United States Patent

Rodder

[15] **3,635,345**

[45] **Jan. 18, 1972**

[54] CHROMATOGRAPHY

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[22] Filed: **Mar. 13, 1969**

[21] Appl. No.: **808,375**

Related U.S. Application Data

[63] Continuation of Ser. No. 503,067, Oct. 2, 1965, abandoned.

[52] **U.S. Cl.** .....**210/198 C,** 117/120, 137/568, 137/593, 210/31 C

[51] **Int. Cl.**.....**B03d 1/00**

[58] **Field of Search** .....117/120; 210/31 C, 198 C; 137/568, 593

[56] **References Cited**

UNITED STATES PATENTS

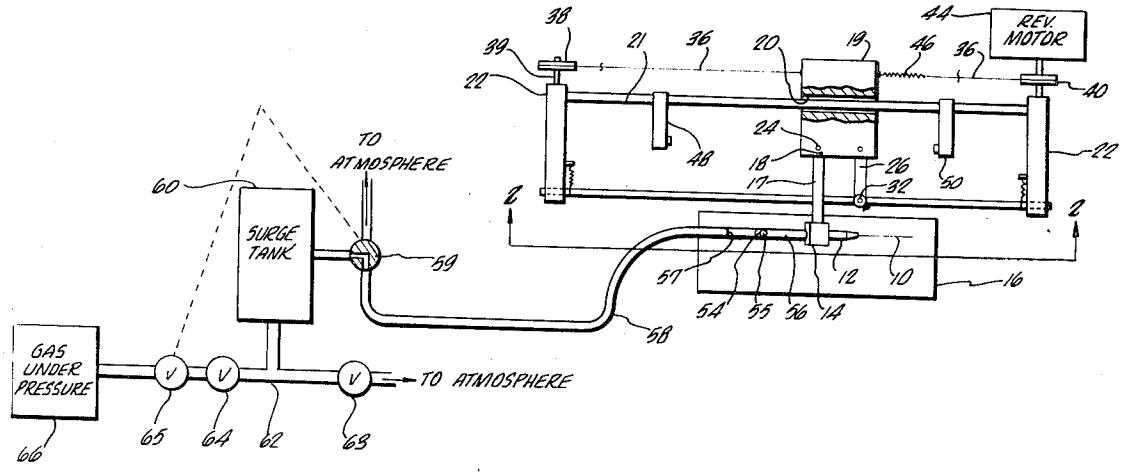
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[57] **ABSTRACT**

A thin line chromatography dispenser having an elongated, flexible capillary tube which is supported over an adsorbent surface such that the angle between the surface and the tube is substantially less than 90°. The angle is made as small as practicable, and preferably is less than 20°. Means are provided for moving the tube over the adsorbent surface so that liquid can be discharged onto the surface in a thin straight line.

