed, the injection device 2 of the present invention has the injection cylinder 84 and the injection needle 81 appropriately held in the movable holder 30-1. In particular,

displacement of the injection cylinder 84 and the injection needle 81 in the moving direction when injecting the contents is restricted by the flange fitting portion 31 and the needle base stopper 33.

5 Therefore, even in the case of using a substance having a highly viscous, gel-like structure as the content to be injected by injection, and a high pressure is applied to the injection cylinder during the use, the connected state between the injection needle 81
10 and the injection cylinder 84 is not eliminated. Therefore, a precise injection operation can be realized by the injection device 2.

 Furthermore, in the embodiment, since the backing operation is performed in the two stages, the
15 needle tube is pulled out after the injection has been completed. Therefore, in the case of injecting valuable contents such as cells or the like by a minute amount into the test object, the injected operation can be performed without an overflow of the injected contents
20 from the surface of the test object.

[Application procedure]

 In order to determine an injection spot and an injection direction, before injection, a hole in the center of the injection template 100 is aligned with the
25 center of the injection spot (FIG. 15(b)), and marking is performed aligned with six elongated holes by a sterilized oil-based pen (FIG. 15(c)). If it is desired to inject at the same spot repeatedly with intervals, marking is performed on the injection spot with a dye for
30 art making or the like. In the case of injecting into a hair-covered spot such as the scalp, the hairs are cut in advance around the injection spot. Before injection, the surroundings of the injection spot are disinfected, dried,

and then, anesthetized.

A syringe 80 is taken out of the package, to fill the injection cylinder 85 with an injection solution. In order to set the syringe 80 into the injection device 1, the button 42h at the rear end of the pressing part 40 is pushed to be slid to the rearmost end opposite to the contact head 10 (FIG. 16(a)).

The syringe 80 that is coupled with the injection needle 81 and the plunger 88 and contains the test preparation is installed in the movable holder 30 of the injection device 1, while carefully handling the needle tip (the tip of the needle tube) so as not to contact the main components 10, 20, etc., of the injection device 1. More specifically, as illustrated in FIG. 16(b), the syringe 80 is fitted obliquely from the needle tip, and the flange (wing) 86 of the injection cylinder 84 is placed upright and pushed horizontally (FIGs. 16(c) and 16(d)). Then, the flange 86 is rotated to engage with the flange fitting portion 31 (FIG. 16(e)). Thereafter, the pressing part 40 of the injection device 1 is slowly moved until it comes into contact with the head portion 88h of the plunger 88, and thus, the preparation work is completed (FIG. 16(f) and FIG. 16(g)).

Using the injection device 1 having the syringe 80 installed (FIG. 17(a)), the positioning groove of the contact head 10 is aligned with the marks made with the sterilized oil-based pen. In this state, the contact head 10 is firmly pressed against the scalp (FIG. 17(b), START in FIG. 8).

In this state, the movable holder 30 is manually pushed toward the contact head 10 side, and the needle tube 83 of the injection needle 81 moving together with the movable holder 30 is punctured into the scalp

(corresponding to S1 in FIG. 8). At this time, the elongated-hole-shaped opening 11 in the center portion of the contact head 10 is visually observed from the top to confirm that the needle tube 83 is punctured into the
5 scalp.

Then, by slowly releasing the hand from the movable holder 30 of the injection device 1, the preparation is injected into the scalp (corresponding to S2 in FIG. 8). Then, after completion of the injection
10 operation, the injection device 1 is separated from the scalp (corresponding to END in FIG. 8).

In the case of performing injection on the same injection spot for multiple times in different directions, the marks of the oil-based pen on the skin
15 are aligned with the grooves 15 provided around the contact head 10 in different directions, to repeat the above injection operation. By repeating this at six points having the injection marks, in the case of using a 1-mL injection cylinder, 1.0 mL of the test preparation
20 is injected in total.

The injection cylinder 84 and the injection needle 81 are removed from the used injection device, to be discarded. Then, the injection device is cleaned, maintained, and packed in an individual sterilization bag
25 to be sterilized. Sterilization can be performed by any of autoclave, EO gas, gamma ray sterilization, and the like.

Here, the configuration described above enables to maintain the connected state between the
30 injection cylinder 84 and the injection needle 81 in the injection device 1 or 2 during the period of performing the injection operation. Therefore, it can be considered that the contents hardly leak out to the inside of the

injection devices 1 and 2. Therefore, it is sufficient to perform the cleaning and sterilizing process selectively on the lower surface 12 of the contact head 10. Compared with a conventional injection device in which the injection cylinder is expected to be attached and detached, virtually no consideration needs to be taken for contamination inside the injection device to which the syringe is attached.

