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(54) APPARATUS FOR DISPENSING LIQUID MATERIAL TO A SUBSTRATE

(57) The invention relates in a first aspect to an apparatus (1, 1') for dispensing liquid material to a substrate, the apparatus (1, 1') comprising:
- a housing (3) having an inlet (13) for supplying liquid material from a material source to the inlet (13),
- a nozzle (5) communicating with the inlet (13) and having a discharge opening (19) for dispensing the liquid material,
- a valve assembly (7) comprising a movable plunger (21) being formed at least partly of a magnetic material and mounted within the housing (3) for reciprocal movement in an axial direction between a closed and an open position, wherein in the open position, liquid material is dispensed from the discharge opening (19) and in the closed position, liquid material is prevented from being dispensed from the discharge opening (19), an electromagnetic coil (24) having a bobbin (35, 35', 35") formed at least partly of a magnetic material and a wire (37) wrapped around the bobbin (35, 35', 35"), wherein the electromagnetic coil (24) is configured to apply an electromagnetic force on the plunger (21) to move the plunger (21). The invention achieves its object according to the first aspect in that the bobbin (35, 35', 35") comprises a shaft portion and a magnetic flux element coaxially arranged to the shaft portion, wherein the flux element extends beyond the shaft portion in radial direction and has a slot (45, 45', 45") extending in radial direction. The invention achieves its object for an apparatus of the aforementioned type in a second aspect in that the bobbin (35, 35') comprises a shaft portion and a magnetic flux element coaxially arranged to the shaft portion, wherein the flux element extends beyond the shaft portion in radial direction, and in that the shaft portion has a distal end and the flux element is arranged at a distance to the distal end.

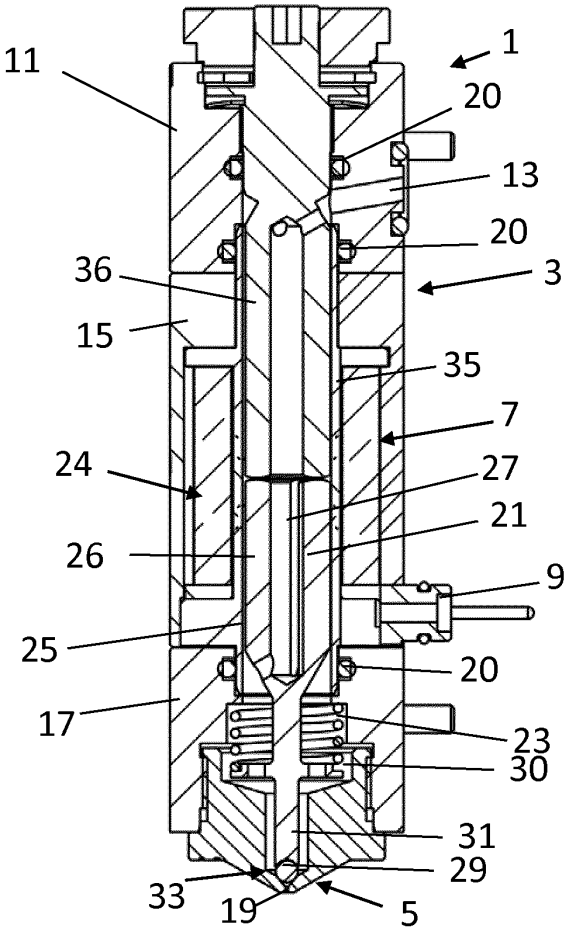

Fig. 1

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Description

[0001] The present invention relates to an apparatus for dispensing liquid material to a substrate, the apparatus comprising:

- a housing having an inlet for supplying liquid material from a material source to the inlet,
- a nozzle communicating with the inlet and having a discharge opening for dispensing the liquid material,
- a valve assembly comprising: a movable plunger being formed at least partly of a magnetic material and mounted within the housing for reciprocal movement in an axial direction between a closed and an open position, wherein in the open position, liquid material is dispensed from the discharge opening and in the closed position, liquid material is prevented from being dispensed from the discharge opening, an electromagnetic coil having a bobbin formed at least partly of a magnetic material and a wire wrapped around the bobbin, wherein the electromagnetic coil is configured to apply an electromagnetic force on the plunger to move the plunger.

[0002] Apparatus for dispensing liquid material to a substrate, in particular electrically-operated apparatus of the aforementioned type, are known in the art. Such dispensing apparatus are used in many industrial applications for intermittent delivery and application of liquids onto various substrates or objects. For example, dispensing apparatus are used in order to apply adhesive, coloring materials or the like onto automobile parts, packages, furniture or paper, on large areas, in beads, or in dots. Generally, an electrically-operated dispensing apparatus includes a valve assembly comprising a movable plunger for reciprocal movement in an axial direction between a closed and an open position and an electromagnetic coil. The plunger is moved relative to the electromagnetic coil by selectively energizing and de-energizing the electromagnetic coil. When energized an electromagnetic field is produced by the electromagnetic coil thereby magnetizing the plunger and a bobbin of the electromagnetic coil. The resulting movement of the plunger in the opened position releases the flow of liquid material within the flow channels of the apparatus into the discharge opening of the nozzle such that liquid material is dispensed. The movable plunger or a valve element attached to the plunger cooperates with a valve seat to release or interrupt the material flow.

[0003] Such an electrically-operated dispensing apparatus is cycled periodically between the open and the closed state and position at the plunger to initiate and interrupted fluid flow for dispensing small, discrete volumes of a substrate. The cycle rate of the dispensing apparatus has an influence on the shape of the material dispensed on a substrate. In order to improve the cycle rate, at least one flux element or flux guide element is conventionally employed in order to strengthen the magnetic field by improving the magnetic flux. These flux guide elements can be tubular structures surrounding the plunger and/or the electromagnetic coil.

[0004] During operation, eddy currents can be generated within the flux elements, which can decrease the cycle rate. Circumferential electrical currents retard the dissipation of the magnetic field and therefore the time for the (reciprocal) movement in axial direction of the plunger into the closed position.

[0005] In order to reduce such eddy currents, US patent 6,994,234 suggests a gap in a flux guide element which is formed by the housing and further, US patent application US 2008/0179352A1 suggests a bobbin having a slot extending in axial direction. Such an air gap formed by a gap or slot dissipates residual magnetism after the electromagnetic coil is de-energized.

[0006] However, there is still a need to further improve the performance characteristics, in particular the cycle rate of a fluid dispensing apparatus capable of operating with high frequencies. Thus, it is the object of the invention to provide an improved apparatus for dispensing liquid material onto a substrate.

[0007] The invention attains the aforementioned object by suggesting an apparatus according to claim 1. In particular, the invention suggests that the bobbin comprises a shaft portion and a magnetic flux element coaxially arranged to the shaft portion, wherein the flux element extends beyond the shaft portion in radial direction and has a slot extending in radial direction.

[0008] The invention advantageously recognizes, that such a slot provided in the flux element and extending in radial direction further improves the performance characteristics such as the cycle rate by avoiding eddy currents within the plunger and the electromagnetic coil. The slot preferably extends essentially from the outer periphery of the flux element to an inner or center portion of the flux element. In particular, the slot extends to essentially the center of the bobbin, wherein the bobbin is coaxially arranged to the flux element. The slot results in an interruption of eddy currents within the plunger or the electromagnetic coil so that upon de-energization of the electromagnetic coil, the plunger is moved faster into the closed position. By providing the slot at the flux element that extends beyond the shaft portion of the bobbin in radial direction, the eddy currents surrounding the plunger are interrupted without need for providing an additional flux element surrounding the plunger and/or the coil. By simply extending beyond the outer periphery of the plunger and/or the bobbin, the slotted flux element can sufficiently interrupt the magnetic field thereby significantly avoiding eddy currents and increasing the cycle rates.

