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M. W. RUCHELMAN

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AUTOMATIC SAMPLE INJECTOR

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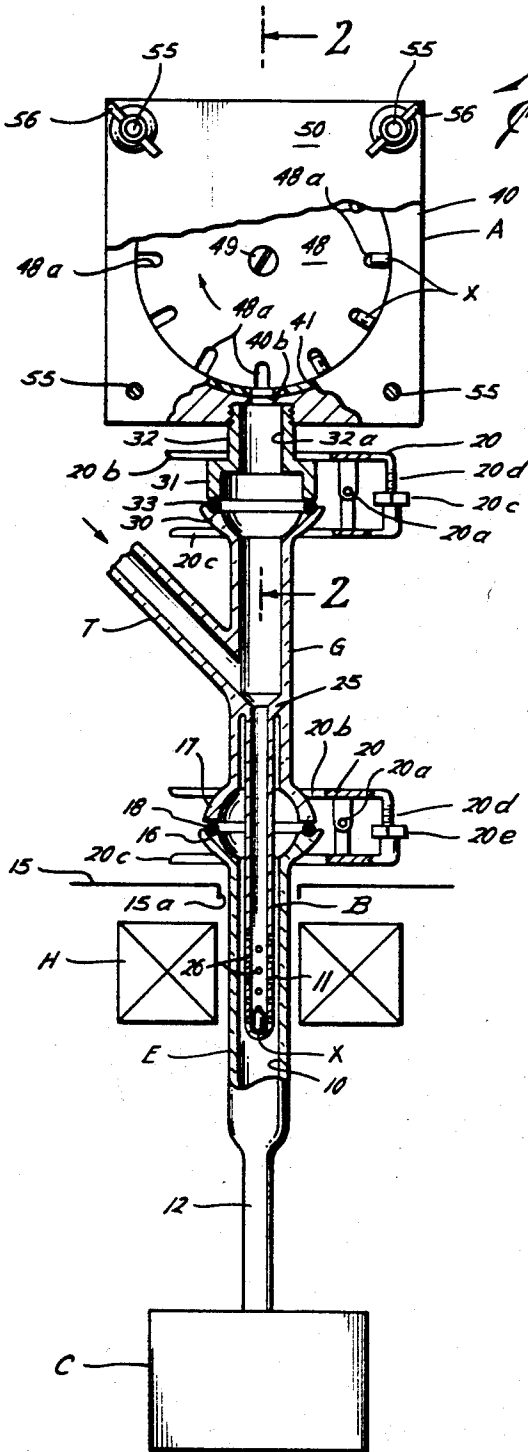
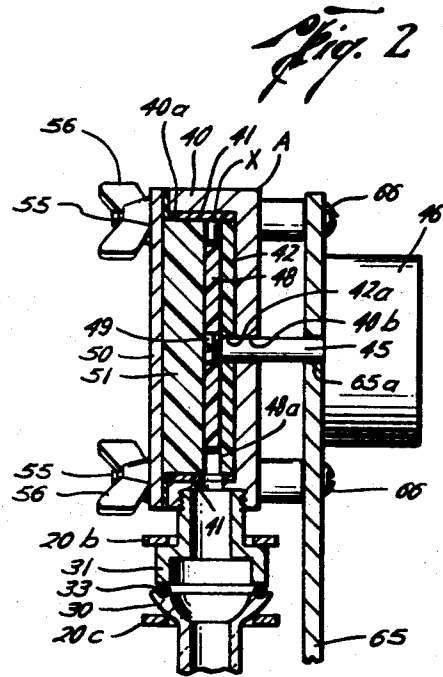
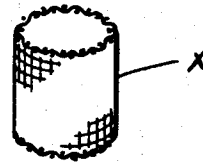


Fig. 3



Maryon W. Ruchelman
INVENTOR.

BY Hayden & Pravel
ATTORNEYS

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AUTOMATIC SAMPLE INJECTOR
Maryon W. Ruchelman, 5422 Maple St.,
Bellaire, Tex. 77401

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ABSTRACT OF THE DISCLOSURE

Sample injector for gas chromatograph apparatus and the like wherein an injection apparatus is adapted to hold a plurality of samples and automatically introduce each sample successively into a sample-evaporation chamber of the apparatus.

An object of the present invention is to provide a new and improved sample injector which is particularly suitable for automatically injecting solid samples into gas chromatograph apparatus.

The preferred embodiment of this invention will be described hereinafter, together with other features thereof, and additional objects will become evident from such description.

The invention will be more readily understood from a reading of the following specification and by reference to the accompanying drawings forming a part thereof, wherein an example of the invention is shown, and wherein:

FIG. 1 is an elevation, partly in section, illustrating the preferred form of the apparatus of this invention; and

FIG. 2 is a vertical sectional view taken on line 2-2 of FIG. 1 to further illustrate the apparatus of this invention; and

FIG. 3 is a perspective view of a sample-carrier used in conjunction with the apparatus of this invention.