5 Claims, 5 Drawing Figures



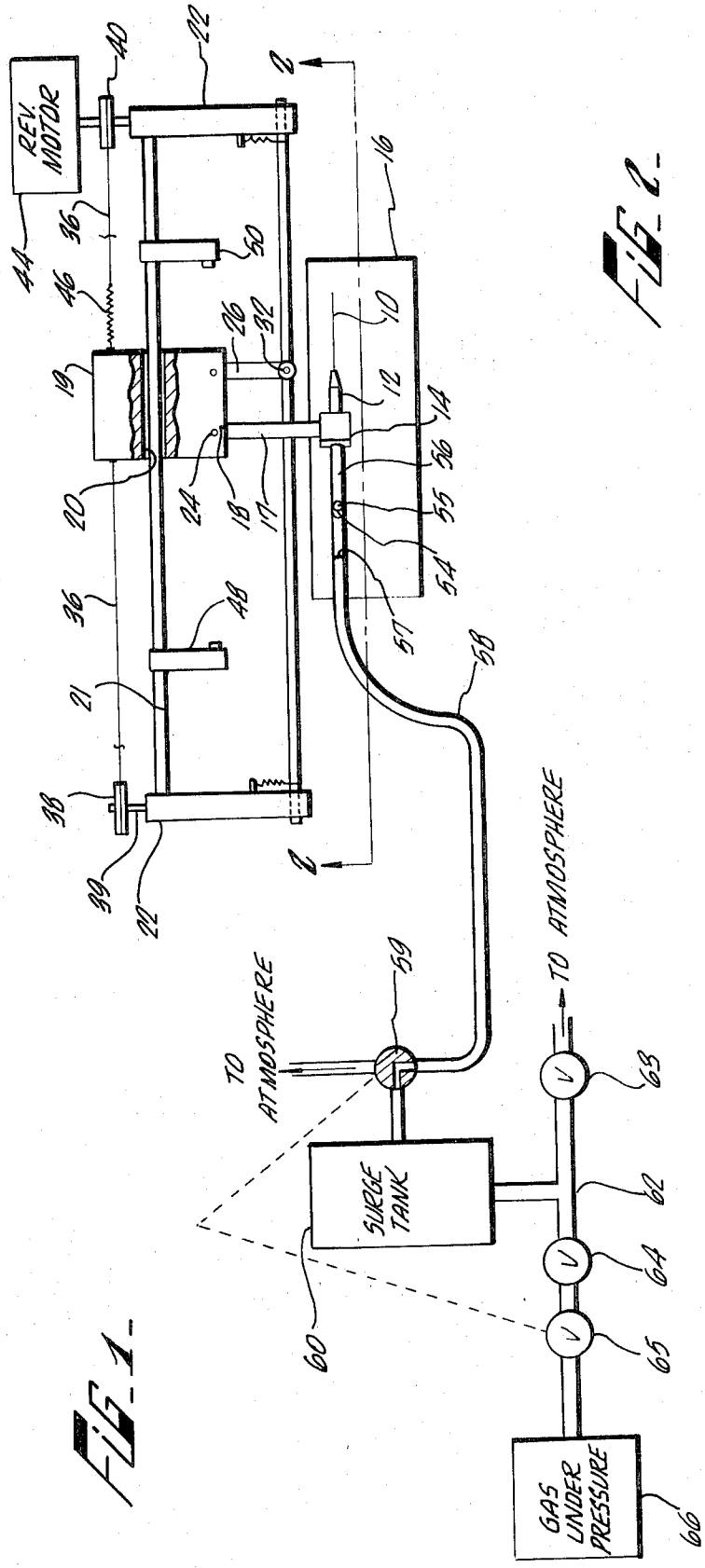


FIG. 1.