[0009] It will be understood, that a flux element can have any form preferably having a center that is aligned with the center of the bobbin in a cross sectional area that is orthogonal to the axial direction of the plunger. Preferably such a flux element has a cylindrically preferably flat form such as a flux ring or a flange or flange-like structure.

[0010] In a preferred embodiment of the invention, the slot extending in radial direction has a width of at least 1,5 mm. By having a width of at least 1,5 mm the performance characteristics are further improved. In a preferred embodiment of the invention, the shaft portion is a first shaft portion and the flux element is a first flux element, wherein the bobbin further comprises a second shaft portion and a second magnetic flux element coaxially arranged to the second shaft portion, and wherein the second flux element extends beyond the second shaft portion in radial direction and has a slot extending in radial direction. By providing a second shaft portion and a second magnetic flux element having a slot extending in radial direction, eddy currents are further reduced and thereby the cycle time of the dispensing apparatus is increased.

[0011] In a particularly preferred embodiment, the slot of the first flux element is aligned with the slot of the second flux element in in axial direction. The first and second flux element are axially spaced apart from each other. By arranging the first and second flux elements, such that the slot of the first flux element is aligned with the slot of the second flux element, the invention advantageously achieves, that the eddy currents formed between the flux element during magnetization of the electromagnetic coil are interrupted by said gap defined by the first and second slot, wherein the projection of the slot is extending along the bobbin in longitudinal direction.

[0012] Preferably, the first shaft portion is formed of a magnetic material. By forming the first shaft portion of a magnetic material, the shaft portion also forms a flux element thereby strengthening the magnetic field by improving the magnetic flux and thus improving the reaction times and the cycle rate of the dispensing apparatus. It is preferred, that the first shaft portion and the first flux element are integrally formed.

[0013] Preferably, the second shaft portion is formed of a magnetic material. Thereby, it is particular preferred, that the second shaft portion and the second flux element are integrally formed. As mentioned above, by providing a magnetic shaft portion, the magnetic field is further strengthened by improving the magnetic flux.

[0014] In a preferred embodiment of the invention, the bobbin comprises an intermediate portion formed of a non-magnetic material, preferably a non-magnetic stainless steel, and the intermediate portion being configured to magnetically isolate the first and second shaft portion. By providing an intermediate portion that is formed of a non-magnetic material, the invention advantageously recognizes, that such an intermediate portion forms a magnetic spacer element between the first and second shaft portion, that supports the de-magnetization of the first and second shaft portion, when the electromagnetic coil is de-energized for moving the plunger from the opened position to the closed position, and thereby increases the maximum achievable operational frequency of the dispensing apparatus.

[0015] Preferably, the bobbin is integrally formed. By forming the bobbin as an integral part, the plurality of parts to be assembled is reduced in thereby the manufacturing costs decrease. Further, by forming the bobbin as an integral part, the bobbin can provide an internal passage for the liquid adhesive providing sufficient sealing.

[0016] Preferably, the second shaft portion, the intermediate portion and the first shaft portion are joined by material joining, preferably by welding. Coupling the first shaft portion, the second shaft portion and the intermediate portion by material joining provides a heat, mechanical and chemical resistant bonding between said parts, thereby improving the assembling of the dispensing apparatus by reducing the number of parts to be assembled.

[0017] In a preferred embodiment of the invention, the housing is formed at least partly of a magnetic material and has a slot axially aligned to the slot provided at the first flux element and/or to the slot provided at the second flux element. By providing a magnetic housing having a slot extending from the outer periphery of the housing towards the center of the housing, the cycle rates are further optimized by reducing the eddy currents by means of the slotted housing. One or a plurality of such slots may be provided in the housing.

[0018] In another preferred embodiment of the invention, the housing is a first inner housing and the apparatus further comprises a second outer housing enclosing the inner housing, and wherein the outer housing is formed of a non-magnetic material. Preferably, the slot provided at the housing is axially aligned with a slot provided at the first and/or second flux element. By providing an outer housing enclosing the inner housing, the dispensing apparatus is sealingly enclosed by said second housing formed of a non-magnetic material. Thus, the inner housing is configured to reduce the eddy currents by providing a slot and the outer housing encloses said inner housing, can be formed of any material providing a simplified manufacturing or a reduction of manufacturing and especially material costs.

[0019] Preferably, the plunger is coaxially arranged to the bobbin, and wherein the plunger has a slot axially aligned to the slot provided at the first flux element and/or to the slot provided at the second flux element. Thereby the eddy currents are further reduced thereby increasing the cycle rate of the dispensing apparatus. The slot extends preferably essentially from the outer periphery to an inner portion of the plunger. The slot may extend to essentially the center of the plunger or to an inner bore within the plunger. The slot results in an interruption of eddy currents within the plunger, so that upon de-energization of the electromagnetic coil, the plunger is moved faster into the closed position.

[0020] The aligned slots of the first and second flux element, and/or the plunger, and/or the housing respectively, serve for the accelerated decomposition of the magneticfield, thereby improving the reduction of eddy currents provided by a slotted magnetic element and enabling faster dispensing cycles.

[0021] According to a preferred embodiment of the present invention, that is also a second aspect of the invention, the invention achieves the initially mentioned object by an apparatus according to claim 14. In particular, the invention suggests that the bobbin comprises a shaft portion and a magnetic flux element coaxially arranged to the shaft portion, wherein the flux element extends beyond the shaft portion in radial direction, and in that the shaft portion has a distal end and the flux element is arranged at a distance to the distal end. The examples and preferred embodiments of the apparatus according to the first aspect of the present invention as described above are also the preferred embodiments and preferred examples of the apparatus according to the second aspect and vice versa. By arranging the flux element at a distance to the distal end of the shaft portion, the dimensioning of the bobbin is more flexible and thereby providing for example a guiding for the plunger and/or a fluid passage extending in axial direction through the center of the bobbin.

[0022] If such a shaft portion is formed of a magnetic material, the dimensioning of the shaft portion and in particular that the shaft portion extends beyond the position of the flux element provides an increased strengthening of the electromagnetic field by the magnetic shaft portion along its entire length.

[0023] If such a shaft portion is formed of a non-magnetic material, the arrangement of the flux element at a distance to the shaft portion can for example form a magnetic-isolating gap between the plunger and the magnetic flux element the de-magnetization of the plunger is fastened thereby increasing the cycle time of the dispensing apparatus.

[0024] Preferably, the shaft portion is a first shaft portion and the flux element is a first flux element, the bobbin further comprises a second shaft portion and a second magnetic flux element coaxially arranged to the second shaft portion, wherein the second flux element extends beyond the second shaft portion in radial direction, and in that the second shaft portion has a distal end and the second flux element is arranged at a distance to the distal end. By providing a second shaft portion and a second flux element arranged at a distance to the distal end of the second shaft portion, the bobbin can be formed more flexible thereby allowing constructional features, as for example providing a guidance for the plunger or a fluid passage extending through the center of the bobbin in axial direction.

[0025] If such a first and second shaft portion is formed of a non-magnetic material, the dimensioning of the first and/or second shaft portion extending beyond the flux elements, can strengthened the magnetic field.

[0026] For a more complete understanding of the invention, the invention is described in detail with reference to the accompanying drawings. The detailed description will illustrate and describe what is considered as a preferred embodiment of the invention.