In the drawings, the letter C designates generally a gas chromatograph apparatus, which is schematically shown, and with which the apparatus of this invention is employed. A sample-vaporization chamber E is disposed in communication with the gas chromatograph apparatus C and is arranged so as to be heated by a conventional heater H. A perforated basket B is disposed within the sample-vaporization chamber E (FIG. 1) and it is preferably integral with, or connected to, a carrier gas conduit G having a carrier gas inlet tube T therewith. An automatic sample injector unit or means A is disposed above and in communication with the conduit G for the purpose of injecting successively and automatically solid samples which have previously been deposited upon a sample-carrier such as indicated at S (FIG. 3). Briefly, each of the sample-carriers X with the solid sample deposited thereon is contained within a compartment or pocket of its own within the injector unit or means A prior to dropping each of such sample-carriers downwardly through the conduit G and into the basket B. With the present invention, there is no contact by the carrier gas with the sample on each sample-carrier X until such carrier X has dropped downwardly from its injector unit A, thereby avoiding any inadvertent loss of sample or misleading readings on the chromatograph apparatus C, as will be more evident hereinafter. The heat device D for vaporizing the solid samples on the sample-carriers X is remote from the samples themselves prior to disposing the samples within the basket B so that heat effects which might otherwise cause decomposition of the samples is avoided with the present invention. It is also important to note that the present invention provides for the automatic injection of samples successively at predetermined time intervals without the presence of an operator or technician,

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thus making it possible to inject samples without the technician watching carefully for the proper injection time, and also allowing for continued testing even after the ordinary workday.

Considering the invention more in detail, the sample-vaporizer chamber E is preferably a glass tube having an enlarged bore 10 for receiving the basket B with an annular space 11 therebetween. The lower end 12 of the vaporization chamber E is shown as directly connected to the gas chromatograph apparatus C, although it will be appreciated that suitable connections from the tube 12 to the apparatus C may be provided, with any intervening couplings or equipment as may be desired for the purpose of operation. The gas which is created in the vaporization chamber E by the heater H passes from the chamber E through the line 12 to the gas chromatograph apparatus C, or other similar analyzing equipment, for analysis purposes.

It is to be noted that the heater H is indicated only schematically since it is a conventional type of heating equipment which is supported by any suitable means within a unit having a table top or surface 15. An opening 15a is provided in such top through which the upper end of the chamber E extends. For the purpose of connecting the chamber E to the conduit G, a connector is formed by mating annular connecting ends 16 and 17 which are suitably grooved to receive an O-ring 18 or other seal formed of rubber or similar material therebetween.

The connecting ends 16 and 17 are clamped tightly together by a clamp 20 formed of metal or other similar material which is capable of applying a compressive force to bring the ends 16 and 17 into tight sealing engagement with the seal ring 18. Such clamp 20 is laterally removable from the ends 16 and 17 for disassembly of the conduit G from the chamber E when desired. The clamp 20 may be of any conventional construction, and one type is illustrated wherein a pivoted connection 20a is provided between upper and lower clamping forked fingers 20b and 20c. The fingers 20b and 20c are moved towards and away from each other by any suitable adjusting mechanism such as a threaded shaft 20d which is rotatably and threadedly engaged with a rotatable nut 20e so that by rotating the nut 20e, the adjustment may be made.

The conduit G is also preferably formed of glass or other inert material, and it is provided with a suitable connection at 25 to the upper end of the basket B. The basket B may thus be integral with, or connected to the interior of the conduit G; and it likewise is preferably formed of glass or other inert material. The basket B extends downwardly into the bore 10 of the evaporation chamber E and is of a smaller diameter so as to provide for the annular space 11, as previously mentioned. The basket B is formed with a plurality of holes or perforations 26 so that a carrier gas which is introduced through the inlet T may pass through the basket B and pick up the gas formed by the vaporization of the solid sample on the sample-carrier X within the basket B. The combined carrier gas and the gas from the sample may thus flow through the chamber E and the tube 12 thereof to the gas chromatograph apparatus C.

The tube T forms part of the conduit G, or it may be suitably connected thereto, and it is connected in the known manner to a source of carrier gas, which is an inert gas such as nitrogen that has no effect upon the analysis made in the gas chromatograph apparatus.

The upper end of the conduit G is formed with a connector end 30, which is in mating engagement with an end 31 on a coupling 32. A suitable O-ring of rubber or other suitable seal 33 is disposed between the ends 30 and 31 and is preferably clamped tightly in sealing engagement

by means of a clamp 20 which is preferably identical to the other clamp 20 heretofore described for holding the ends 16 and 17 in sealing engagement.

The coupling 32 is threaded or is otherwise connected to a housing 40 of the automatic injector unit A. The housing 40 is formed with a circular recess 40a which preferably has a liner 41 formed of "Teflon" or other suitable inert sealing material. A solid disk or plate 42 formed of "Teflon" or other similar material is disposed at the bottom or inner surface of the recess 40a (FIG. 2), and it has an opening 42a therethrough, through which a shaft 45 extends. Also, the housing 40 has a suitable opening 40b through which such shaft 45 extends. The shaft 45 is a motor shaft connected to a motor 46 which may be a clock motor or any other suitable type of drive mechanism for regulating the rotation of the shaft 45, and a rotatable disk 48 secured thereto by a screw 49 or other attachment means. The disk 48 is also preferably formed of "Teflon" or other sealing material which is in sealing engagement with the plate 42 and the annular strip 41. The disk 48 has a plurality of circumferentially-spaced pockets or compartments 48a, each of which is adapted to receive a sample-carrier X for discharge therefrom upon reaching the lowermost position illustrated in FIGS. 1 and 2. Thus, the lowermost pocket 48a is aligned with an opening 40b which extends through the housing 40 and the inner sealing liner 41. The opening 40b is also in alignment with the bore 32a of the coupling 32 and the bore of the conduit G so that when the lowermost pocket 48a reaches the position shown in FIGS. 1 and 2, the sample-carrier X drops downwardly through the conduit G and into the basket B as illustrated in FIG. 1.

The housing 40 also includes a removable cover 50 which has a "Teflon" or other sealing material facing 51 secured thereto and removable therewith. Such facing 51 is in sealing engagement with the surface of the disk 48, without interfering with the rotational movement of the disk 48 relative to the facing 51 so as to fully enclose each of the pockets 48a. It is to be noted that "Teflon" (polytetrafluoroethylene) is especially suitable for the liner 41, plate 42, disk 48, and facing 51 because the samples or other compounds on the sample-carriers X are not adsorbed by such material nor adhered or otherwise stuck to such material, thereby avoiding the contamination of each sample by the other samples. In view of the significance of avoiding contamination of the samples, any other material used in place of "Teflon" should likewise have such properties.

The cover 50 is removably mounted as a part of the housing 40 by means of a plurality of studs 55 secured to the rear portion of the housing and which extend through appropriate openings or holes in the cover 50 so that removable wing nuts 56 may be secured to such studs 55. When the nuts 56 are removed, the cover 50 and its facing 51 are likewise removed from the rest of the housing 40 so as to expose the pockets 48a. Each of the pockets 48a is then adapted to receive a sample-carrier X, or an operator may decide to use alternate pockets 48a for the carriers X or any variations thereof to provide predetermined time intervals for the dropping of the sample-carriers X into the basket B. The intervals are governed by the spacing of the pockets 48a and the speed of the drive from the motor 46. Assuming that the spaces 48a are approximately in the ratio indicated in the drawings, the clock drive 46 may be adjusted so that a new sample-carrier X drops into the basket B every forty-five minutes if there is a carrier X in each of the pockets 48a. If the technician or operator desires to record or analyze a sample every hour and one-half, then sample-carriers X are placed in only the alternate pockets 48a, and it will be appreciated that various other combinations or variations of time intervals may be employed.

The electric drive motor 46 and the housing 40 therewith are suitably supported by a frame 65 which preferably extends up from the surface 15 or other base member.

Such brace or frame 65 is suitably connected to the housing 40 with retaining screws 66 or other securing means. An opening 65a is provided in the frame 65 through which the rotatable shaft 45 extends. The motor 46 itself may be fastened by any suitable means (not shown) to the frame or plate 65.

In FIG. 3, an enlarged view of a sample-carrier X is illustrated, wherein the carrier X is shown as being made from wire gauze wrapped as a cylinder. The wire gauze may be coiled in a plurality of layers or formed in any other suitable manner so long as it is capable of holding a sample which has been solidified thereon and which will fit into the pockets 48a. The solid sample is deposited on the sample-carrier X in the known manner prior to placing the carrier X within the appropriate pocket 48a.

In the use or operation of the apparatus of this invention, the sample-carriers X are prepared with the appropriate samples deposited as a solid thereon. Then, the cover 50 is removed from the rest of the housing 40 and the sample-carriers X with the samples thereon are disposed in the pockets 48a, in the positions desired. The cover 50 is then returned to the sealing position illustrated in the drawings and the wing nuts 56 are tightened to securely hold the cover 50 in position, with the pockets 48a completely enclosed, with the exception of the lowermost pocket 48a. Thus, the samples are all isolated from each other and from the heating zone H prior to actual use. Likewise, the samples are remote from and are isolated from the carrier gas which is introduced through the inlet tube T.

The motor drive 46 is initiated to start the rotation of the shaft 45 after the sample-carriers X have been positioned in the appropriate pockets 48a. With the heater H operating in the known manner and with the gas chromatograph apparatus C operating in the known manner, the samples can then be automatically discharged as each of the pockets 48a reaches the lowermost position. Thus, the samples are successively and automatically injected into the basket B over predetermined time intervals, without the necessity for the presence of a technician or operator.

The foregoing disclosure and description of the invention is illustrative and explanatory thereof and various changes in the size, shape and materials, as well as in the details of the illustrated construction, may be made within the scope of the appended claims without departing from the spirit of the invention.

I claim:

1. A sample injector for automatically injecting solid samples into a gas chromatograph apparatus and the like, comprising:

- (a) sample-evaporation chamber having an enlarged bore,
- (b) a perforated tubular basket mounted in said enlarged bore of said chamber and having an open upper end for receiving successive samples,
- (c) a conduit extending above said basket and having an inlet for introducing a carrier gas into the open upper end of the basket for flow therethrough,
- (d) the external width of said basket being smaller than the internal width of said bore of said chamber for the flow of the carrier gas through the basket and into said chamber, and
- (e) automatic injector means disposed above said conduit and in communication therewith for holding a plurality of samples and introducing each of said samples successively and automatically into the open upper end of the basket for disposition in the basket and in the flowstream of the carrier gas.

2. The structure set forth in claim 1, wherein said automatic injector means includes:

- (a) a movable holder having a plurality of pockets each of which is adapted to hold a sample carrier, and
- (b) means for moving said holder to successively align

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each of said pockets with said conduit for successively dropping the sample carriers into said conduit and said basket as each pocket is thus aligned to thereby successively deposit the sample carriers in said basket for vaporization of the sample thereon in said chamber. 5

3. The structure set forth in claim 1, wherein said automatic injector means includes:

- (a) a movable holder having a plurality of pockets each of which is adapted to hold a sample carrier, 10
- (b) means for moving said holder to successively align each of said pockets with said conduit for successively dropping the sample carriers into said conduit and said basket as each pocket is thus aligned to thereby successively deposit the sample carriers in said basket for vaporization of the sample thereon in said chamber, and 15
- (c) means for sealing off each of said pockets except the pocket aligned with said conduit to thus isolate each sample until released from said holder. 20

4. The structure set forth in claim 1, wherein said automatic injector means includes:

- (a) a rotatable disk having a plurality of circumferentially-spaced pockets in the periphery thereof, 25
- (b) a housing enclosing said disk for rotation therein, and
- (c) said housing having a discharge opening therein aligned with said conduit and successively alignable with each of said pockets as said disk is rotated. 30

5. The structure set forth in claim 1, wherein said automatic injector means includes:

- (a) a rotatable disk having a plurality of circumferentially-spaced pockets in the periphery thereof, 35
- (b) a housing enclosing said disk for rotation therein,
- (c) said housing having a discharge opening therein aligned with said conduit and successively aligned with said conduit and successively alignable with each of said pockets as said disk is rotated, and 40
- (d) means for rotating said disk for aligning each of said pockets successively with said discharge opening at predetermined time intervals whereby samples may be periodically discharged from said disk into said basket. 45

6. The structure set forth in claim 1, wherein said automatic injector means includes:

- (a) a rotatable disk having a plurality of circumferentially-spaced pockets in the periphery thereof,
- (b) a housing enclosing said disk for rotation therein,

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(c) said housing having a discharge opening therein aligned with said conduit and successively alignable with each of said pockets as said disk is rotated, and

(d) said housing having a removable cover adapted to be removed from the rest of the housing for exposing said pockets for filling same.

7. The structure set forth in claim 1, wherein:

(a) an annular space is provided around said basket for the flow of the carrier gas and vaporized sample therewith from the basket and through the chamber.

8. The structure set forth in claim 1, wherein said automatic injector means includes:

- (a) a housing having a circular recess formed therein,
- (b) a removable housing cover adapted to cover said circular recess,
- (c) a rotatable disk disposed in said circular recess for rotation relative to said housing,
- (d) said disk having a plurality of circumferentially-spaced pockets in the periphery of said disk for receiving sample carriers,
- (e) said housing having a discharge opening in communication with said conduit and in position for successive alignment with each of said pockets for discharging the sample carriers from the pockets successively, and
- (f) sealing material on said housing and said cover for sealing engagement with said disk to seal off each of said pockets.

9. The structure set forth in claim 1, wherein:

- (a) said perforated basket and said conduit are integral, and
- (b) releasable connecting means for connecting said chamber, basket and conduit, and automatic injector means are provided.

10. The structure set forth in claim 1, including:

- (a) heater means in the vicinity of said chamber for vaporizing each solid sample received in said basket.

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RICHARD C. QUEISSER, *Primary Examiner*.

VICTOR J. TOTH, *Assistant Examiner*.