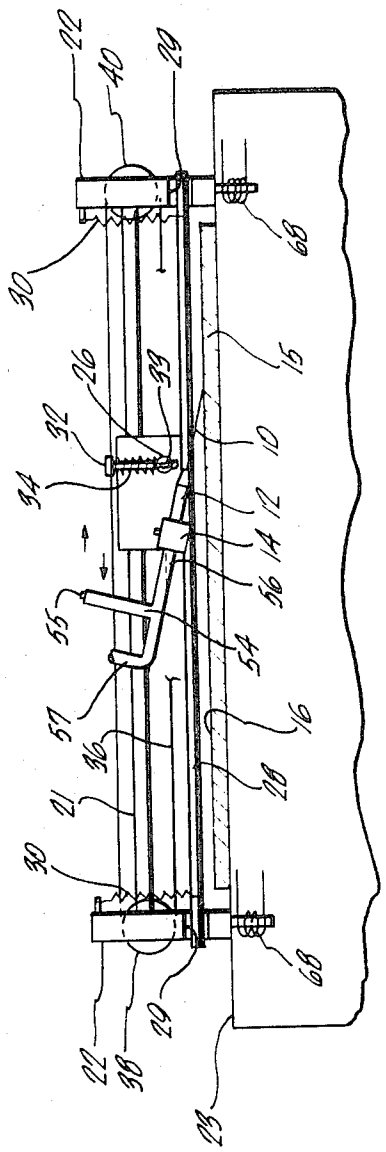
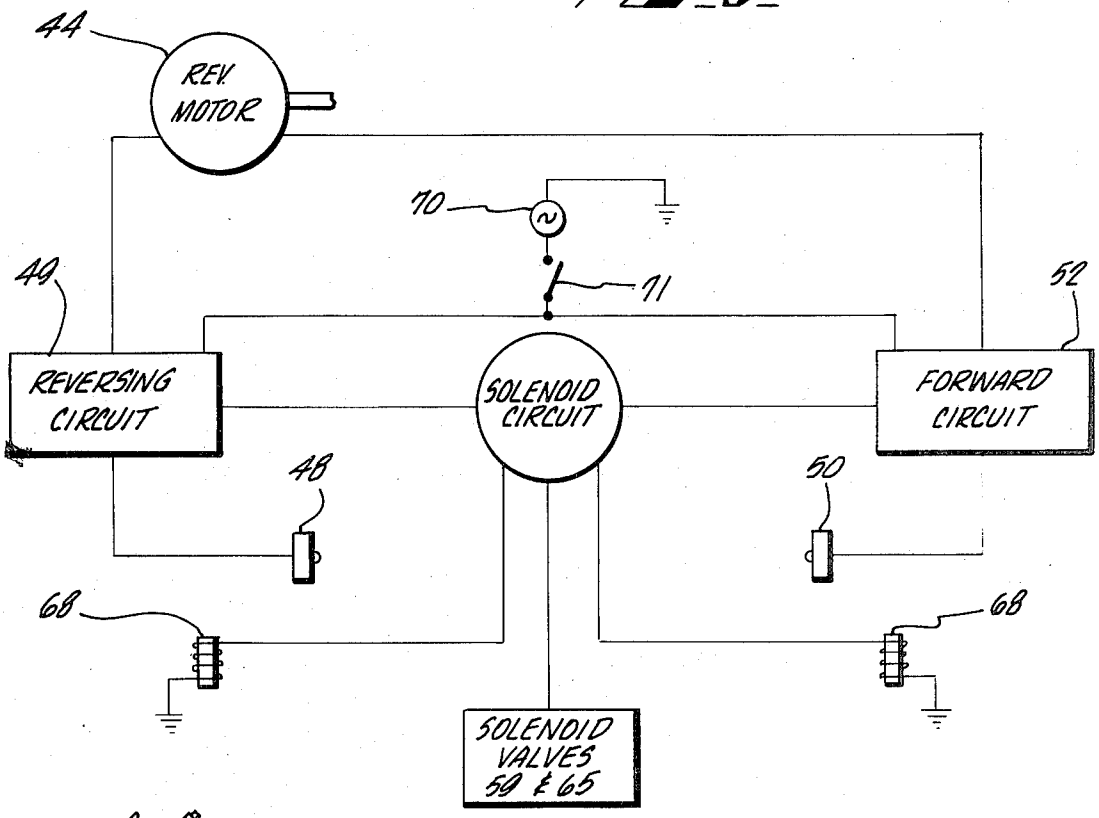


FIG. 2.

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FIG. 3



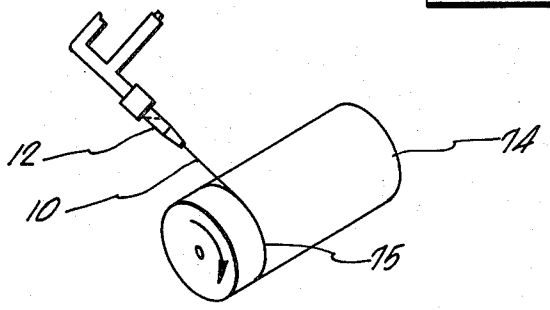


FIG. 4

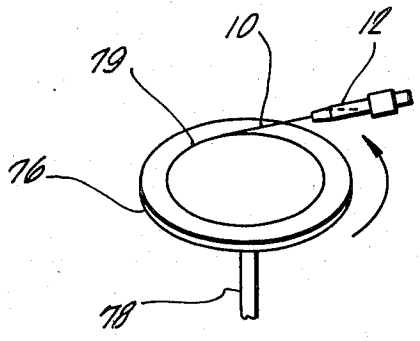


FIG. 5

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CHROMATOGRAPHY

This application is a continuation of my copending application Ser. No. 503,067, filed Oct. 23, 1965, now abandoned.