Figure 1 shows a preferred embodiment of the apparatus for dispensing a liquid fluid in a sectional view,

Figure 2 shows the apparatus according to claim 1 in a side view,

Figure 3 shows the electromagnetic coil and the associated housing portion in a perspective view,

Figure 4 shows the electromagnetic coil and associated housing portion in an upper view

Figure 5 shows the electromagnetic coil according to a first preferred embodiment in a perspective view,

Figure 6 shows the preferred embodiment according to figure 5 in a sectional view,

Figure 7 shows the electromagnetic coil according to a second preferred embodiment in a perspective view,

Figure 8 shows the preferred embodiment according to figure 7 in a sectional view,

Figure 9 shows the electromagnetic coil according to a third preferred embodiment in a perspective view,

Figure 10 shows the preferred embodiment according to figure 9 in a sectional view,

Figure 11 shows the plunger in a perspective view, and

Figure 12 shows the apparatus according to a second preferred embodiment in a sectional view.

[0027] For the purpose of this description words of direction such as "upward", "vertical", "horizontal", "right", "left", "upper", "lower", "above", and the like are applied in conjunction with the drawings for purpose of clarity in the present description only. As is well known, liquid dispensing apparatus may be oriented in substantially any orientation, so these directional word should not be used to imply any particular absolute directions for an apparatus according to the invention.

[0028] Figure 1 and 2 show a first preferred embodiment of the dispensing apparatus 1. The dispensing apparatus 1 comprises a housing 3 a nozzle 5 and a valve assembly 7. The nozzle 5 and the valve assembly 7 are at least partly arranged in the housing 3 or at least partly attached to the housing. The apparatus 1 further comprises a plug connector 9 extending from the housing 3 and being configured to couple the apparatus 1 to a source of electric power.

[0029] The housing 3 comprises a first housing portion 11 forming an upper housing portion. The upper housing portion 11 has an inlet 13 configured to be coupled to a fluid supply. The housing 3 further comprises a second housing portion 15 adjacent to the upper housing portion 11 and a third housing portion 17 that forms the lower housing portion according to this embodiment. The lower housing portion 17 partly encloses the nozzle 5.

[0030] A number of sealings 20 is arranged in the housing 3, and in particular two sealings are arranged in the

upper housing portion 11 configured for sealingly separating the fluid inlet 13 from the valve assembly 7 and in particular from the electromagnetic coil 24. A third sealing 20 is arranged in the lower housing portion 17 for sealingly separating the lower housing portion in in particular from the discharge opening 19 communicating with the fluid passage 27 from the electromagnetic coil 24. The nozzle 5 has a discharge opening 19.

[0031] The valve assembly 7 comprises a plunger 21 movably mounted in the housing 3, a spring element 23 configured to apply a retention force on the plunger 21 and an electromagnetic coil 25 configured to apply an electromagnetic force on the plunger 21 in order to urge the movement of the plunger 21 in axial direction towards the electromagnetic coil and against the retention force applied by the spring element 23. The electromagnetic coil 24, the plunger 21 and the spring element 23 are arrange coaxially in the housing 3.

[0032] The plunger 21 comprises a sliding portion 26 being slidably in contact with an internal wall portion of the electromagnetic coil 24. The plunger 21 further comprises a fluid passage 27 being in fluid communication with the inlet 13 and the discharge opening 19 provided in the nozzle 5. The plunger 21 further has a valve element 29 coupled to the sliding portion 26 by a valve stem 31. The valve element 29 is configured to sealingly close a valve seat 33 provided at the nozzle 5 in a closed position of the plunger 21 and to release the valve seat 33 and thus material flow in an opened position of the plunger 21. The valve stem 31 is projecting from the sliding portion 26 and carries the preferably ball-shaped valve element 29 and a valve plate 30 axially spaced apart from the valve element 29. The valve element 29 is dimensioned and shaped to seat against the valve seat 33 for establishing a liquid-tight engagement there between when the plunger 21 is in its closed position.

[0033] The spring element 23 biases the sliding portion 26 of the plunger 21 in an axial direction generally parallel to longitudinal axis away from the electromagnetic coil 24. The biasing force applied by the spring element 23 urges the valve element 29 into contact with the valve seat 33, and maintains the contact there between, when the electromagnetic coil 24 is de-energized for closing the dispensing apparatus 1. The spring element 23 is located between the bobbin 35 and the valve plate 30.

[0034] In the following, the adventures and function of the apparatus 1 will be further described.

[0035] The electromagnetic coil 24 comprises a bobbin 35 and a wire (not shown) wrapped around the bobbin 35. The bobbin 35 is coaxially arranged with reference to the plunger 21. The bobbin 35 is formed as a hollow cylindrical portion having the internal wall portion 25 that is slidably in contact with the sliding portion 26 of the plunger 21.

[0036] The upper housing portion 11 and the lower housing portion 17 provide two circumferential grooves to receive two of the sealings 20, such as an elastomer 0-ring, capable of providing a liquid seal with a pole piece 36 arranged in the bobbin 35. The lower housing portion 17 provides a circumferential groove to receive one of the sealings 20.

[0037] As is shown in the sectional view according to figure 3, the upper housing portion 11 has the fluid inlet 13 for a fluid communicating coupling to a fluid supply. The middle housing portion 15 has an opening 38 for the plug connector 9 and a slot 39 extending in longitudinal direction along the entire housing portion 15.

[0038] The lower portion 17 of the housing 3 particularly encloses the nozzle 5 providing a discharge opening 19 for dispensing amounts of liquefied fluid.

[0039] The dispensing apparatus 1 is cycled to its opened state and position of the plunger 21 by energizing the electromagnetic coil 24 with a sufficient coil current or power so that the generated electromagnetic field produces an attractive force between the plunger 21, in particular the sliding portion 26 of the plunger 21, and the bobbin 35 of the electromagnetic coil 24 of a magnitude effective for overcoming the biasing force applied by the spring element 23. Because is stationary, the attractive force causes the plunger 21 to move toward the pole piece 36 The movement of the plunger 21 towards the pole piece 36 disengages the valve element 29 from the valve seat 33 for opening the dispensing apparatus 1. In the open position liquid material can flow from the inlet 13 through the internal fluid passage 27 through the valve plate 30 and finally discharge by the discharge opening 19. Power is sustained to the electromagnetic coil 24 to maintain the attractive force for a time sufficient to allow a desired volume of liquid to be discharged by the discharge opening 19. The electromagnetic coil 24 is de-energized to closed the dispensing apparatus 1 and cause the valve element 29 to contact the valve seat 33 in a closed position of the plunger 21, thus preventing liquid flow through the internal fluid passage 27 and through the discharge opening 19.

[0040] Figures 3 and 4 illustrate the electromagnetic coil 24 and the associated middle housing portion 15 in a perspective view and in an upper view. The slot 39 provided at the middle housing portion 15 is extending from the periphery of the housing portion 15 towards the center of the housing portion 15. The slot 39 is extending from the upper part of the housing portion 15 to its lower end where the connector opening 38 is provided.

[0041] The housing portion 15 is essentially cube-shaped having a circular recess configured to house the bobbin 35.

[0042] Figures 5 and 6 illustrate a first preferred embodiment of the electromagnetic coil in a perspective view and in a sectional view.

[0043] The bobbin 35 comprises a first preferably cylindrical shaft portion 41defining the upper portion of the bobbin 35 and a first preferably flange-like flux element 43 having a first slot 45 extending from the outer periphery of the flux element 43 towards the center.

