Nov. 4, 1969 R. R. WALTON 3,476,119

SMOKING MACHINE

Filed Nov. 2, 1967 3 Sheets-Sheet 1

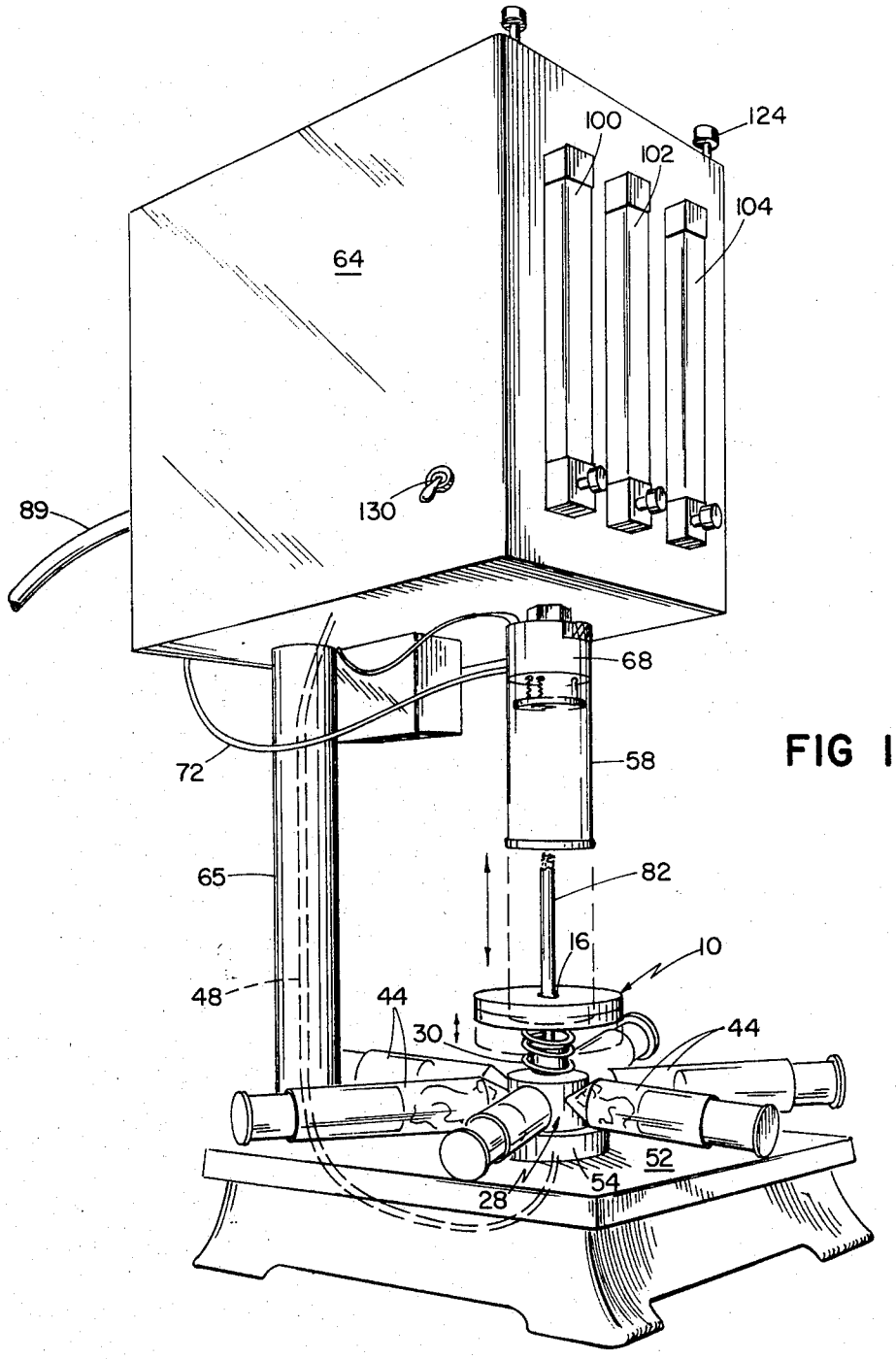


FIG 1

