

Device for the Metered Delivery of a Viscous Liquid

The invention concerns devices in accordance with the preamble of patent claims 1 and 7.

5 Such a device is known for example from the Patent Specification US 4 485 387. In this specification a system is described for the application of a thick-film printing ink onto a substrate with which an intake channel and a discharge channel are envisaged with a double cylinder arranged transversely to them. Via a rotary valve, the intake channel is alternately connected to one cylinder while at the same time the other cylinder is connected to the discharge channel and vice versa. Diametrically opposed coupled
10 pistons are arranged in both diametrically opposite cylinders which are constantly moved back and forth by a motor. The valve is simultaneously turned back and forth in time with the piston movement. In this way, a specific amount of printing ink is taken into one cylinder and the previously measured amount of printing ink is simultaneously discharged at the other cylinder. The stroke of the piston is adjustable so that the amount of printing ink taken in and discharged can be adjusted as necessary. In order to
15 guarantee faultless operation of the device presented, it has relatively large dimensions and therefore a large weight. This device is therefore connected via long tubes to a writing head which is movable across the substrate.

In order to apply electrical connections to integrated circuits or ICs, connection fingers interconnected
20 by means of a frame, so-called leadframes, are punched out of a thin metal sheet. By means of a so-called die bonder, the integrated circuit is subsequently applied which then adheres to the connection fingers. For this purpose, a pattern of epoxy adhesive for a specific size of integrated circuit is applied to the respective leadframe which is preferably done by means of a device as described above. Because, depending on their composition, the epoxy adhesives or resins have a short work life, with time remains
25 are left behind in the metering device so that it has to be regularly cleaned. For this purpose, the device has to be dismantled and rinsed with a cleaning paste (tenside) similar to soft soap. Afterwards, the device must be carefully re-assembled which requires a certain amount of skill, especially with the seals. In particular, the stuffing boxes present in the device are to be tightened with a torque wrench. The long tubes to the writing head also have to be cleaned and, if necessary, replaced. It goes without saying that
30 these devices are quite complicated and therefore expensive especially with relation to the piston drive.

For this and other reasons, the object of the presented invention is to improve a device of the above type in such a way that it has less weight, is considerably easier and cheaper to manufacture and that more simplified cleaning is possible.

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This object is solved by means of a device with the features of patent claim 1 or patent claim 7.

9903371-4 14 JUL 1990

With the devices in accordance with the invention, a particularly small construction is possible so that they can even be assembled together with the movable writing head of a device for the application of adhesive to a substrate.

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Further advantages of the invention follow from the dependent patent claims and from the following description in which the invention is described in more detail based on the embodiments presented in the schematic diagrams. It is shown in:

- Fig. 1 a plan view of a metering device,
- 10 Fig. 2 a side view of the metering device,
- Fig. 3 a plan view of the metering device expanded with a valve, and
- Fig. 4 a side view of the metering device expanded with the valve and mounted on a writing head,
- Fig. 5 a further metering device,
- 15 Fig. 6 the further metering device in various phases of operation, and
- Fig. 7 a device for applying adhesive to a substrate.

Figures 1 and 2 show a plan view or a side view of a metering device for the metered delivery of a viscous liquid which comprises a body 1, a slide 2 rotatable around a turning axis A and a cover plate 3. There is a cavity between the body 1 and the cover plate 3 so that when the slide 2 is inserted a circular channel 4 is formed. At the end areas 5 and 6, the channel 4 is connected to connection nipples 9 via feed channels 7 and 8. In the channel 4 there is an indentation 10 close to the end area 5 which serves the initial filling of the channel 4 with the liquid. The slide 2 has a cam 2a projecting into the channel 4 with which the liquid can be pushed through the channel 4.

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The rotatable slide 2 is moved by a motor 11 whereby a reduction gearbox 12 is connected between the motor 11 and the slide 2. The body 1 and the cover plate 3 are detachably connected together, for example, by means of screws 13 or by means of snap-on elements. The body 1 has a drill hole 14 into which the slide 2 can be plugged with light pressure. The surface 3 of the disk 2 facing towards the cover plate 3 has a recess 15 so that the area touched by the cover plate 3 and the slide 2 can be lightly held and which is only so large as is necessary for an adequate seal. The edge of the slide 2 is therefore formed as a sealing lip. In this way, it is ensured that the seal is effective at a predetermined location, namely along the edge of the circular slide 2 and, of course, at cam 2a. Further recesses 16 on the slide 2 have the effect that the area touched by the slide 2 and the body 1 is also comparably small. The dimensions of the slide 2 are selected so that, in the assembled state of the metering device, the slide 2 is clamped between the body 1 and the cover plate 3, however it is thereby preferably that it can still be