[0044] The bobbin 35 further comprises a second preferably cylindrical shaft portion 47 and a second prefera-

bly flange-like flux element 49 having a second slot 51. The first slot 45 and the second slot 51 are axially aligned. The projection of the first and second slot 45, 51 defines a gap along the entire length of the bobbin thereby reducing the eddy currents.

[0045] The first flux element 43 is formed as a flux ring or rather a flange. The second flux element 49 is formed in accordance to the first flux element 43. The second flux element 49 is in particular formed as a flux ring or a flange having the second slot 51. The second flux element 49 is connected to the plug connector 9 enabling a conductive coupling of the plug connector 9 and the wire 37 wrapped around the bobbin 35.

[0046] The wire 37 is wrapped around the bobbin 35 at least partly along the first and second shaft portion 41, 47 and an intermediate shaft portion 53 between the first and second flux element 43, 49.

[0047] The first flux element 43 is arranged at a distance (in the axial direction) to the distal and of the first shaft portion 41. Accordingly, the second flux element 49 is arranged at a distance to the distal end of the second shaft portion 47. The first and second shaft portion 41, 47 are integrally formed. The first flux element 43 is joined with a first shaft portion 41 by material joining and preferably by welding. The second flux element 49 is accordingly joined with a second shaft portion 47 by material joining and preferably by welding. Thus, a conductive coupling between the first and second flux element 43, 49 and the first and second shaft portion 41, 47 is provided. Preferably the first and second shaft portion are formed of a magnetic material thereby strengthening the electromagnetic field and optimizing the cycle times.

[0048] Figures 7 and 8 illustrate an alternative preferred embodiment of the plunger 35' of the electromagnetic coil 24.

[0049] In contrast to the first embodiment, the bobbin 35' comprises a first shaft portion 41', a second shaft portion 47' and an intermediate shaft portion 53' arrange between the first and second shaft portion 41', 47'. The bobbin 35' further comprises a first flux element 43' and a second flux element 49'. The first shaft portion 41' and the first flux element 43' are joined by material joining and preferably welding and formed of a magnetic material. Accordingly, the second shaft portion 47' and the second flux element 49' are formed of a magnetic material and joined by material joining and preferably by welding.

[0050] The first and second flux element 43', 49' each have a slot 45', 51' axially aligned to each other extending from the outer periphery of the flux element 43', 49' towards the center.

[0051] The intermediate portion 53 is formed of a non-magnetic material and configured to magnetically isolate the first and second shaft portion 41', 47'.

[0052] The first shaft portion 41', the intermediate shaft portion 53 and the second shaft portion 47' are joined by material joining and are preferably welded, such that the bobbin 35' is formed as an integral part. The first flux element 43' is disposed at a distance to the distal end of the first shaft portion 41'. Accordingly, the second flux element 49' is disposed at a distance to the distal and of the second flange portion 47'. Thereby, the first and second flange portion 41', 47' define an elongated bobbin, providing a sufficiently strong electromagnetic field advancing the movement of the plunger.

[0053] Figures 9 and 10 illustrate the electromagnetic coil according to a third preferred embodiment.

[0054] The electromagnetic coil comprises a bobbin 35" and a wire 37".

[0055] The bobbin has a first shaft portion 31", an intermediate shaft portion 53' and a second shaft portion 47". The shaft portions 41", 53', 47" are joined by material joining and preferably by welding.

[0056] The bobbin 35" further comprises a first flux element 43" having a first slot 55" extending in radial direction and a second flux element 49" having a second slot 51" extending in radial direction.

[0057] The first shaft portion 41" and the first flux element 43" are formed of a magnetic material. The second shaft portion 47" and the second flux element 59" are accordingly formed of a magnetic material.

[0058] The intermediate shaft portion is formed of a non-magnetic material thereby isolating the first shaft portion 41" including the first flux element 43" from the second shaft portion 47" having the second flux element 49". By magnetically isolating the shaft portions, when the electromagnetic coil is de-energized for moving the plunger from the opened position to the closed position, the operational frequency of the dispensing apparatus is increased.

[0059] The first flux element 43" is formed as a flux ring disposed at the distal end of the first shaft portion 41". The second flux element 49" is in particular formed as a flux ring being coupled to the plug connector 9".

[0060] Figure 11 illustrates the plunger 21 in a perspective view. The plunger 21 comprises the sliding portion 26 and an internal fluid passage 27 extending in axial direction through the center of the sliding portion 26. The plunger 21 further comprises a valve element 29 and a valve plate 30 axially spaced apart from the valve element 29, the valve element 29and the valve plate 30 being coupled to the sliding portion 26 by means of a valve stem 31.

[0061] The sliding portion 26 has a slot 57 extending in axial direction from the outer periphery of the sliding portion towards the internal fluid passage 27. The sliding portion 26 further comprises a number of grooves arranged on the outer circumference. The grooves 58 are extending in axial direction configured to improve the sliding of the plunger 21 inside the housing.

[0062] The sliding portion 26 further comprises an outlet of the internal fluid passage 27 configured to discharge liquid to pass the valve seat in order to be dispensed by the discharge opening 19.

[0063] The valve plate 30 has a number of recesses 61 circumferentially arranged and configured to conduct

the liquid passing the outlet 59. The valve element 29 is dimensioned such that the valve seat (not shown) is sealingly closed by the valve element 29 in the closed position of the plunger 21. The open position of the plunger 21 liquid adhesive can pass the recesses 61 of the valve plate 30 in order to be dispensed by the apparatus 1 through the discharge opening 19.

[0064] Figure 12 illustrates a second preferred embodiment of the apparatus 1' according to the invention. The apparatus 1' differs from the embodiment shown in figure 1 by a second housing 63 enclosing the inner housing 3. The second housing 63 is thereby formed of a non-magnetic material providing a simplified manufacturing and a plurality of possible designs according to the specific requirements of the users.

Reference signs

[0065]

1, 1'	dispensing apparatus
3	housing
5	nozzle
7	valve assembly
9	plug connector
11	first (upper) housing portion
13	Inlet
15	middle (slotted) housing portion
17	third lower (nozzle) housing portion
19	discharge opening
20	sealing
21	plunger
23	spring element
24	electromagnetic coil
25	internal wall portion
26	sliding portion
27	fluid passage
29	valve element
31	valve stem
33	valve seat
35	bobbin
36	pole piece
37	wire
38	connector opening
39	housing slot
41, 41', 41"	first shaft portion
43, 43', 43"	first magnetic flux element
45, 45', 45"	first slot
47, 47', 47"	second shaft portion
49, 49', 49"	second magnetic flux element
51, 51', 51"	second slot
53, 53'	intermediate portion
57	plunger slot
59	outlet
61	recesses
63	second outer housing

Claims

1. Apparatus (1, 1') for dispensing liquid material to a substrate, the apparatus (1, 1') comprising:

- a housing (3) having an inlet (13) for supplying liquid material from a material source to the inlet (13),
- a nozzle (5) communicating with the inlet (13) and having a discharge opening (19) for dispensing the liquid material,
- a valve assembly (7) comprising

a movable plunger (21) being formed at least partly of a magnetic material and mounted within the housing (3) for reciprocal movement in an axial direction between a closed and an open position, wherein in the open position, liquid material is dispensed from the discharge opening (19) and in the closed position, liquid material is prevented from being dispensed from the discharge opening (19),
an electromagnetic coil (24) having a bobbin (35, 35', 35") formed at least partly of a magnetic material and a wire (37) wrapped around the bobbin (35, 35', 35"),
wherein the electromagnetic coil (24) is configured to apply an electromagnetic force on the plunger (21) to move the plunger (21),
characterized in that the bobbin (35, 35', 35") comprises a shaft portion and a magnetic flux element coaxially arranged to the shaft portion, wherein the flux element extends beyond the shaft portion in radial direction and has a slot (45, 45', 45") extending in radial direction.