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SMOKING MACHINE

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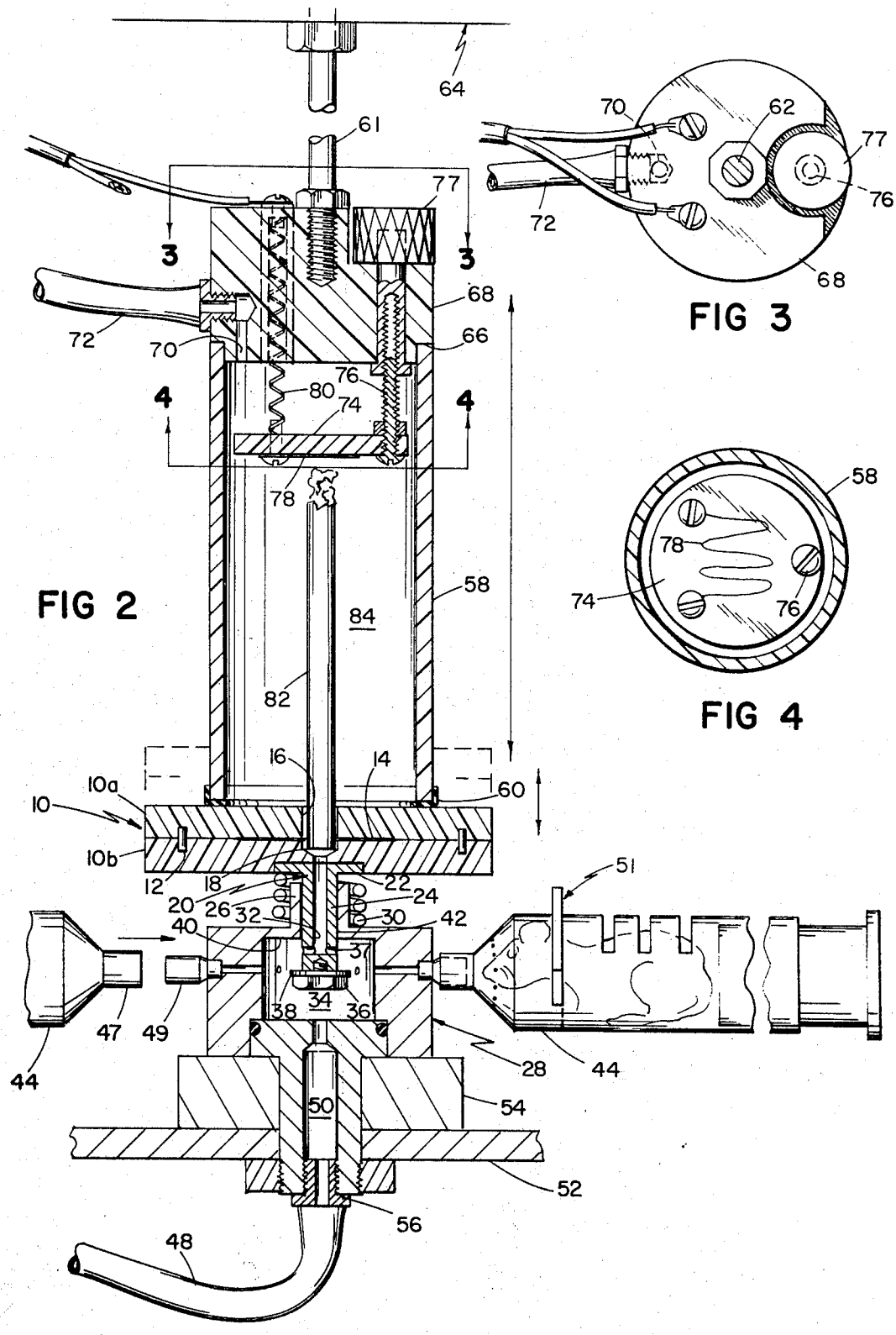