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turned by hand. Because of the circular form of the channel 4 (Fig. 1), the metering device has a compact construction which results on the one hand in the adequate seal effected by the press fit of the slide 2 so that the liquid can not emerge and, on the other hand, in the friction between the slide 2 and the body 1 as well as the cover plate 3 being low enough, by means of the recesses 15 and 16, so that the slide 2 can always be turned through a specific angle ϕ with the necessary accuracy. It goes without saying that the recesses 15 and 16 can also be applied on the cover plate 3 or the body 1. For cleaning of the metering device 1, the cover plate 3 is removed and the slide 2 is taken out. The gearbox 12 and the motor 11 do not come into contact with the liquid to be applied.

The body 1 and the cover plate 3 are made, for example, out of steel, the slide 2 is manufactured from plastic so that ideal sliding characteristics result between the slide 2 and the body 1 as well as the cover plate 3. It is also conceivable that all these parts are manufactured from plastic as injection moulded parts.

In Figures 3 and 4, the metering device is presented in combination with a valve 17 which enables the continuous operation of the metering device in both directions of rotation of the slide 2. The metering device and the valve 17 are preferably formed as one piece as illustrated, can however be separate. The valve 17 is designed for example as a rotary valve 17 which has two diametrically opposed connecting channels 18 and 19 and an intake channel 20 turned by 90° with a delivery channel 21 diametrically opposed to it. The feed channels 7 and 8 verge directly into the connecting channels 18 or 19 and can be kept very short. Channels 18 to 21 all open into a pocket hole 22 in which a rotary slide 23 can basically be moved back and forth between two positions. The rotary slide 23 is actuated by a motor 24 whereby a reduction gearbox 25 is connected between the motor 24 and the rotary slide 23. In the first position of the rotary slide 23 as presented, the left-hand connecting channel 18 is connected to the intake channel 20 and the right-hand connecting channel 19 to the delivery channel 21. When the rotary slide 23 is turned by 90° to the second position presented by a broken line, the situation is reversed. In operation, the intake channel 20 is connected to a reservoir containing the viscous liquid. The metering device complete with the rotary valve 17 is preferably mounted onto a movable writing head 26, whereby the delivery channel 21 is formed directly as a writing nozzle.

On initial filling of the metering device, the rotary slide 23 of the rotary valve 17 is located in the first position presented in Figure 3 and the rotatable slide 2 of the metering device is located in the position shown in Figure 1. The viscous liquid - not presented here - such as epoxy adhesive is now pressed under a pressure of approximately 5 bar via the left-hand connecting channel 18 into the circular channel 4 and discharged again out of the delivery channel 21 via connecting channel 19. Because the slide 2 is located in the indentation 10, the liquid pushed in under pressure through the feed channel 7 can easily

flow round the slide 2 and into the channel 4. Air present in the feed channel 7 is thereby pushed in front of the liquid and finally transported out of the metering device 1 via the delivery channel 21. Special openings as in prior art for venting the metering device, described by experts as "bleeding", are not necessary. In this way, air bubbles in the pump are automatically eliminated, ie, without external manipulations being necessary.

Then, the rotatable slide 2 is turned in clockwise direction until the cam 2a takes up a position marked with E. The metering device is now filled with the viscous liquid and is ready to dispense the liquid onto the substrate which is not presented. With each dispensing action, the slide 2 is turned through a predetermined angle ϕ whereby the amount of adhesive discharged is proportional to the angle ϕ . After a predetermined number n of dispensing actions, the cam 2a of the slide 2 is located in the position F presented by a broken line. In this state, the rotary slide 23 of the rotary valve 17 is now moved to its second position and the direction of rotation of the slide 2 is reversed. Therefore, after n further dispensing actions, the slide 2 arrives back at position E. To apply the liquid, the slide 2 is moved back and forth in n steps respectively between positions E and F, whereby the position of the rotary slide 23 of the rotary valve 17 is changed in positions E and F respectively. The largest amount of liquid is applied to the substrate when $n=1$.

If the metering device complete with rotary valve 17 is mounted on the movable writing head 26, then the distance between the slide 2 determining the amount of liquid to be applied and the writing nozzle can, with this construction, be kept very short. This results in a very high reproducibility accuracy of the amount of liquid discharged with each dispensing action. If a comparably longer tube, typically 300 mm, is located between the delivery channel 21 and the writing nozzle as is usual with prior art where the metering device is not mounted on the writing head then, because of the characteristics of the liquid, the tube filled with liquid works as a "low-pass" and the control of the amount of liquid to be discharged is much more difficult.

For the person skilled in the art, it goes without saying that the metering device described above functions not only with a circular channel 4 and a rotatable slide 2 but that a straight channel with a slide moving back and forwards within it can also be envisaged.

Fig. 5 shows a further metering device for the metered delivery of a liquid. The metering device has a first body 30 with three parallel arranged, continuous and horizontally running drill holes 31, 32 and 33 as well as two further bodies 34 and 35 attached to each of which are a guide rod 36 or 37 and a piston 38 or 39 running parallel to it. The bodies 30, 34 and 35 consist preferably of plastic. The drill hole 32 takes up the first guide rod 36, drill hole 33 the second guide rod 37 and drill hole 31 the two pistons 38

and 39, whereby body 34 is located on one side of the drill hole 31 and body 35 on the other side of drill hole 31. The drill hole 31 is widened at both ends to accept one sealing element 40 and one bearing element 41 each for the corresponding piston 38 or 39. The central area of the drill hole 31 connects two chambers 42 and 43 installed in the body 30, whereby in operation the first chamber 42 is connected to a reservoir containing the liquid and the second chamber 43 is connected to the writing nozzle 44. For this purpose, for example, a nipple 45 for attaching a tube or the writing nozzle 44, respectively, are directly inserted into the corresponding chamber 43 or 42.

The bodies 34 and 35 and with them the guide rods 36 and 37 and the pistons 38 and 39 are movable in the direction of the drill holes 31, 32 and 33. The guide rods 36 and 37 take over the actual support of the two pistons 38 and 39. Drive of the bodies 34 and 35 is carried out by means of two cam discs 46 and 47 arranged on a rotational axis and driven by a common motor. For this purpose, the bodies 34 and 35 have a cam 48 adjacent to the corresponding cam disc 46 or 47. The two bodies 34 and 35 are connected by means of a pre-tensioned spring 49 so that the cams 48 always remain in contact with the corresponding cam disc 46 or 47 and the movements of the pistons 38 and 39 follow the stagger of the assigned cam disc 46 or 47. A single 360° revolution of the motor or the cam discs 46 and 47 leads to one single back and forth movement of the pistons 38 and 39.

Figs. 6A-F now show schematically the relative position of the pistons 38 and 39 in six different angle positions during one single revolution of the cam discs 46 and 47. At the start, the faces of the pistons 38 and 39 are located within the first chamber 42, whereby a small slit is formed between the two faces of the pistons 38 and 39 (Fig. 6A). First of all, only the piston 38 moves so that the slit between the two pistons 38 and 39 is enlarged. The enlarged slit immediately fills with liquid (Fig. 6B). Afterwards, both pistons 38 and 39 move from the first chamber 42 to the second chamber 43 whereby the width of the slit remains constant (Fig. 6C). In this way, a predetermined amount of liquid is transported from chamber 42 to chamber 43. After that, piston 39 remains stationary (Fig. 6D) while piston 38 is moved back until the slit between the faces of the two pistons 38 and 39 again achieves the originally small width (Fig. 6E). During this phase, the amount of liquid which is located in the slit between the pistons 38 and 39 is pressed into chamber 43. Subsequently, both pistons 38 and 39 are moved back whereby the slit between the faces maintains the small width (Fig. 6F) until, after one complete revolution of the motor, they are again located in the initial position (Fig. 6A). Therefore, during one back and forth movement of the pistons 38 and 39, the distance between their faces varies whereby the distance during the forward movement is larger than during the backward movement so that a predetermined volume of liquid is transported from the first chamber 42 to the second chamber 43.

VespeI, a hard, plastic which can be processed like brass is a suitable material for the body 30. The pistons 38, 39 and the guide rods 36, 37 are preferably formed from conventional clipping punches as

are used, for example, as ejector pins in the injection moulding technique. Such clipping punches have an extremely smooth surface. The ends of the pistons 38, 39 are rounded. The sealing elements 40 (Fig. 5) are made of comparably soft plastic, for example Teflon. For a short distance, the inside diameter of the sealing elements 40 is selected slightly smaller than the diameter of the pistons 38, 39 so that the sealing elements 40 tightly surround the corresponding piston 38 or 39, however, without leaving the range of elastic deformation. The seal is therefore created on the short distance located on the side of the sealing element 40 facing towards the chamber 42 or 43. The bearing elements 41 on the other hand are formed out of a harder plastic than the sealing elements 40 so that the support for the pistons 38, 39, so long as it is not produced by the guide rods 36 or 37, is effected by the bearing elements 41 and not by the sealing elements 40.

Because the spring 49 is tensioned between the two bodies 34 and 35, its expansion varies only by the amount of the difference between the minimum and maximum width of the slit. Engagement of the spring 49 in the bodies 34 and 35 takes place as close as possible to the guide rods 36, 37 so that the torques from the guide rods 36 and 37 exerted on the respective drill hole 32 or 33 because of the spring 49 remain as low as possible. These torques could be eliminated completely by means of additional springs.

The diameter of drill hole 31 and the difference between the minimum and maximum width of the slit between the faces of the pistons 38 and 39 are dimensioned corresponding to the minimum volume of liquid $V_{\min}$, to be delivered. The volume of liquid to be applied with one single dispensing action can be increased to n times the liquid volume $V_{\min}$ in that the motor carries out n revolutions. The device is equally suitable for the spot application of liquid portions for which the writing axis remains stationary as well as for the writing of liquid lines and patterns for which the writing axis is moved with a predetermined speed along predetermined lines. The direction of rotation and the speed of the motor are coordinated and controlled with regard to the writing movement so that the predetermined amount of liquid is applied to the substrate at the predetermined location in accordance with the given liquid pattern.

A particular advantage of this device can be seen in that it gets along without a valve. A backward run is also possible whereby liquid is then transported from the second chamber 43 to the first chamber 42. The maintaining of a minimum, finite width of the slit between the faces of the two pistons 38 and 39 guarantees wear-free operation.

Both metering devices can be built very compactly so that they can be directly mounted onto the writing head of an apparatus for the application of adhesive to a substrate as is described, for example, in the European Patent application EP 901 155 and which is explicitly incorporated here as reference. Fig. 7

corresponds to the Fig. 1 of EP 901 155. The liquid is supplied to the dispensing head 50 via a tube 51 in accordance with the teaching of the EP 901 155 whereby a not presented pump is located at the other end of the tube 51 with which the amount of adhesive to be applied is metered. One of the metering devices in accordance with the invention can now be mounted directly onto the cradle 52 instead of the dispensing head 50, so that the pump metering the amount of adhesive is located on the writing head 53 and is moved with it. In this way, a shorter distance results between the metering device exercising the function of the pump and the tip of the writing nozzle 44 with the advantage that the coordination of the writing movement and the pump action, ie, the control of the direction of rotation and speed of the motor as a function of time with reference to the writing movement, is simplified even with very high writing speeds and a short writing cycle.

Both metering devices are equally suited for the application of adhesives which mostly have a high viscosity as well as of liquids with lower viscosities which, for example, serve as globtop or underfill material for a flipchip.



Claims

1. Device for the metered delivery of a viscous liquid with an intake channel (20), via which the liquid is supplied and a delivery channel (21) via which the liquid is delivered, a valve (17) operable in two positions and a single channel (4) the end areas of which (5, 6), by means of the valve (17), are alternately connectable to the intake channel (20) or the delivery channel (21), whereby in the channel (4) the cam (2a) of a slide (2) is movable back and forth between two positions (E, F), **characterized in that** the channel (4) has an indentation (10).
2. Device in accordance with Claim 1, **characterized in that** the channel (4) has a circular form and that the slide (2) is rotatable on a rotating axis (A).
3. Device in accordance with Claim 1 or 2, **characterized in that** the device has a body (1) and a cover plate (3) and that the slide (2) can be plugged into a drill hole (14) of the body (1).
4. Device in accordance with Claim 3, **characterized in that** the slide (2) or the body (1) or the cover plate (3) has at least one recess (15; 16) to reduce the area touched by the slide (2) and the body (1) or the slide (2) and the cover plate (3).
5. Device in accordance with one of Claims 1 to 5, **characterized in that** the slide (2) consists of plastic.
6. Device in accordance with one of Claims 3 to 5, **characterized in that** the body (1), the slide (2) and the cover plate (3) consist of plastic.
7. Device for the metered delivery of a viscous liquid, with a body (30) with a first chamber (42), via which the liquid is supplied, and a second chamber (43), via which the liquid is delivered, **characterized in that** the two chambers (42, 43) are connected via a drill hole (31) and that two pistons (38, 39) can be moved back and forth in the drill hole (31), whereby the distance between the faces of the two pistons (38, 39) facing towards each other varies during the back and forth movement.
8. Device according to Claim 7, **characterized in that** each of the two pistons (38, 39) is supported in the drill hole (31) by means of a bearing element (41) and is sealed against the drill hole (31) by means of a sealing element (40), whereby the bearing element (41) consists of harder material than the sealing element (40).
9. Apparatus for the application of a liquid to a substrate with a movable writing head (26; 53), **characterized in that** a device for the metered delivery of liquid is mounted on the writing head (26; 53).

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