2. Apparatus (1, 1') according to claim 1,
characterized in that the shaft portion is a first shaft portion (41, 41', 41") and the flux element is a first flux element (43, 43', 43"),
the bobbin (35, 35', 35") further comprises a second shaft portion (47, 47', 47") and a second magnetic flux element (49, 49', 49") coaxially arranged to the second shaft portion (47, 47', 47"),
wherein the second flux element (49, 49', 49") extends beyond the second shaft portion (47, 47', 47") in radial direction and has a slot (51, 51', 51") extending in radial direction.

3. Apparatus (1, 1') according to claim 1,
characterized in that the slot (45, 45', 45") of the first flux element (43, 43', 43") is aligned with the slot (51, 51', 51") of the second flux element (49, 49', 49") in in axial direction.

4. Apparatus (1, 1') according to claim 1,
characterized in that the first shaft portion (41, 41', 41") is formed of a magnetic material.

5. Apparatus (1, 1') according to claim 1, **characterized in that** the second shaft portion (47, 47', 47") is formed of a magnetic material.

6. Apparatus (1, 1') according to claim 1 or 2, **characterized in that** bobbin (35', 35") comprises an intermediate portion (53, 53') formed of a non-magnetic material, preferably a non-magnetic stainless steel, and **in that** the intermediate portion (53, 53') is configured to magnetically isolate the first and second shaft portion (41', 41", 47', 47").

7. Apparatus (1, 1') according to any one of the preceding claims, **characterized in that** the bobbin (35, 35', 35") is integrally formed.

8. Apparatus (1, 1') according to claim 7, **characterized in that** the second portion, the intermediate portion (53, 53') and the first portion are joined by material joining, preferably by welding.

9. Apparatus (1, 1') according to any one of the preceding claims, **characterized in that** the housing (3) is formed at least partly of a magnetic material and has a slot (39) axially aligned to the slot (45, 45', 45") provided at the first flux element (43, 43', 43") and/or to the slot (51, 51', 51") provided at the second flux element (49, 49', 49").

10. Apparatus (1') according to claim 8, **characterized in that** the housing (3) is a first inner housing (3) and the apparatus (1') further comprises a second outer housing (63) enclosing the inner housing (3), and wherein the outer housing (63) is formed of a non-magnetic material.

11. Apparatus (1') according to any one of the preceding claims, **characterized in that** the plunger (21) is coaxially arranged to the bobbin (35, 35', 35"), and wherein the plunger (21) has a slot (57) axially aligned to the slot provided at the first flux element (43, 43', 43") and/or to the slot (51, 51', 51") provided at the second flux element (49, 49', 49").

12. Apparatus (1, 1') for dispensing liquid material to a substrate, preferably according to anyone of the preceding claims, the apparatus (1, 1') comprising:

- a housing (3) having an inlet (13) for supplying liquid material from a material source to the inlet (13),
- a nozzle (5) communicating with the inlet (13) and having a discharge opening (19) for dispensing the liquid material,
- a valve assembly (7) comprising a movable plunger (21) formed at least party of a magnetic material and mounted for reciprocal movement in an axial direction within the housing (3) between a closed and an open position, wherein in the open position, liquid material is dispensed from the discharge opening (19) and in the closed position, liquid material is prevented from being dispensed from the discharge opening (19),

an electromagnetic coil (24) having a bobbin (35, 35') formed at least party of a magnetic material, and a wire (37) wrapped around the bobbin (35, 35'), wherein the electromagnetic coil (24) is configured to apply an electromagnetic force on the plunger (21) to move the plunger (21),

characterized in that the bobbin (35, 35') comprises a shaft portion and a magnetic flux element coaxially arranged to the shaft portion, wherein the flux element extends beyond the shaft portion in radial direction, and **in that** the shaft portion has a distal end and the flux element is arranged at a distance to the distal end.

13. Apparatus (1, 1') according to claim 12, **characterized in that** the shaft portion is a first shaft portion (41, 41') and the flux element is a first flux element (43, 43'), the bobbin (35, 35') further comprises a second shaft portion (47, 47') and a second magnetic flux element (49, 49') coaxially arranged to the second shaft portion (47, 47'),

wherein the second flux element (49, 49') extends beyond the second shaft portion (47, 47') in radial direction, and **In that** the second shaft portion (47, 47') has a distal end and the second flux element (49, 49') is arranged at a distance to the distal end.

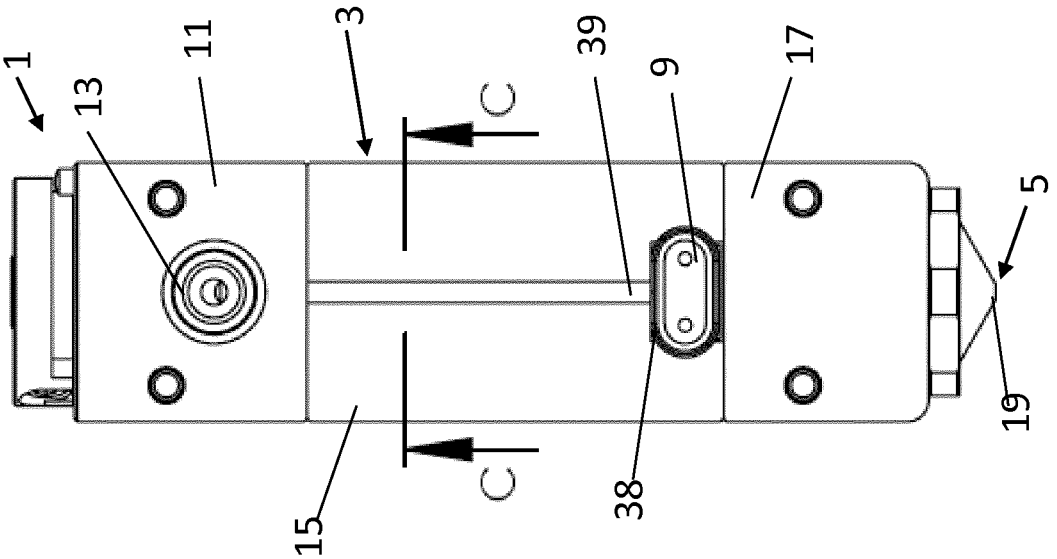
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Fig. 2