FIG 2

FIG 3

FIG 4

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SMOKING MACHINE

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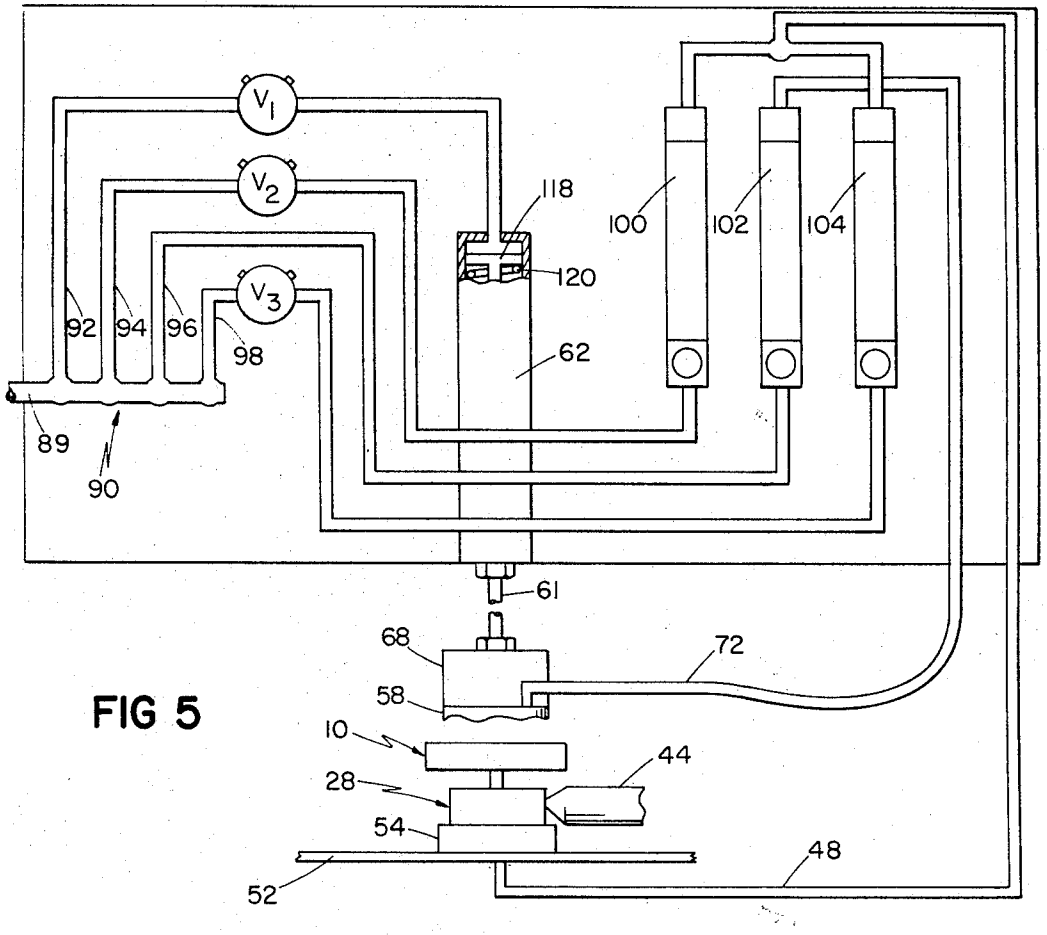


FIG 5

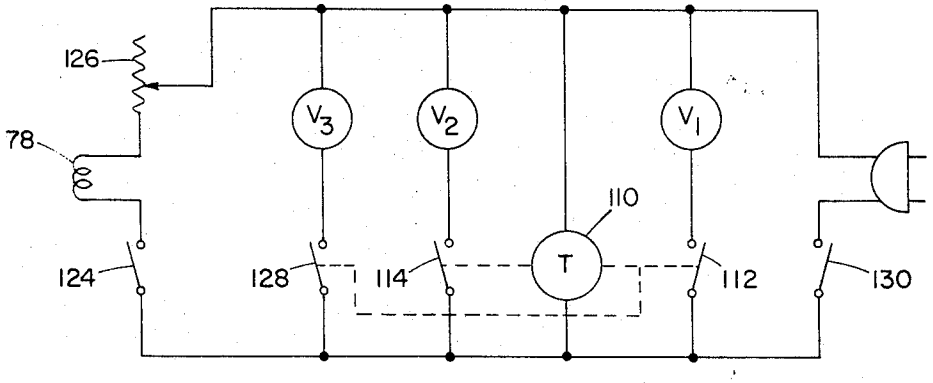


FIG 6

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3,476,119

SMOKING MACHINE

Richard Rhodes Walton, Boston, Mass., assignor to Council for Tobacco Research-U.S.A., New York, N.Y., an unincorporated committee