This invention relates to chromatography and, more particularly, to methods and apparatus for preparative thin layer chromatography.

In conventional preparative thin layer chromatography, a thin layer of liquid solution of a material to be analyzed is deposited along a straight and narrow line on a suitable chromatographic adsorbent. A typical adsorbent is made from a liquid slurry of tiny silica gel crystals spread over a flat glass baseplate and then baked to solidification. The thickness of the adsorbent varies so that the surface is rough and not planar.

A conventional liquid dispenser for thin layer chromatography is a hypodermic syringe in which the plunger is moved either manually, by a spring, or by a motor drive. The needle is held in a vertical position above the glass baseplate which is horizontal. The needle and glass plate are moved relative to each other so the needle traces a line over the surface of the adsorbent. Liquid is dispensed from the needle as it moves over the surface to leave a line of liquid on the adsorbent. The liquid is a solution of the chemical to be analyzed, usually a mixture of organic compounds which are adsorbed on the surface with different forces of attraction. After the solution is applied to the adsorbent, an elutriant (solvent) is applied to the adsorbent and allowed to diffuse by capillary action in a direction normal to the line of adsorbed organic compounds. As the elutriant sweeps over the line, the organic compounds which are less strongly adsorbed are swept along in the direction of diffusion of the elutriant. This process is continued until the different organic compounds have been separated and can be separately scraped off the plate and analyzed.

The accuracy and reliability of thin layer chromatography depends on the quality of the line or thin layer of solution to be analyzed applied to the adsorbent. For best results, the line must be straight, narrow, and uniform.

With the liquid dispensers conventionally used before this invention, the vertical needle cannot make uniform contact with the adsorbent surface during the application of the layer because of the rough adsorbent surface. If the vertical needle is held close enough to make contact with the surface throughout the length of its travel, some of the adsorbent is scraped off the base. If the needle is held spaced above the surface, a nonuniform line or layer of liquid is deposited because of the varying thickness of the adsorbent. It is also difficult to control accuracy and change the speed of the plunger in the hypodermic syringe. Finally, the syringe has to be taken apart and carefully cleaned and refilled between analyses.

This invention provides apparatus and method for dispensing a straight, narrow, and uniform line of liquid on a suitable adsorbent without the disadvantages of the prior dispensers.

The dispenser of this invention provides continual contact of the dispensing tip with the absorbent during the application of the liquid, resulting in a straight, narrow, and uniform line. Moreover, the dispensing tip is arranged so that it does not damage or change the surface of the adsorbent. The dispenser of this invention also provides a simple and reliable means for easily and accurately regulating the rate at which fluid is transferred from the dispenser. Finally, the dispenser is easily filled and cleaned.

In terms of apparatus, the dispenser includes a tube and means for supporting the tube over the adsorbent surface so that the angle between the surface and the tube is substantially less then 90°. One end of the tube is in contact with the surface, and means are provided for moving the surface and tube relative to each other so that the apparent motion of the tube with respect to the adsorbent surface is in the same general direction in which the tube extends away from the surface. Means are provided for supplying liquid to the tube under sufficient pressure to discharge the liquid on the surface as it moves relative to the tube.

Preferably, the tube is an elongated, flexible capillary tube which is deflected with a light spring action when it is in contact with the adsorbent surface. Thus, the point of the tube is at an angle substantially less than the remainder of the tube. In general, the angle is made as small as practicable, and it preferably is less than 20°. Especially favorable results are obtained when the angle is between about 3° and about 10°.

The tube preferably includes an upright filling conduit and pressurizing conduit so that liquid to be applied to the adsorbent surface can be added to the tube through the filling conduit and forced out the end of the capillary tube in contact with the adsorbent by gas pressure applied to the pressurizing conduit.