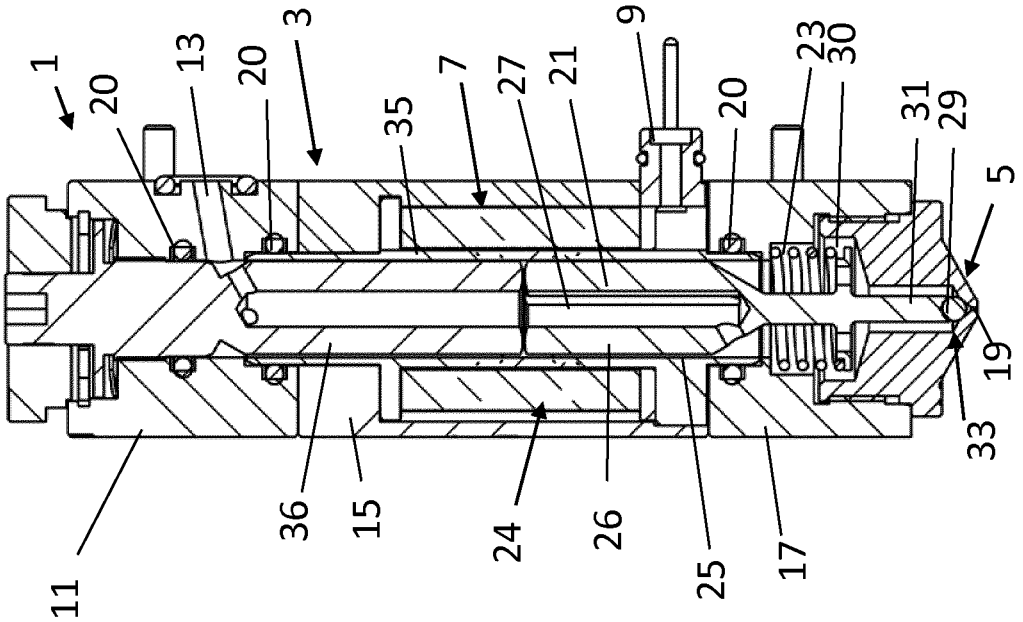
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Fig. 1