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U.S. Cl. 131—171 10 Claims

ABSTRACT OF THE DISCLOSURE

A laboratory machine for administering fresh mainstream cigarette smoke to the skin, lungs or other organs of animals on a controlled basis and simulating conditions of cigarette smoking in which the cigarette is held in a smoking chamber which is opened and closed by raising and lowering a cover. Air is supplied under pressure to the closed chamber and passes down through the cigarette to a mixing chamber to mix with diluting air supplied in controlled volume. A manifold provides smoke passages from the mixing chamber to one or more animal-holding stations. Smoke to the mixing chamber is controlled by a valve which is actuated by reciprocal movement in unison of the cover and the base on which it rests. A timer opens and closes the smoking chamber, controls the diluting air, and directs purging air into the mixing chamber at the desired intervals.

This invention relates to a new and improved machine for administering tobacco smoke to laboratory animals for experimental purposes.

The invention makes possible the administration of fresh mainstream cigarette smoke to laboratory animals almost as it comes from the cigarette, diluted to whatever degree desired, in "puffs" of any desired length, and at controllable intervals, the animals between the "puffs" being subjected to fresh air which purges the smoke path.

According to the invention I provide a machine for administering cigarette smoke to skin, lungs, or other organs of laboratory animals on a controlled basis and simulating conditions of actual smoking comprising a base having an opening to receive and hold a cigarette by its butt and a cover spaced from the base, together with mechanism for moving the cover and base toward and away from each other from a first position wherein the cigarette is exposed to a second position wherein the cover is in sealing engagement with the base to define therewith a smoking chamber which encloses the cigarette. A body is mounted adjacent the base having a mixing chamber in communication with the cigarette holding opening. This body is provided with one or more passages leading from the mixing chamber to one or more animal holding stations. Further, I provide an air supply control mechanism for supplying air under controlled pressure and flow rate to the smoke chamber so that the smoke will be forced through the cigarette from the lighted end through its butt and the opening to the mixing chamber and a duct communicating with the mixing chamber for supplying diluting air which will uniformly mix with and dilute the smoke. A valve is disposed between the opening and the mixing chamber to control the admission of smoke and an additional air supply is arranged for supplying purging air to the mixing chamber when the valve is closed, the latter serving when so closed to prevent the purging air from reaching and "smoking" the cigarette. A timer in my preferred embodiment actuates the mechanism which produces relative movement of the cover and base and controls the diluting and purging air supply in timed relation to the opening and closing of the smoke chamber. The invention further includes

the provision of a non-injurious flexible gasket mounted in the opening for gripping and sealingly engaging the butt of the cigarette and an incandescant filament of low mass mounted within the cover for lighting the cigarette so that the animal will receive the very first "puff." Likewise in a preferred embodiment the parts are so arranged that the mechanism for producing the relative movement between cover and base serves to lower the cover into sealing engagement with the base and then causes movement in unison of the cover and base, the valve being opened by such movement in unison in one direction and being closed by such movement in unison in another direction.

Further objects, features, and advantages of the invention will be apparent from the following detailed description taken together with the accompanying drawings illustrating a preferred embodiment.

FIG. 1 is a view in perspective of the entire machine;

FIG. 2 is a vertical section through a portion of the machine as seen in FIG. 1 showing the smoking chamber, ignition system, manifold chamber and duct arrangement for conducting the smoke to the laboratory animals in their holders;

FIG. 3 is a plan view taken on line 3—3 of FIG. 2 showing the ignition wiring connections;

FIG. 4 is a detail of the lighting filament from beneath taken on line 4—4 of FIG. 2.

FIG. 5 is a diagram of the air supply system; and

FIG. 6 is a wiring diagram of the control system.

Vertically movable base **10** comprises two flat sheets **10***a* and **10***b* of suitable material, such as acrylic plastic, locked together by fasteners **12**. Sandwiched between the two sheets is an apertured thin rubber gasket **14** which may be a piece of dental dam rubber or the like. The member **10***a* has a central opening **16** of suitable diameter to receive the butt of a cigarette **82**. The lower member **10***b* has a cavity **18** registering with the opening **16** and which is narrowed at the bottom and is adapted to communicate with the central passage **32** of fitting **20**. The rubber gasket **14** is designed non-injuriously to grip the cigarette, holding it upright in the center of the base, and likewise to simulate the human lips in preventing leakage of air around the outside of the cigarette to the cavity **18**.