In the presently preferred form of the invention, means are provided for reciprocating the tube to retrace the same path over the adsorbent. During the travel of the tube in the direction in which it is inclined from the surface of the adsorbent, the discharge end of the tube is in contact with the adsorbent, and liquid is forced out of the tube at a uniform rate. When the end of the path is reached, liquid discharge from the end of the tube is stopped. The tube is automatically moved out of contact with the adsorbent, returned to the starting point, lowered into contact with the adsorbent, and moved again over the same path to deposit another layer of liquid on top of the first.

Usually the liquid is a solution of organic compounds of low volatility in a liquid of relatively high volatility. A typical solvent is chloroform which evaporates almost as fast as it is applied to the adsorbent, leaving the organic compounds adsorbed on the adsorbent. The repeated application of solution to the line on the adsorbent is continued until sufficient quantity of the organic compounds to be analyzed are deposited. Thereafter, the compounds are separated by an elutriant in a conventional manner.

While the needle travels over the adsorbent during the dispensing cycle, it is necessary to apply carefully controlled pressure to the liquid to insure its uniform transfer from the tube. This is done in accordance with this invention by a carefully regulated gas supply which is intermittently applied to the tube. During the dispensing portion of the cycle, the gas pressure is applied to the liquid in the tube, and during the retrace cycle, the gas pressure is removed from the liquid in the tube.

The preferred apparatus for supplying the accurately controlled low gas pressure to the tube or an outlet includes a source of gas under pressure connected by a first conduit to a first leg of a T-connection. A bleedoff valve is connected to the second leg of the T-connection, and the third leg of the T-connection is connected to the outlet or tube from which the liquid is to be dispensed. Means are provided for adjusting the bleedoff valve to regulate the pressure supplied by the source to the outlet. If the bleedoff valve is completely closed, the pressure applied is that of the gas source. As the bleedoff valve is opened, less pressure is applied to the gas source. To improve the sensitivity of the control and reduce waste of gas from the source, a metering valve is connected between the source and the T-connection to limit the amount of gas which flows from the source even when the bleedoff valve is wide open. Preferably, a three-way valve is connected between the T-connection and the outlet so that it can be positioned to supply gas pressure either to atmosphere or to the tube with the liquid, depending on whether the tube is in the dispensing or retracing portion of its cycle.

In another form of the invention, the dispenser is arranged so that the end of the tube is in contact with the surface of an adsorbent mounted on a cylindrical drum which is rotated continuously as liquid is forced from the end of the tube in contact with the adsorbent surface. In yet another form of the invention, the tube is mounted to be in contact with an adsorbent surface on a rotary table which can be rotated to draw a circular line of liquid on the adsorbent. In these latter two arrangements, the need for reciprocating the tube back and forth over the surface is eliminated.

In terms of method for depositing a layer of liquid on a surface of an adsorbent, the invention includes the steps of disposing a tube adjacent the surface of an adsorbent with one end of the tube in contact with the surface and with the tube extending away from the surface at an angle substantially less than 90°. The surface and tube are moved relative to each other so that the apparent movement of the tube relative to the surface is toward the direction in which the tube extends from the surface. Liquid is supplied to the tube under sufficient pressure so that the liquid flows out of the end of the tube in contact with the surface as the tube moves over it. Preferably, the tube is resilient and is held in spring contact with the surface throughout the travel of the tube from a first point to a second point. In the presently preferred method, the tube is moved in one direction from the first point to a second point with the end of the tube being in constant contact with the surface. On reaching the second point, the tube is moved out of contact with the surface, returned to the first point, lowered in contact with the surface, and moved again to the second point. Liquid is forced from the tube as it travels from the first to the second point, but it is not forced from the tube when the tube is moved out of contact with the surface and returned to the first point.

These and other aspects of the invention will be more fully understood from the following detailed description and the accompanying drawings, in which:

FIG. 1 is a plan view of the presently preferred apparatus for depositing a straight, narrow, uniform line of liquid on an adsorbent surface;

FIG. 2 is a view taken on line 2—2 of FIG. 1;

FIG. 3 is a schematic drawing of the electrical circuit used to control the apparatus of FIGS. 1 and 2;

FIG. 4 is a schematic perspective view of another embodiment of the invention in which a layer of liquid is applied to a cylindrical surface of adsorbent; and

FIG. 5 is a schematic perspective view of another embodiment of the invention used to apply a layer of liquid to an adsorbent surface mounted on a rotary table.