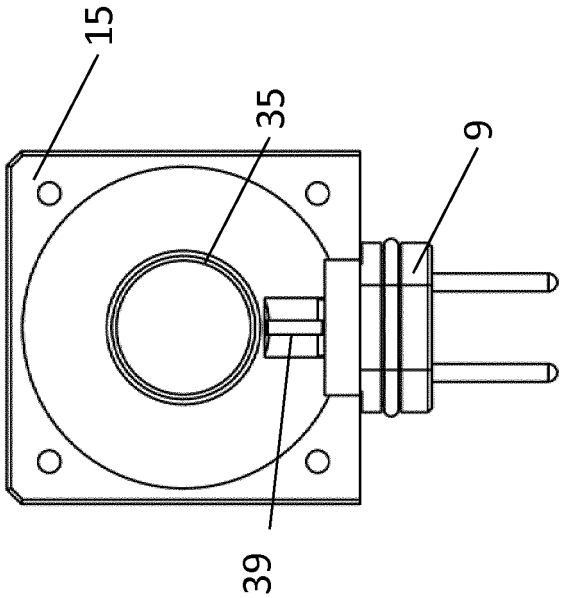

Fig. 4

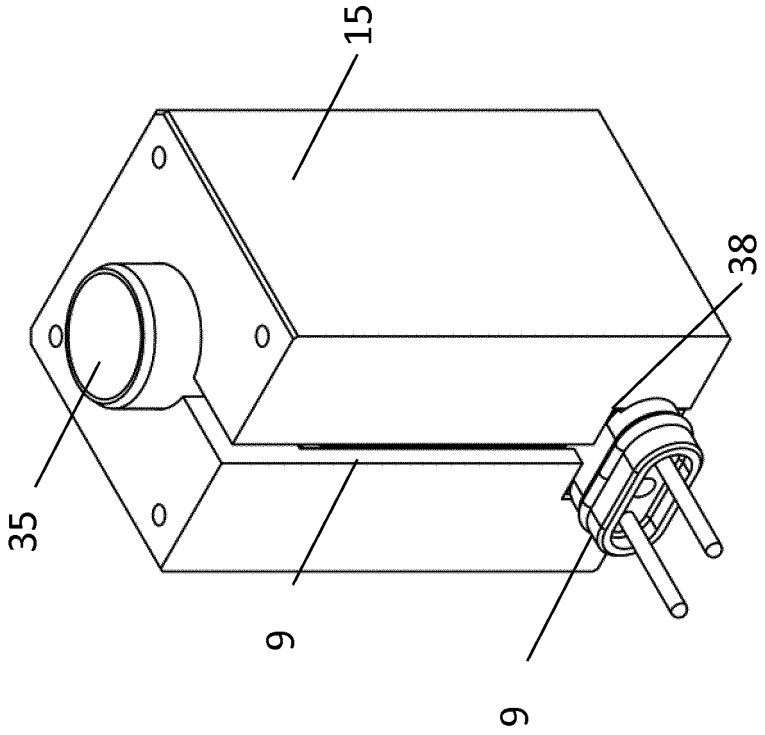

Fig. 3

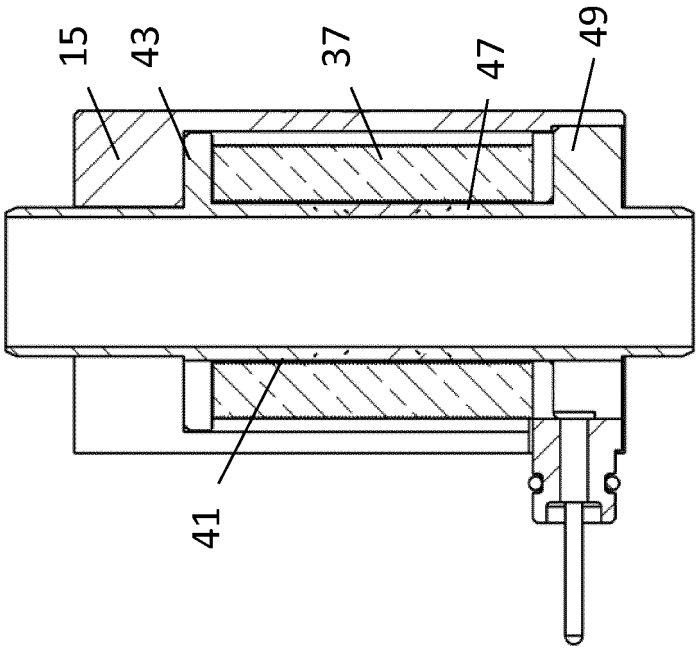

Fig. 6

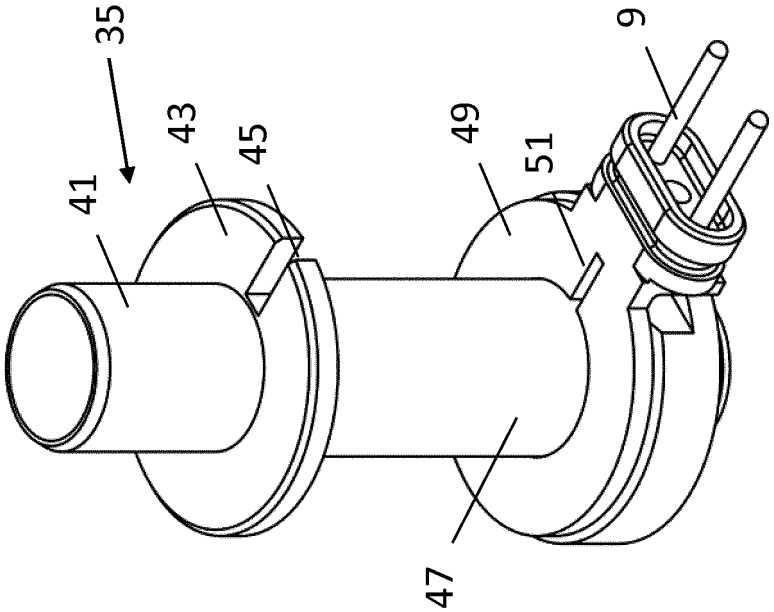

Fig. 5

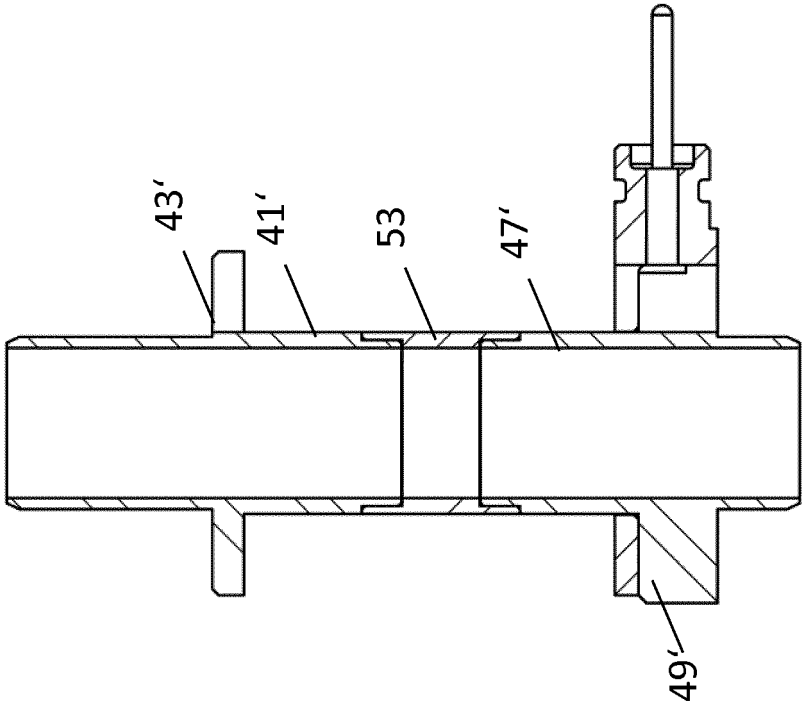

Fig. 8

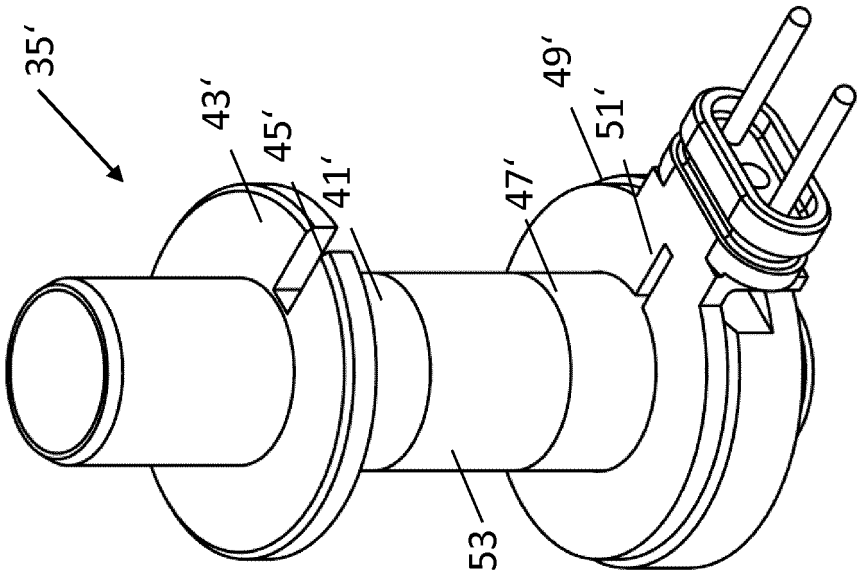

Fig. 7

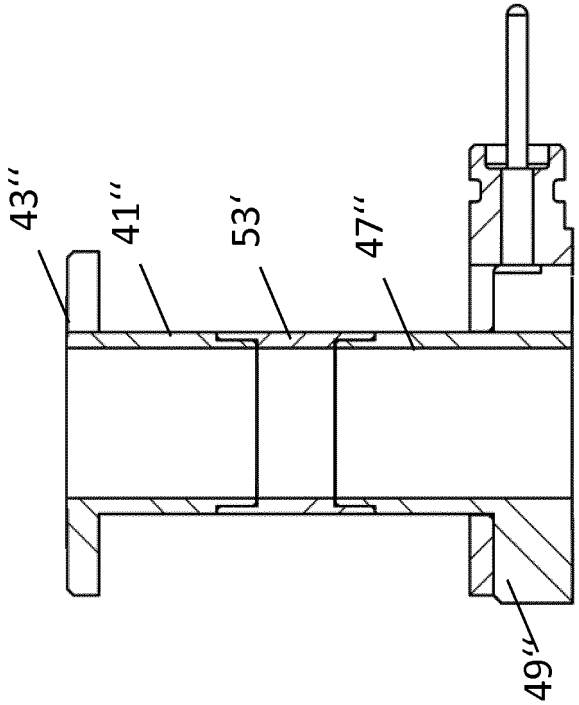

Fig. 10

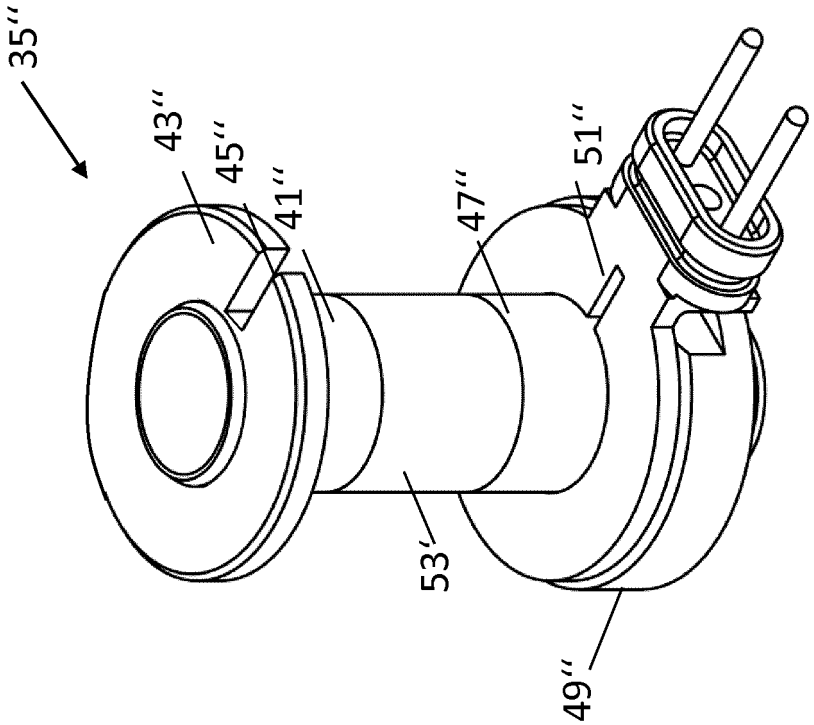

Fig. 9

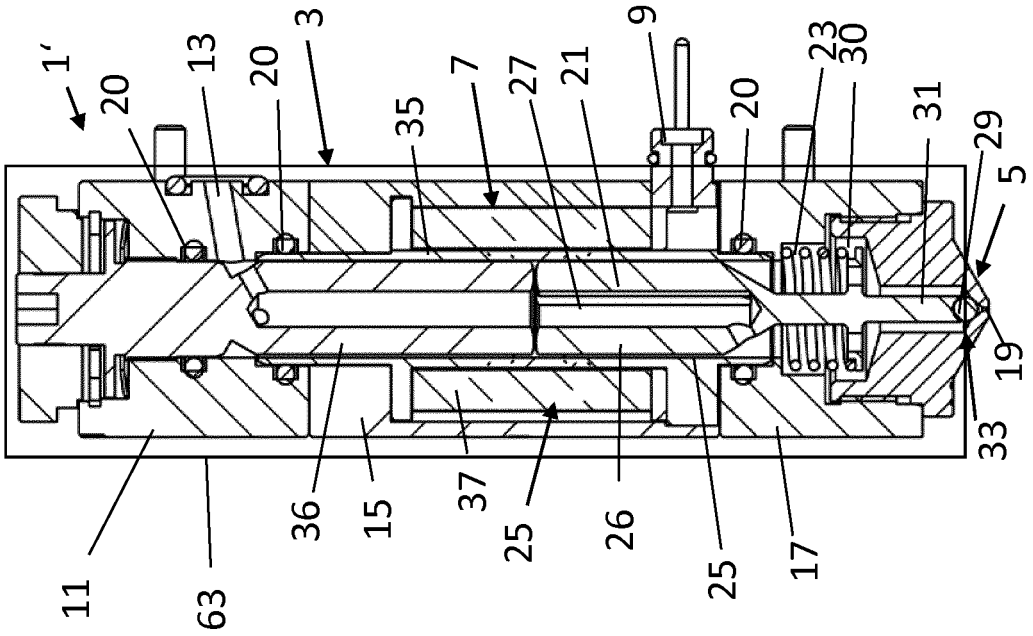
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Fig. 12

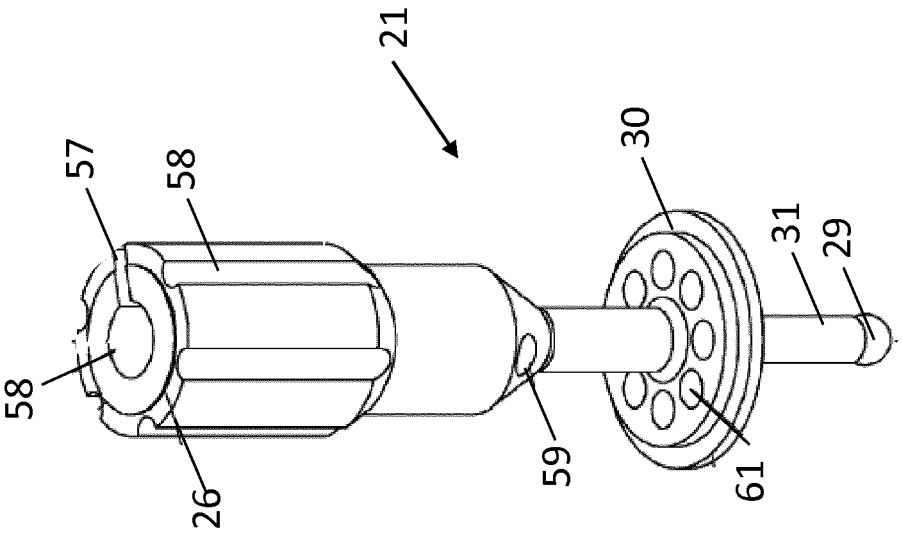
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Fig. 11

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EUROPEAN SEARCH REPORT

Application Number
EP 19 16 0346

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X Y	US 2003/205589 A1 (RIGHOLT HENDRIK-JAN [NL] ET AL) 6 November 2003 (2003-11-06) * abstract; figures 1-4 * * paragraph [0028] * * paragraph [0035] - paragraph [0038] *	1-5 6-11	INV. B05C5/02 B05C11/10
Y	US 4 476 451 A (KOSUGI SEIJI [JP]) 9 October 1984 (1984-10-09) * abstract; claim 6; figures 1-5 * * column 5, line 5 - line 18 * * column 2, line 3 - column 60 *	6-11	
Y	US 4 443 775 A (FUJITANI HIDETSUGU [JP] ET AL) 17 April 1984 (1984-04-17) * abstract; figures 1-9 * * column 2, line 6 - line 15 *	6-11	
X A	WO 00/62941 A1 (NORDSON CORP [US]) 26 October 2000 (2000-10-26) * abstract; figures 1-2 * * page 9, line 10 - line 16 *	12,13 1-11	TECHNICAL FIELDS SEARCHED (IPC)
A,D	US 6 994 234 B2 (NORDSON CORP [US]) 7 February 2006 (2006-02-07) * abstract; figures 1-6 *	1-13	B05C B65D B05B H01F
A,D	US 2008/179352 A1 (LEEUW VICTOR DE [NL]) 31 July 2008 (2008-07-31) * abstract; figures 1-5 *	1-13	F16K
X	US 6 257 445 B1 (MEANS SCOTT [US] ET AL) 10 July 2001 (2001-07-10) * figures 1-4 *	12,13	
X	US 2012/037823 A1 (JUERGENS ERIC [DE] ET AL) 16 February 2012 (2012-02-16) * abstract; figures 1-4 * * paragraph [0020] - paragraph [0021] *	12,13	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	21 November 2019	Ciotta, Fausto

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

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Application Number
EP 19 16 0346

CLAIMS INCURRING FEES

The present European patent application comprised at the time of filing claims for which payment was due.

☐ Only part of the claims have been paid within the prescribed time limit. The present European search report has been drawn up for those claims for which no payment was due and for those claims for which claims fees have been paid, namely claim(s):

☐ No claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for those claims for which no payment was due.