Contents (substances) to be used in the injection device according to the embodiments of the present invention described above may be selected within a group constituted with cell suspensions, gel-like materials, therapeutic substances, cosmetic substances, and diagnostic substances. For example, contents (substances) used in the injection device described above may be selected within a group constituted with cell suspensions, gel-like materials, therapeutic substances, cosmetic substances, and diagnostic substances.

Cosmetic substances to be injected may include but are not limited to adipocytes such as filler, hyaluronic acid, and Botulinum toxins (Botox, Btx) used in wrinkle treatment. Therapeutic substances may include but are not limited to antibiotics, anesthetics, analgesics, vaccines, and antibodies.

Furthermore, the injection device of the present invention may be used to inject cells in a suspension or cells in a liquid medium, as contents contained in a syringe, into a subject.

Furthermore, a cell suspension may be mixed with growth factors as contents contained in the syringe. Alternatively, a cell suspension may contain a gel-like structure. Such a gel-like structure favorably represents a mixture of extracellular matrix proteins

imitating an extracellular environment of a distinct tissue, and more favorably a gel-like structure such as hyaluronic acid.

In addition, an injection device according to
5 the embodiments of the present invention may be used to inject a substance into separate tissues of a subject. In particular, the injection device can be used for injecting cells into the skin as a cell suspension in the treatment of hair loss, alopecia such as alopecia areata,
10 or other symptoms associated with lack of hair or too little hair.

Also, an injection device of the present invention is favorably used to inject a liquid into a subject, such as a drug, a cytokine, or a growth factor.
15 This application of the liquid to the subject is favorably carried out in connection with the treatment of hair loss, alopecia such as alopecia areata, or other symptoms associated with lack of hair or too little hair.

Alternatively, an injection device according
20 to the embodiments of the present invention may be used for injecting a substance into a muscle of a subject, or for injecting a substance into a tendon of a subject.

Furthermore, the test object to which an injection device according to the embodiment of the
25 present invention is applied is not limited to a human (a subject), and may be an animal such as a fish or a mouse. Also, the test object may be tissue, such as skin or organ, taken out from a subject or an animal to be tested.

As above, favorable embodiments of the present
30 invention have been described in detail. Note that the present invention is not limited to the specific embodiments described above, and various modifications and changes may be made within the scope of the subject

matters of the present invention as described in the claims.

This international application claims priority based on Japanese Patent Application No. 2016-084281
 5 filed on April 20, 2016, the entire contents of which are incorporated herein by reference.

DESCRIPTION OF THE REFERENCE NUMERALS

- 1, 2 injection device
- 10 10, 10-1 contact head
- 11 opening
- 12 bottom surface
- 12c center of lower surface
- 14 side surface
- 15 15 mark positioning groove
- 16 flange portion
- 20, 20-1 support mechanism
- 21 holder guide path (insertion hole)
- 22 movement guide rail
- 20 23 side wall of support mechanism
- 23 opening
- 24 top cover of support mechanism
- 25 opening cut on lower surface of support mechanism
- 30, 30-1 movable holder
- 25 31 flange fitting portion
- 32 outer cylinder part holding portion
- 33 needle base stopper
- 34 circumferential surface holding portion
- 35 flat part
- 30 36, 37 protrusion (spring holding member)
- 36S, 37S side surface of protrusion
- 38 adhesive member
- 310 front holder

- 320 rear holder
- 330 movement support portion
- 331 first through hole
- 40 pressing part (injection control mechanism)
- 5 41 pawl (leaf spring)
- 42 leaf spring support rod
- 42h button
- 43 pressing part spring
- 44 cover
- 10 51, 51-1 guide rod
- 51r engagement rack
- 52 interlocking rod
- 52r engagement rack
- 53, 53-1 connection rod
- 15 53T large-diameter end portion of connecting rod
- 54, 55 coil spring (first elastic member)
- 80 syringe
- 81 injection needle
- 82 needle base
- 20 83 needle tube
- 84 injection cylinder (syringe)
- 85 outer cylinder part
- 86 flange
- 87 cylinder tip
- 25 88 plunger (plunger)
- 88h plunger head
- 89 gasket
- 60 control mechanism
- 61 control plate
- 30 61S side plate of control plate
- 61SG, 61SJ side surface plate fixing part
- 61SP, 61SQ side surface plate pin insertion hole
- 61T top plate of control plate