Referring to FIGS. 1, 2, and 3, an elongated capillary tube 10 is secured at one end to a glass reservoir 12 which is mounted in a block 14 over a glass plate 15 coated with a layer of adsorbent 16, say, silica gel. The block is secured to one end of a horizontal arm 17, the other end of which fits into a recess 18 in a traveling sleeve 19 which has a longitudinal bore 20 through it to receive a guide rod 21 which is secured at its opposite ends in upright supports 22 mounted on a worktable 23.

The arm 17 is rotatable about its longitudinal axis and can be clamped in any desired position by a setscrew 24 in the sleeve which permits adjustment of the angle between the capillary tube and the adsorbent surface.

One end of a horizontal finger 26 secured to the sleeve extends toward the capillary tube and terminates over a horizontal lifting bar 28 which is disposed in a pair of notches 29 in each support 22. A separate tension spring 30 is secured at its upper end to each support 22 and at its lower end to the adjacent respective end of the lifting bar so the lifting bar is held up against the top surface of notches 29. A vertical adjusting screw 32 is threaded through a vertical bore 33 in the outer end of the finger 26 so the lower end of screw 32 rides on the lifting bar. A compression spring 34 disposed around the lower screw between the screwhead and finger holds the adjusting screw in any position in which it is set. Thus, the height of the capillary tube 10 is determined by the position of adjusting screw 32. Ordinarily, the screw is set so that when the lifting bar is held down in the notches as described below, the free end of the capillary tube is in contact with the adsorbent surface, and the capillary tube is bowed slightly concave upwardly so there is a light spring action in the capillary tube which tends to hold its free end in constant contact with the adsorbent surface.

The traveling sleeve makes a close sliding fit over the guide rod, but is free to rotate about the longitudinal axis of the guide rod so that the block 14 and capillary tube 10 can be moved up and down as adjusting screw 32 is turned. A first end of a drive belt 36 is secured to the sleeve, looped around an idler pulley 38 mounted on a stub shaft 39 on one of the supports 22 to rotate about a horizontal axis. The belt extends over and around a drive pulley 40 mounted on the other support block to rotate about a horizontal shaft 41 and be driven by driving shaft 42 from a reversible motor 44. The other end of the drive belt 36 is connected by tension spring 46 to the side of the traveling sleeve opposite that which the first end of the drive belt is attached.

The reversing motor is operated to turn in either a forward or a reverse direction as explained in detail below with reference to FIG. 3. During the forward or dispensing cycle of the operation of the apparatus, the motor turns to move the sleeve from the left (as viewed in FIGS. 1 and 2) until it contacts a first limit switch 48 which then actuates a reversing circuit 49 (FIG. 3) which causes the reversing motor to be driven in the opposite direction (to the right, as viewed in FIGS. 1 and 2) until the sleeve contacts a second limit switch 50 mounted on the guide rod. The second limit switch actuates a forward circuit 52 (FIG. 3) which causes the reversing motor to drive in the forward direction. Thus, the sleeve, block, and capillary tube is reciprocated over the surface of the adsorbent.

As shown best in FIG. 2, the reservoir 12 includes an upright filling conduit 54 which is closed by a removable stopper 55. To fill the reservoir, the stopper is removed and a liquid 56 is poured down the filling conduit into the reservoir, and the stopper is then replaced. An upright pressurizing conduit 57 is connected to the end of the reservoir remote from the capillary tube, and it is connected by an elongated plastic flexible hose 58 to a three-way solenoid valve 59 which is operated by the circuit shown in FIG. 3 to connect a surge tank 60 either to atmosphere or to the flexible hose 58. The surge tank is connected to one leg of a T-connection 62. Another leg of the T-connection is connected through a bleedoff valve 63 to atmosphere. Yet another leg of the T-connection is connected through a manually controlling metering valve 64 to a source of gas under pressure 66. Solenoid valve 59 is operated by the circuit shown in FIG. 3 so that it disconnects the reservoir 12 and the surge tank when it is rotated 90° in a clockwise (as viewed in FIG. 1) direction to connect the surge tank to atmosphere.