LACK OF UNITY OF INVENTION

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

see sheet B

☒ All further search fees have been paid within the fixed time limit. The present European search report has been drawn up for all claims.

☐ As all searchable claims could be searched without effort justifying an additional fee, the Search Division did not invite payment of any additional fee.

☐ Only part of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the inventions in respect of which search fees have been paid, namely claims:

☐ None of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims, namely claims:

☐ The present supplementary European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims (Rule 164 (1) EPC).

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LACK OF UNITY OF INVENTION
SHEET B

Application Number
EP 19 16 0346

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

1. claims: 1-11

Apparatus for dispensing liquid material to a substrate, the apparatus comprising a magnetic flux element provided with a slot.

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2. claims: 12, 13

Apparatus for dispensing liquid material to a substrate, the apparatus comprising a magnetic flux element arranged at a distance to the distal end of the shaft of the bobbin.

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 19 16 0346

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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21-11-2019

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2003205589 A1	06-11-2003	NONE	
US 4476451 A	09-10-1984	DE 3200014 A1	29-07-1982
		FR 2498002 A1	16-07-1982
		JP S6116662 Y2	22-05-1986
		JP S57115221 U	16-07-1982
		US 4476451 A	09-10-1984
US 4443775 A	17-04-1984	DE 3202704 A1	12-08-1982
		US 4443775 A	17-04-1984
WO 0062941 A1	26-10-2000	AU 4345200 A	02-11-2000
		DE 60006659 T2	07-10-2004
		EP 1169135 A1	09-01-2002
		JP 2002542020 A	10-12-2002
		WO 0062941 A1	26-10-2000
US 6994234 B2	07-02-2006	NONE	
US 2008179352 A1	31-07-2008	CN 101229533 A	30-07-2008
		EP 1949977 A1	30-07-2008
		ES 2366657 T3	24-10-2011
		US 2008179352 A1	31-07-2008
US 6257445 B1	10-07-2001	NONE	
US 2012037823 A1	16-02-2012	BR PI1012093 A2	20-09-2016
		CN 102449359 A	09-05-2012
		DE 102009022496 A1	05-01-2011
		EP 2435737 A1	04-04-2012
		JP 5456158 B2	26-03-2014
		JP 2012527593 A	08-11-2012
		RU 2011152485 A	10-07-2013
		US 2012037823 A1	16-02-2012
		WO 2010136096 A1	02-12-2010

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Patent documents cited in the description

- US 6994234 B **[0005]**
- US 20080179352 A1 **[0005]**