- 62, 63 movement adjustment pin
- 64, 65 coil spring (second elastic member)
- 66, 67 lock pin
- 23P, 23Q pin insertion hole
- 5 24-1 upper surface of support mechanism
- 26 cut
- 27L, 27M vertical surface (support-side guide surface)
- 28L, 28M groove
- 39 engagement protrusion
- 10 39L, 39M vertical surface (holder-side guide surface)
- 100 template for injection

CLAIMS

1. An injection device to inject a content into a test object by a syringe that includes a plunger, an injection cylinder into which the plunger is inserted, and an injection needle including a needle base connected to the injection cylinder and a needle tube to be punctured into the test object, the injection device comprising:
 - a contact head configured to contact the test object and to have an opening formed through which the needle tube passes;
 - a movable holder configured to hold the injection cylinder and the injection needle;
 - a support mechanism configured to be fixed to the contact head; and
 - a content injection control mechanism configured to push the plunger into the injection cylinder,
- wherein the movable holder moving along the support mechanism moves the injection cylinder and the injection needle with respect to the contact head,
- wherein the syringe is attachable to and detachable from the injection device,
- wherein the content injection control mechanism includes a pressing part configured to push the plunger into the injection cylinder,
- wherein the movable holder moving in a forward direction approaching the contact head causes the needle tube to puncture the test object and to enter an inside of the test object,
- wherein the movable holder moving in a backward direction away from the contact head causes the needle tube to move backward with respect to the test object, and causes the movable holder to approach the pressing part and to push the plunger into the injection cylinder to inject the content into the test object,
- wherein the injection cylinder includes an outer cylinder part to contain the content, and a flange provided at a rear end of the outer cylinder part,
- wherein at an upper part of the movable holder is provided with a flange fitting portion to hold the flange and to restrict a movement of the flange in the backward direction with respect to the movable holder, and

an outer cylinder part holding portion to restrict displacement of the outer cylinder part in a sideward direction with respect to the movable holder,

wherein the flange fitting portion holds, in a front-end direction and in a rear-end direction, a part extending in the sideward direction from the outer cylinder part,

wherein the outer cylinder part holding portion has linear protrusions standing on an upper surface of the movable holder, to sandwich and hold the outer cylinder part, and

wherein the outer cylinder part holding portion and the flange fitting portion are open upward, and a central part and a lower part of the flange fitting portion are open, the central part and the lower part corresponding to a part of the outer cylinder part in the rear-end direction.

2. The injection device as claimed in claim 1, wherein on the upper surface of the movable holder, a plane portion is provided in which the protrusion is partially discontinuous at a part not including a front end and a rear end of the protrusion of the outer cylinder part holding portion.

3. The injection device as claimed in claim 1 or 2, wherein the movable holder includes a needle base stopper to stop a movement of the injection needle by a protrusion to contact a vicinity of a front end of the needle base so as to hold the needle base, and the needle base stopper restricts a movement of the needle base in the forward direction with respect to the movable holder.

4. The injection device as claimed in any one of claims 1 to 3, wherein the movable holder includes a circumferential surface holding portion to hold the needle base in a circumferential shape, and the circumferential surface holding portion restricts displacement of the needle base in a sideward direction with respect to the movable holder.

5. The injection device as claimed in claim 1 or 2, wherein the flange is a flange having a wing-like part extending in two directions,

wherein the flange fitting portion has a pair of U-shaped parts to hold the flange in a lateral direction and in a front-back direction by holding the wing-like extending part of the flange in a state of being virtually parallel with the upper surface of the movable holder, and

wherein when attaching the syringe to the injection device, in a state where the wing-like extending part of the flange is shifted to be virtually orthogonal to the upper surface of the movable holder, after the flange being pressed from a rear of an interval at an inside edge of a surface at the rear end of the flange fitting portion moves the injection cylinder in a forward direction on the movable holder along the outer cylinder part holding portion, the injection cylinder is rotated on the movable holder so as to have the wing-like extending part of the flange engaged with the flange fitting portion.

6. The injection device as claimed in any one of claims 1 to 5, wherein the content injection control mechanism includes

a guide rod movably engaged with the movable holder and the pressing part,

an interlocking rod fastened to the movable holder and movably engaged with the pressing part, and

a connecting rod that extends on a same straight line as the interlocking rod, and has a rear end facing a front end of the interlocking rod, wherein the rear end is capable of coming into contact with or being separated from the front end of the interlocking rod and is located inside the movable holder.

7. The injection device as claimed in claim 6, wherein each of the interlocking rod and the guide rod has an engaging rack with inclination on a part of a circumferential surface that is allowed to face the pressing part,

wherein the pressing part includes a pawl to engage with the engaging rack of the interlocking rod and the guide rod, and

wherein the pressing part constitutes a ratchet mechanism that is movable relative to the interlocking rod and the guide rod in a direction in which the plunger is pushed into the injection cylinder to

approach the movable holder, and is locked to be immovable in a direction away from the movable holder.

8. The injection device as claimed in claim 6 or 7, wherein first elastic members are provided in the movable holder,

wherein the movable holder includes a movement support portion in which a first through hole through which the guide rod slidably passes is formed, and a second through hole through which the connecting rod is slidably inserted at a front end, and the interlocking rod is fastened to a rear end on a same straight line as the front end, is formed,

wherein when the movable holder moves in the forward direction approaching the contact head, respective compressive forces are applied to the first elastic members from the guide rod and the connecting rod with respect to the first elastic members; and

wherein restoring forces of the first elastic members move the movable holder in a direction away from the support mechanism.

9. The injection device as claimed in claim 8, wherein a spring holding member protruding from an inner wall of each of the first through hole and the second through hole is provided on the inner wall,

wherein each of the guide rod and the connecting rod provides a small diameter portion and a large diameter portion, the small diameter portion is located around a center of the movable holder in an extending direction of the guide rod and the connecting rod, and the large diameter portion is located on a front end side of the movable holder, and

wherein each of the first elastic members has a front end held by a side surface of the guide rod or the connecting rod located where a diameter is reduced from the large diameter portion to the small diameter portion, and has a rear end held by the spring holding member.

10. The injection device as claimed in claim 9, wherein a side wall on a rear end side of the support mechanism has an opening into which a part of the movable holder is inserted, has a front end of the guide rod and a front end of the connecting rod fixed,

wherein when the movable holder moves in the forward direction approaching the contact head, the side wall of the supporting mechanism coming into contact with the part of the movable holder stops the movement of the movable holder in the forward direction approaching the contact head, and

wherein when the restoring forces of the first elastic members move the movable holder in the backward direction away from the contact head, the content is injected into the test object, and simultaneously, the needle tube is moved backward from a desired depth to a surface of the test object to pull out the needle tube.

11. The injection device as claimed in claim 10, wherein the support mechanism includes a cover to cover at least the injection needle and a portion of the movable holder to hold the injection needle on a top side and lateral sides in a circumferential direction, and the movable holder is inserted inside the support mechanism.

12. The injection device as claimed in any one of claims 1 to 11, wherein a part close to an edge of the lower surface of the contact head is formed to continuously or discontinuously protrude in a surface direction of the lower surface with respect to a surface of surroundings of the opening part, and

wherein when injecting the content into the test object, the part close to the edge formed to continuously or discontinuously protrude contacts the test object so as to enclose the surroundings of the opening part, and the surroundings of the opening part do not contact the test object.

13. The injection device as claimed in claim 12, wherein the lower surface of the contact head has virtually a circular shape, and the part close to the edge formed to continuously or discontinuously protrude has virtually a ring shape.

14. The injection device as claimed in any one of claims 1 to

13, wherein before starting a needling operation and after having completed a needle-pulling-out operation, a tip of the needle tube is positioned higher than a portion of the lower surface of the contact head contacting the test object.

15. The injection device as claimed in any one of claims 1 to 14, wherein with respect to the lower surface of the contact head, the opening of the contact head penetrates in bifurcating directions of a direction in which the needle tube passes along with the movement of the movable holder, and a vertical direction of the contact head, wherein on the upper surface of the contact head, the opening has an elongated hole shape that is open and elongated from a position corresponding to the injection point toward the support mechanism.

16. The injection device as claimed in any one of claims 1 to 15, wherein the support mechanism is provided with a movement guide rail having a circumferential shape to slidably support at least a part of the movable holder.

17. The injection device as claimed in claim 16, wherein a lower part of the movement guide rail of the support mechanism is open to prevent a contact of the needle tube when attaching or detaching the syringe,

wherein on the lower surface of the contact head, a cut shape is provided as the opening in a direction in which the needle tube passes along with the movement of the movable holder, from a portion penetrating in the vertical direction toward the support mechanism to reach an edge of the lower surface of the contact head.