As shown best in FIG. 2, a separate electromagnet 68 is mounted under each support 22 so that when the electromagnets 68 are energized, they draw the lifting bar down against the force of tension springs 30 and cause it to rest on the bottom of notches 29. In this position, the free end of capillary tube 10 is brought to bear against the adsorbent by the weight of the block 14, arm 17, and finger 26 which tends to cause the sleeve to pivot about the guide rod 21. The weight of the block, arm, finger, and reservoir is sufficient to bend the capillary tube slightly so it has an upwardly concave curvature. This produces a light spring action in the capillary tube which urges it against the adsorbent with a force sufficient to keep it in contact with the adsorbent but not damage it. When the electromagnets are deenergized, the tension springs 30 pull the lifting bar up to the top of notches 29 which is sufficient to lift the screw 32 and finger 26 and pivot them upwardly about the guide rod 21 so that the capillary tube is moved out of contact with the adsorbent.

In operation, a source of electrical power 70 is connected to the forward and reversing circuits as shown in FIG. 3 by closing a switch 71. Assuming that the sleeve is against the forward microswitch 50, a solenoid circuit 72 is actuated to turn solenoid valve 59 to the position shown in FIG. 1. The electromagnets are energized so the capillary tube is pulled down against the absorbent. Metering valve 64 is opened manually to allow sufficient gas flow into T-connection 62 to provide the regulated gas pressure for operation. Bleedoff valve 63 is opened manually to vent some of the gas to atmosphere, and the remainder of the gas flows through the surge tank 60 and

solenoid valve 59 into pressurizing conduit 57 of the reservoir. Metering valve 64 and the bleedoff valve 63 are set to provide the desired pressure on the liquid in the reservoir. With the arrangement shown in FIG. 1, accurate control of gas at very low pressure (a few ounces per square inch, for example) is easily obtained. The pressure is sufficient to force liquid out of the capillary tube at the desired rate without blowing the stopper out of the filling conduit. The liquid is forced out of the reservoir and the free end of the capillary tube to leave a straight, narrow, uniform layer as the sleeve is carried from right to left (as viewed in FIGS. 1 and 2.) When the sleeve strikes the microswitch 48, the reversing circuit is actuated, causing the solenoid circuit to deenergize the electromagnets 68 so that lifting bar 28 is pulled upwardly by tension springs 30. This lifts the capillary tube out of contact with the adsorbent surface, which normally is rough and uneven. The solenoid valve 59 is actuated so that it connects the surge tank to atmosphere. The reversing motor is driven in the opposite direction so that the capillary tube is carried back to its original starting point over the adsorbent surface. Forward microswitch 50 is engaged by the traveling sleeve to energize the forward circuit which actuates solenoid circuit 72 to energize the electromagnets to pull the lifting bar down and place the free end of the capillary tube in contact with the adsorbent surface. Solenoid valve 59 is restored to its original position so that gas is supplied to the reservoir. The surge tank prevents an abnormal surge of gas pressure from being applied to the liquid in the reservoir when valve 59 is open. The motor is driven in a forward direction to that the needle applies another layer of liquid on top of the first. The foregoing process is repeated as many times as necessary until the desired amount of liquid is applied to the adsorbent surface in a narrow, straight, and uniform line. The solvent in the liquid evaporates in less than the cycle time of the apparatus so that liquid is normally applied to a substantially dry strip of solute left by the evaporated solvent. The deposited material is now ready for further chromatographic analysis by conventional techniques.

Referring to FIG. 4, a hollow, cylindrical drum 74 with a layer of adsorbent (not shown) coated on its surface is mounted to be rotated by a conventional means (not shown). The reservoir 12 and capillary tube are mounted adjacent the drum so the free end of the capillary tube engages the adsorbent surface and extends away from the surface in a direction opposite to the rotation of the drum. Preferably, the reservoir is supported so the capillary tube bends slightly and thus continually contacts the surface of the adsorbent. Air pressure is supplied continuously to the reservoir so that liquid is forced out of the free end of the capillary tube to trace a straight, narrow, uniform line on the adsorbent as the drum rotates. The rate of drum rotation is slow enough to permit the solvent to evaporate as it travels around the drum and before it is returned to the free end of the capillary tube.