The fitting **20** comprises an apertured member having an enlarged upper disc portion **22**, received in a corresponding circular recess in the bottom of the member **10***b* and serving to hold the base **10** in place. The fitting **20** has a depending nipple **24** which is received within the opening **42** of upstanding neck **26** of the body **28** which comprises a manifold housing. Surrounding the neck **26** and bearing on the bottom surface of the disc **22** is a coil spring **30** the bottom of which rests on the upper surface of the manifold body **28**. The spring **30** urges the fitting **20** upward to a position wherein the base **10** is positioned as shown in dotted lines in FIG. 2. The duct **32** within the fitting **20** places the cavity **18** in communication with the central mixing chamber **34** of the manifold **28**.

Carried by the bottom of the fitting **20** is a valve **36** which when the base and fitting are in their lower position is open to permit passage of smoke from the butt of the cigarette through passage **32** and openings **37** into the chamber **34**. When the fitting **20** and base **10** are in their upper position the valve seat **38** closes against the surface **40** of the chamber thereby completely sealing the chamber **34** from the entry of any further smoke from the cigarette and isolating the cigarette from the purging air which then enters the mixing chamber, as described below until the valve reopens.

The manifold chamber **34** communicates with a plurality of suitable animal holders **44** through passages therebetween as seen in FIG. 2. Each holder is detach-

ably mounted by means of connectors **47**, **49** and are provided with any necessary internal animal restraining device and smoke baffle indicated generally by the number **51**. The construction of the animal holder itself does not form part of the present invention. It will be understood that the invention is not limited to the employment of any particular number or type of animal holders. I may provide one or more, within the limits of efficient supply of smoke form the number of cigarettes "smoked" in the smoking chamber, which, ordinarily will be but a single cigarette.

The chamber **34** also communicates with a diluting and purging air tube **48** through passage **50**. The manifold body **28** and the associated part **54** are mounted on a stationary platform **52**. The tube **48** is attached to the manifold body by means of a suitable connection **56**.

Now referring to the upper portion of FIG. 2, it will be seen that I provide an open mouthed cover **58** preferably comprising a transparent plastic cylinder or bell, which is shown in FIG. 1 in its raised position and in FIG. 2 in its fully lowered position. A gasket **60** surrounds its lower rim for sealing engagement with the upper surface of the base **10**. The cover **58** when lowered forms with the base a smoking chamber. It is raised and lowered by rod **61** of piston **118** of cylinder **62** (FIG. 5) mounted within the upper housing **64** (FIG. 1). The latter is supported above the platform **52** by hollow post **65**. The upper rim **66** of the cover **58** is sealed to a body **68** which is provided with an internal duct **70** communicating with the smoking air supply tube **72**. Beneath the body **68** is the filament holder **74** mounted by means of an adjusting screw **76**. The filament **78** itself is a zig-zag flattened piece of suitable chrome nickel wire through which an electrical current is passed and which coolers immediately when the current stops flowing. Electricity may be so applied to the filament **78** through a pair of spring-like wires **80** which permit the holder **74** to be adjusted vertically by the screw **76** turned by knob **77**. The external connections are shown in FIG. 3.

It will be seen that when piston rod **61** is lowered, it will in turn lower the cover **58** so that the gasket **60** on its lower rim contacts the surface of the base **10** to form the smoke chamber. After the gasket makes initial contact, the piston rod continues downward causing the cover to push the base down against spring **30** from the position shown in dotted lines to the position shown in solid lines in FIG. 2 thereby opening valve **36** so that air may flow through the cigarette from the tube **72** and the smoke from the cigarette will reach the manifold chamber **34**. Prior to the first cycle the filament holder **74** is manually adjusted to a suitable height so that filament **78** will contact the top of the cigarette **82** which may be of standard or any king size length. The lighter switch is manually closed to cause the filament to incandesce on the first downward stroke to ignite the cigarette.

In order to provide smoking, purging, and diluting air in the right amounts at the right time, I provide the air systems shown diagrammatically in FIG. 5. There are four distinct systems of ducts and tubes supplied with air under suitable pressure from a common source (not shown) by means of inlet **89** and manifold **90**, and branches **92**, **94**, **96**, and **98**. Three of the systems are provided with control type manometers **100**, **102**, and **104** of a well-known type each of which includes a valve having a control knob surmounted by a vertically arranged transparent case having a hollow ball or the like therein adapted to rise according to the quantity of air passing upwardly therethrough, as shown in FIG. 1. Branch **92** supplies air to actuate the piston **118** in the cylinder **62** to force the piston rod **61** downwardly to close the smoking chamber and open the valve **36**. Branch **94** is arranged to provided purging air through the base **52** to the mixing chamber **34** and thence through the manifold **28** to the animals. This system is arranged to operate upon completion of the smoking cycle so that the animal will receive

fresh air in between each "puff." Branch **96** with its manometer **102** supplies air through tubes **72** to the top of the smoking chamber **84** to smoke the cigarette. This air supply is on at all times when the machine is in use, the rate of flow being adjustably controlled by the manometer **102**, so that when the cover **58** is sealed against the top of the base **10** air from this system will pass from the cigarette chamber through the length of the cigarette, just as if a smoker had taken a puff. Branch **98** supplies diluting air to the manifold chamber **34** in desired quantity controlled by manometer **104** to dilute the smoke before it passes to the animal holders.

In order to operate the systems in proper timed relation I provide several maunal switches and an electrical timer T with associated microswitches and needed solenoid valves as shown in the wiring diagram of FIG. 6. The timer **110** is arranged to activate at desired intervals the piston-cylinder microswitch **112** for opening and closing the chamber **84**, the diluting air microswitch **128** and the purging air supply microswitch **114**. These switches in turn operate solenoid valves V_1, V_3, and V_2, respectively. The switch **112** when closed opens valve V_1 to supply air to the top of the cylinder **62** forcing the piston **118** downwardly against the coil spring **120** and closing the cover of the smoking chamber. Simultaneously the timer closes switch **128** starting the supply of diluting air to the mixing chamber **34**. The timer **110** can be arranged to retain the microswitches **112** and **128** closed for any desired period of time, in this instance two seconds. Opening of the switch **112** closes valve V_1, permitting the spring **120** (FIG. 5) to force the piston **118** and piston rod **61** back to their upper positions, opening the cigarette smoking chamber and exposing the cigarette to the atmosphere as though it had been removed from a smoker's lips. At the same time V_3 is closed by the timer **110** and diluting air is turned off, valve **36**, of course, closes the moment the spring **30** can force the base **10** back to its upper position.

When the smoking cycle is thus completed, the purge microswitch **114** is activated by the timer for a period of time adjustable as desired, say 32 seconds. This opens the purging valve V_2 supplying purging air at a flow rate controlled by manometer **100** to the chamber **34** and thence to the animal holders, giving the animals needed fresh air between "puffs."

In order to light the cigarette, there is provided a manual switch **114** which, as previously described, is momentarily closed immediately before the beginning of the first cycle. A rheostat **126** may be provided to permit adjustment of the voltage applied to the low mass filament **78**. It is desirable thus to be able to administer the very first puff of a newly lighted cigarette to the animals while at the same time adding a minimum amount of heat to the system.

Diluting air is controlled by the manometer **104** and air will flow through the diluting system whenever the microswitch **128** is closed by the timer causing valve V_3 to open and remain open until the smoking cycle ends. A main on and off switch **130** controls the entire electrical system.

In operation a cigarette **82** is first placed in the opening in the base **10** where it is lightly gripped in sealing engagement by the gasket **14** and the smoking air supply under pressure is turned on. The filament holder **74** has previously been adjusted by knob **77** for the proper height of the filament **78** for ignition. The main switch **130** is closed. The timer **110** now takes over to open valves V_1 and V_3 and the cover **58** is thereupon lowered against the upper surface of the base **10**, and then moves further downwardly to open valve **36**; meanwhile the diluting air is flowing to the chamber **34**. Air from the tube **72** will now be forced through the cigarette from the top down, simulating actual smoking. The undiluted smoke travels into the manifold chamber **34** where it is diluted by the diluting air from the tube **48** and then passes to the animal holders **44** through the passages therebetween. After the one or more animals have been given a "puff" of say two

seconds, the timer opens switches **112** and **128** and spring **120** causes the piston rod **61** to elevate the covers **58** permitting the base **10** to be raised by its spring **30** to close valve **36**. Microswitch **114** closes at this point to open valve V_2 so that purging air will be supplied through tube **48**, duct **50** and said passages to the animal holders, the diluting air supply having been cut off by the closing of valve V_3.

By suitable adjustment of the manometers and the electrical timing system, smoke, diluting air, and purging air may be supplied in any selected quantities and for desired periods of time to the laboratory animals. The animals are held in special containers with their heads and/or bodies in chambers of predetermined volume so that administration of the smoke can be effectively maintained. The invention makes possible mounting of the animal holders in very close proximity to the cigarette butt thereby providing the shortest possible path for the mainstream smoke from the cigarette. In this respect the machine of the invention approximates the conditions of smoking by human beings where the smoke travels directly from the lips to the throat and lungs. It will thus be seen that my novel machine permits a high degree of control and simulation of the actual human smoking process in the conduct of tests of the effect of tobacco smoke on laboratory animals.

I claim:

1. In a machine for administering fresh mainstream cigarette smoke to laboratory animals on a controlled basis and simulating conditions of actual smoking, the improvement comprising the combination of:

a base having an opening to receive and hold a cigarette by its butt,

a cover spaced from the base,

mechanism for producing relative movement of the cover and base toward and away from each other from a first position wherein the cigarette is exposed to a second position wherein the cover is in sealing engagement with the base to define therewith a smoking chamber enclosing the cigarette, and

an air supply in communication with the smoking chamber to force smoking air through the cigarette toward its butt and through said opening.

2. The combination as claimed in claim **1** including a body mounted adjacent said base having a mixing chamber in communication with said opening and at least one smoke passage leading from said mixing chamber to an animal holding device.

3. The combination as claimed in claim **2** including an air suplpy communicating with said mixing chamber for supplying smoke diluting air thereto.

4. The combination as claimed in claim **3** including a valve between said opening and said mixing chamber for controlling the admission of smoke thereto.

5. The combination as claimed in claim **4** including an air supply in communication with said mixing chamber for supplying purging air thereto during the intervals when said valve is closed.

6. The combination as claimed in claim **5** including a timer for actuating the mechanism which produces relative movement of the cover and base and for controlling the diluting and purging air supplies in timed relation to the opening and closing of the smoking chamber.

7. The combination as claimed in claim **6** including a non-injurious flexible gasket mounted in said opening for gripping and sealingly engaging the butt of the cigarette.

8. The combination as claimed in claim **1** including an incandenscant filament mounted within said cover for lighting the cigarette.

9. The combination as claimed in claim **4** wherein said first named mechanism after said cover is in sealing engagement with said base causes further movement in unison of said cover and platform and wherein said valve is opened and closed by such movement in unison.

10. A machine for administering cigarette smoke to laboratory animals on a controlled basis and simulating conditions of actual smoking which comprises:

a base provided with an opening to receive and hold the butt end of a cigarette,

said base being vertically movable between an upper position and a lower position,

a vertically movable cover mounted above the base and having a lower rim adapted when the cover is lowered to seal against the base and define therewith a smoking chamber,

an apertured fitting below the base and on which the latter is mounted,

a manifold body fixedly mounted beneath the base and having an opening slidably receiving a portion of the fitting,

a coil spring surrounding the fitting and acting between the bottom surface of the base and the top surface of the manifold body to urge the base to its upper position,

a piston and cylinder mounted above and supporting the cover and arranged to move the same vertically from a first position remote from the base, exposing the cigarette, then to a second position wherein the cover is sealed against the base to form the smoke chamber, and finally to move the cover and base in unison further downwardly to the latter's lower position,

said manifold body having an internal mixing chamber in communication through said fitting with said cigarette holding opening and being provided with passages to a plurality of animal holding stations for supplying smoke thereto,

a valve within said mixing chamber mounted on the end of the portion of said fitting which is received in said manifold body, said valve seating against the internal surface of said mixing chamber to close off the entry of smoke except when said base is in its lower position,

an air pressure supply including a tube in communication with said mixing chamber for supplying diluting air thereto,

an air pressure supply in communication with said smoking chamber through said cover so that smoke will pass downwardly through the cigarette to the mixing chamber when the smoking chamber is closed,

a purging air pressure supply for supplying purging air through said tube to the mixing chamber when the valve is closed, and

a timer for actuating the diluting and purging air supplies and the movements of said piston and cylinder in timed relation to each other.

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JOSEPH S. REICH, Primary Examiner

U.S. Cl. X.R.

73—23; 131—175, 179, 215