In the embodiment shown in FIG. 5, an adsorbent (not shown) is deposited on the upper surface of a horizontal plate on turntable 76 mounted on a vertical shaft 78 which is rotated by conventional means (not shown). The reservoir and capillary tube are mounted adjacent the adsorbent surface so the free end of the capillary tube engages the adsorbent, and the remainder of the tube extends away from the adsorbent surface in a direction opposite to which the surface is carried by the rotatable shaft. Preferably, the capillary tube is located so that it bends slightly and thus continually contacts the surface of the adsorbent as the turntable rotates. Gas pressure applied to the liquid in the reservoir forces the liquid out of the free end of the capillary tube to deposit a uniform, fine circular line of liquid on the adsorbent surface. The rate of rotation of the turntable is sufficiently slow to permit liquid to evaporate before it is carried back under the capillary tube.

The advantage of the apparatus as shown in FIGS. 4 and 5 is that the tube and adsorbent surface do not need a mechanism to make them reciprocate with respect to each other.

The capillary tube is preferably a steel hypodermic needle of about 29 gauge. Such a needle has an I.D. of about 0.005 inch and an O.D. of about 0.008 inch to 0.009 inch. Preferably, the needle is about 2 inches long so that its length in combination with its thin wall lets it touch but not scratch the adsorbent as the tube and adsorbent are moved relative to each other. For sharp chromatographic separation of organic compounds, the line deposited by the dispenser should be between 1 and 2 millimeters wide. The dispenser of this invention produces such a line of liquid so that accurate and reliable chromatographic operation can be made.

I claim:

1. Apparatus for depositing a layer of liquid on a path having a beginning and an end along the surface of an adsorbent, the apparatus comprising an elongated tube with one end disposed adjacent the surface, means responsive to the said one end of the tube being adjacent the beginning of the path for moving the tube toward the surface until the said one end of the tube contacts it at the beginning of the path and the angle between the surface and the tube is less than 20°, means for moving the surface and tube relative to each other in a first direction so the said end of the tube traces a path on the surface in the direction in which the tube extends from the surface, means for applying force to a liquid in the tube to force the liquid from the tube and leave a first liquid layer on the path, means responsive to the said end of the tube reaching the end of the path for lifting the said end of the tube from the surface, means for removing force on the liquid to interrupt its flow from the tube while the said end is out of contact with the surface, means for reversing the relative movement of the tube and surface while they are out of contact with each other, means for stopping the said reverse movement when the said end of the tube is adjacent the beginning of the path so a second layer of liquid can be deposited on the first.

2. Apparatus according to claim 1 in which the tube is placed in contact with the surface with a sufficient force to give the tube a slight concave curvature away from the surface.

3. Apparatus according to claim 1 in which the angle between the surface and the tube is between about 3° and about 20°.

4. Apparatus according to claim 1 which includes means for adjusting the angle between the tube and the surface of the adsorbent.

5. Apparatus according to claim 1 which includes means for applying gas pressure to the liquid in the tube when the surface and the tube move relative to each other in the first direction, and means for decreasing the gas pressure on the liquid in the tube when the surface and tube move relative to each other in the direction opposite to the first.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,635,345 Dated January 18, 1972

Inventor(s) Jerome A. Rodder

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Title page, paragraph [63] "Oct. 2" should read --Oct. 23--.

Col. 1, line 57, "absorbent" should read "adsorbent--.

Col. 4, line 40, "controlling metering" should read --controlled metering--.

Col. 4, line 71, "absorbent" should read --adsorbent--.

Col. 4, line 72, "pressure for" should read --pressure required for--.

Col. 6, line 31, (Claim 1) "less than 20°" should read --less than about 20°--.

Signed and sealed this 27th day of June 1972.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents