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Wagner et al.

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[54] SMOKING MACHINE

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[21] Appl. No.: **229,268**

[52] **U.S. Cl.**.....**131/171 R**, 131/182, 73/23

[51] **Int. Cl.**.....**A24f 13/00**

[58] **Field of Search**.....131/171, 172, 182; 73/23, 28

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Primary Examiner—Joseph S. Reich

Attorney—Granville M. Brumbaugh et al.

[57] **ABSTRACT**

A smoking machine includes a pair of parallel disks alternately rotatable about a common axis and each provided with a number of holders for cigarettes or other smokable articles. Means is provided for automatically lighting the cigarettes. The holders are spaced apart at equal intervals in circular paths respectively centered on the axis of the disks. A shuttle valve is mounted at a smoking station between the two disks and adjacent to each to receive a continuous stream of smoke from the cigarettes in sequence and channel it to a desired location, at which there may be, for example, a holder for an experimental animal. The valve shuttles between the two disks to take a puff on each cigarette as it arrives at the smoking station. The cigarettes carried on one disk are thus puffed alternately with those carried on the other. "Reverse puffing" is employed: i.e., chambers are placed over the lighted ends of the cigarettes and pressurized, so that the smoke is delivered at atmospheric pressure. While a puff is being taken on any given cigarette on one of the disks at the smoking station, the other disk is rotated by an indexer to bring the next cigarette to the smoking station, which is puffed in the same way. The process continues for a number of rotations of the disks, until the cigarettes are smoked to the desired extent, whereupon they are automatically ejected.

11 Claims, 6 Drawing Figures

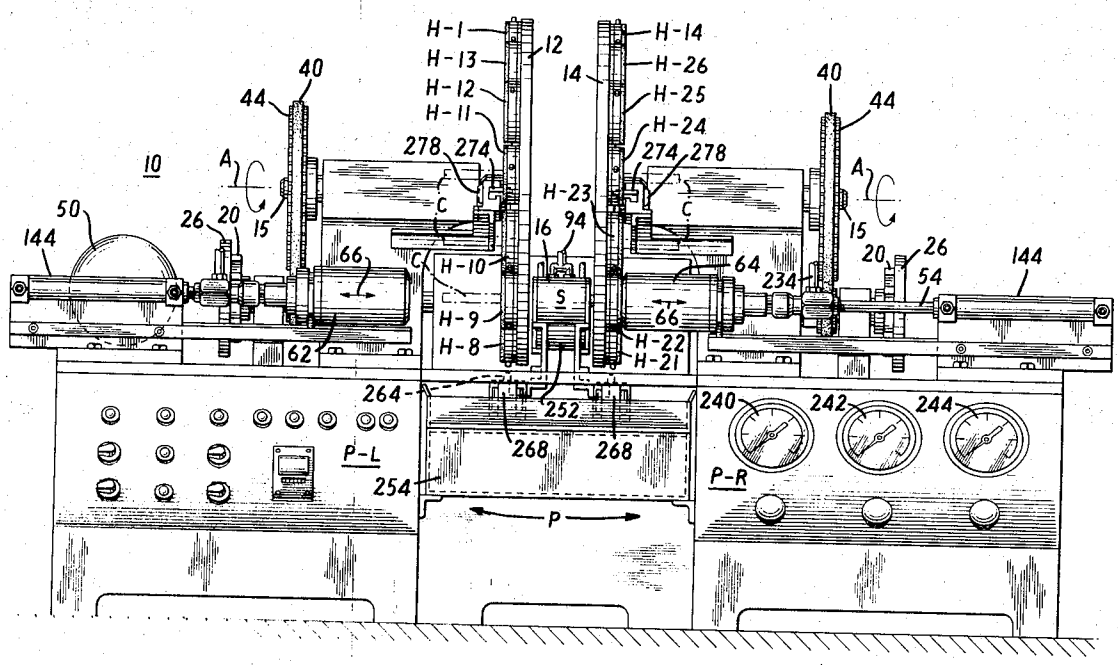


FIG. 1

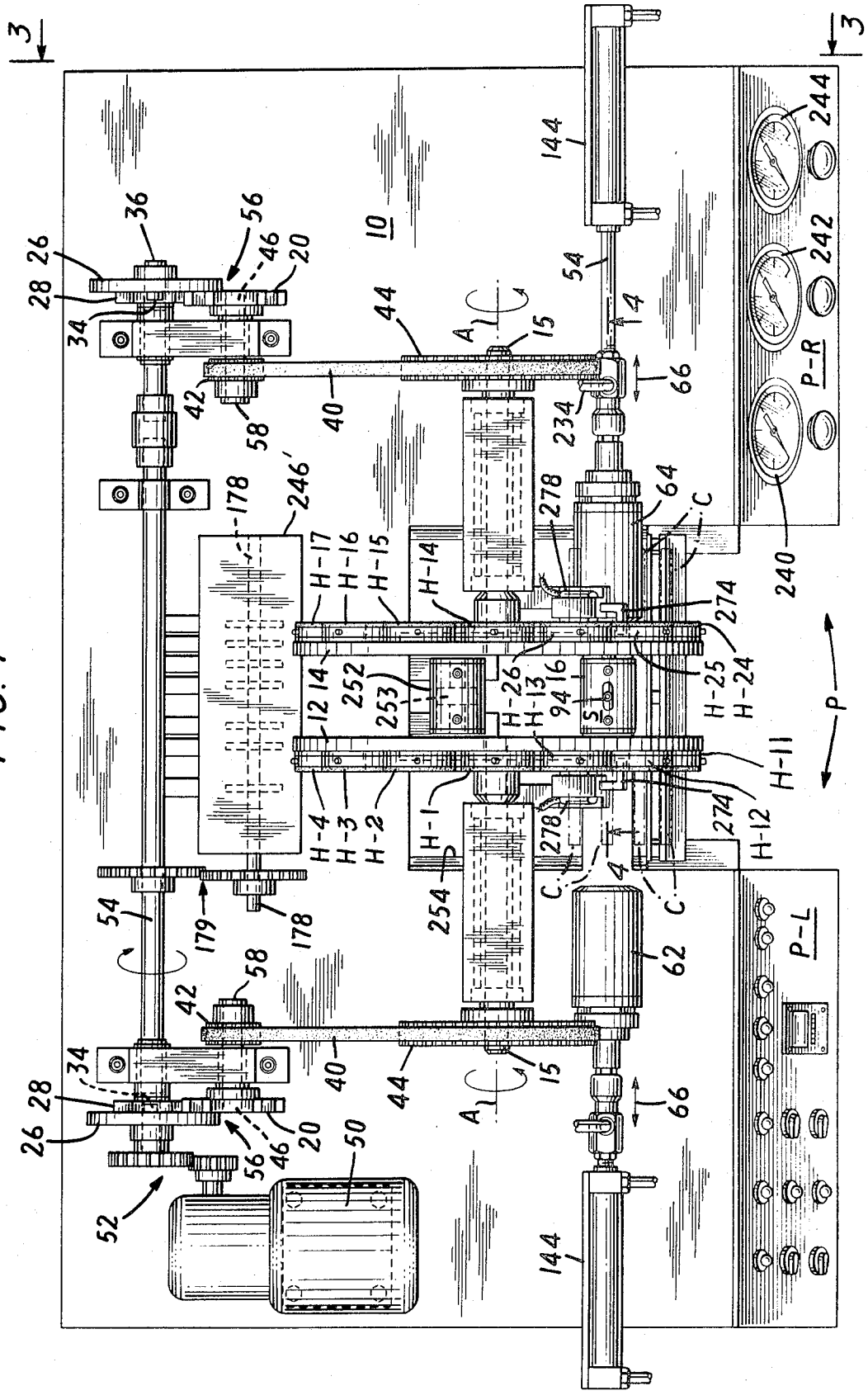
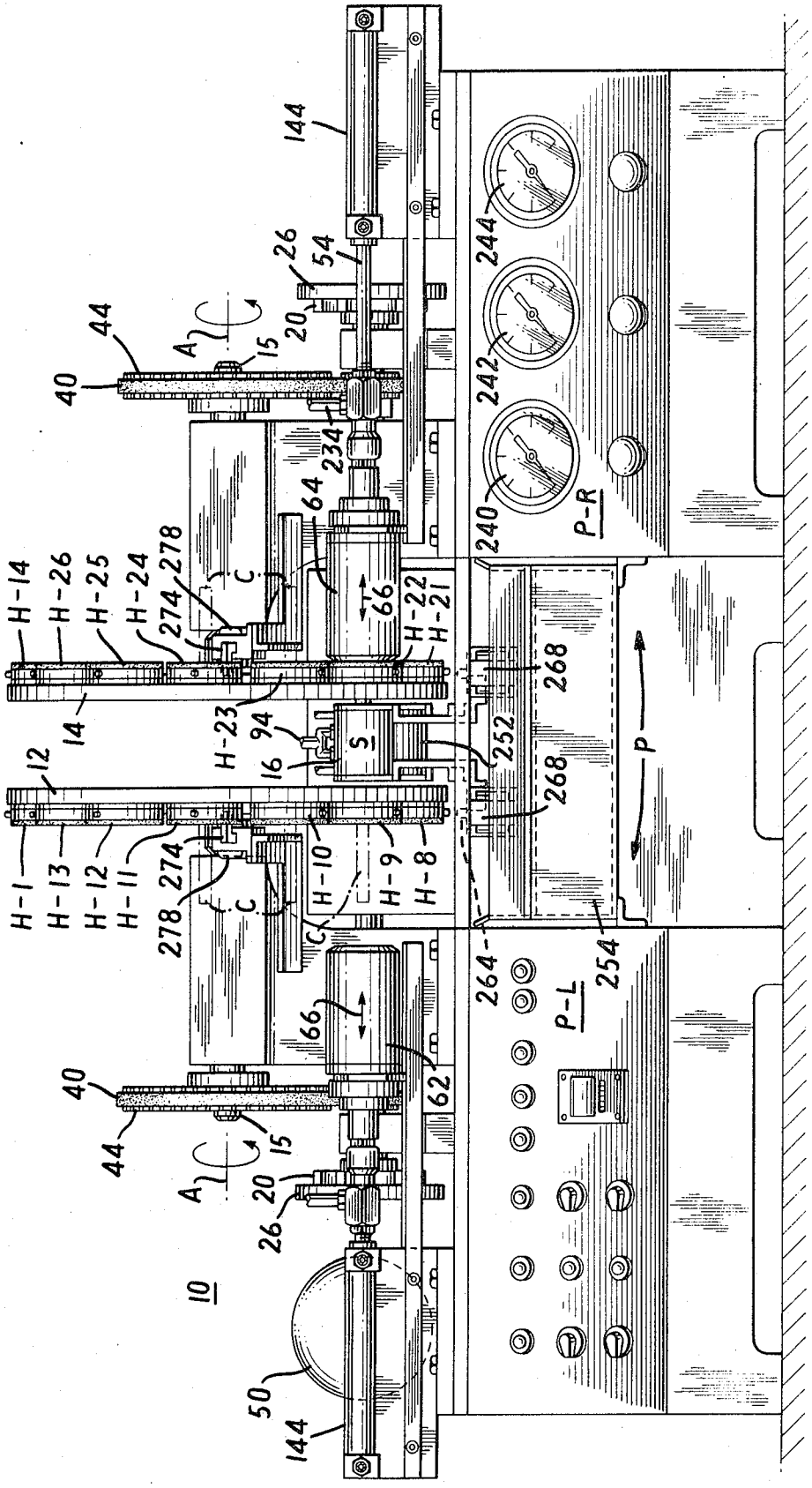

3
3
10
144
244
242
240
P-R
P-L
P
A
A
4
4
4
15
15
20
26
28
34
36
40
42
44
46
50
52
54
56
58
62
64
66
178
179
234
246'
252
253
254
274
278
H-1
H-2
H-3
H-4
H-11
H-12
H-13
H-14
H-15
H-16
H-17
H-24
H-25
H-26
C
C
C
S

FIG. 2


10
144
26
54
20
44
40
A
15
234
64
66
62
50
H-14
H-26
H-25
H-24
274
278
C
H-22
H-21
14
H-23
94
16
S
12
H-1
H-13
H-12
H-11
H-10
H-9
H-8
252
268
P
264
254
P-L
P-R
240
242
244

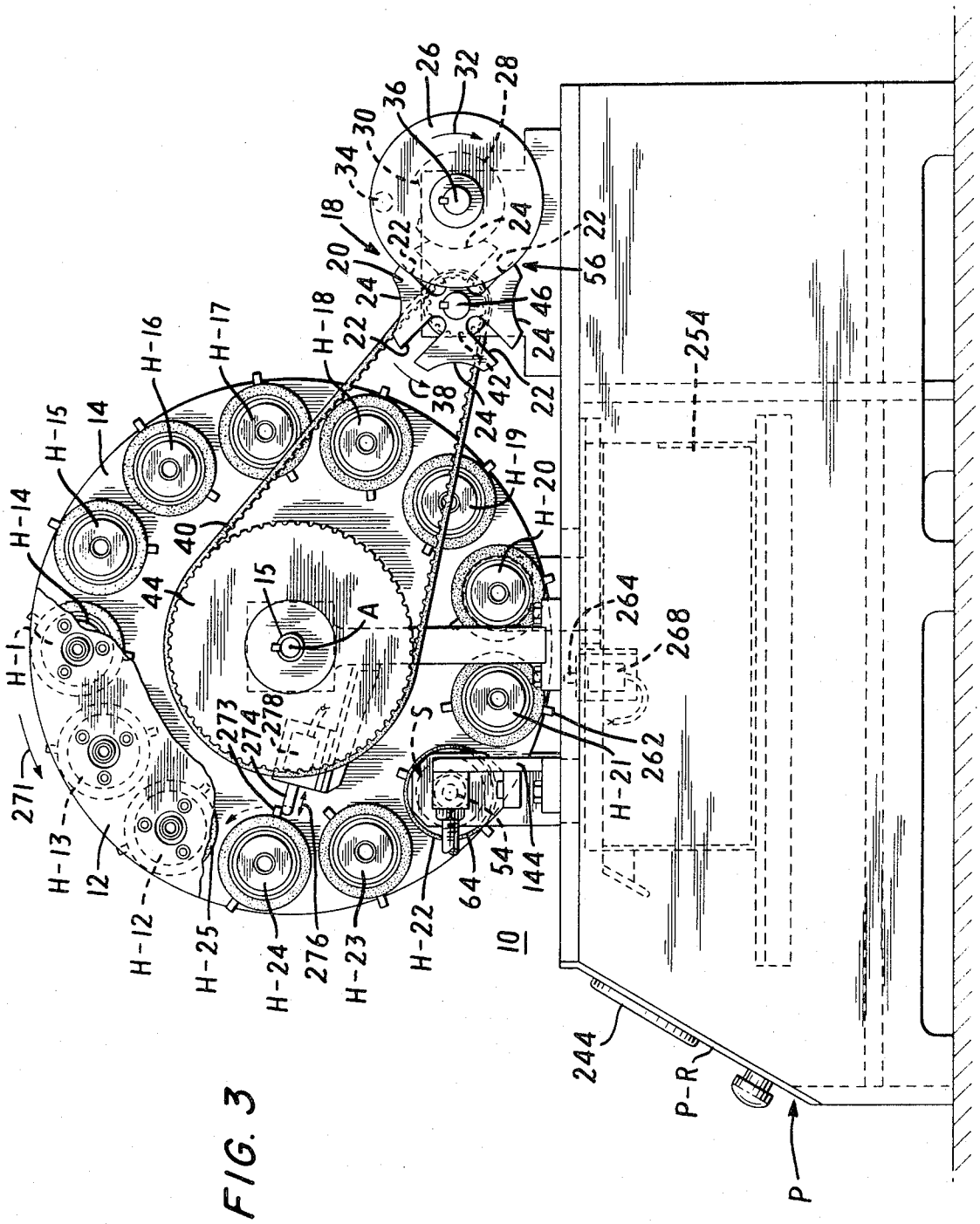

H-1
H-12
H-13
H-14
H-15
H-16
H-17
H-18
H-19
H-20
H-21
H-22
H-23
H-24
H-25
271
12
14
15
A
18
20
22
24
26
28
30
32
34
36
38
40
42
44
46
54
56
64
144
254
262
264
268
273
274
276
278
5
10
244
P-R
P

FIG. 3

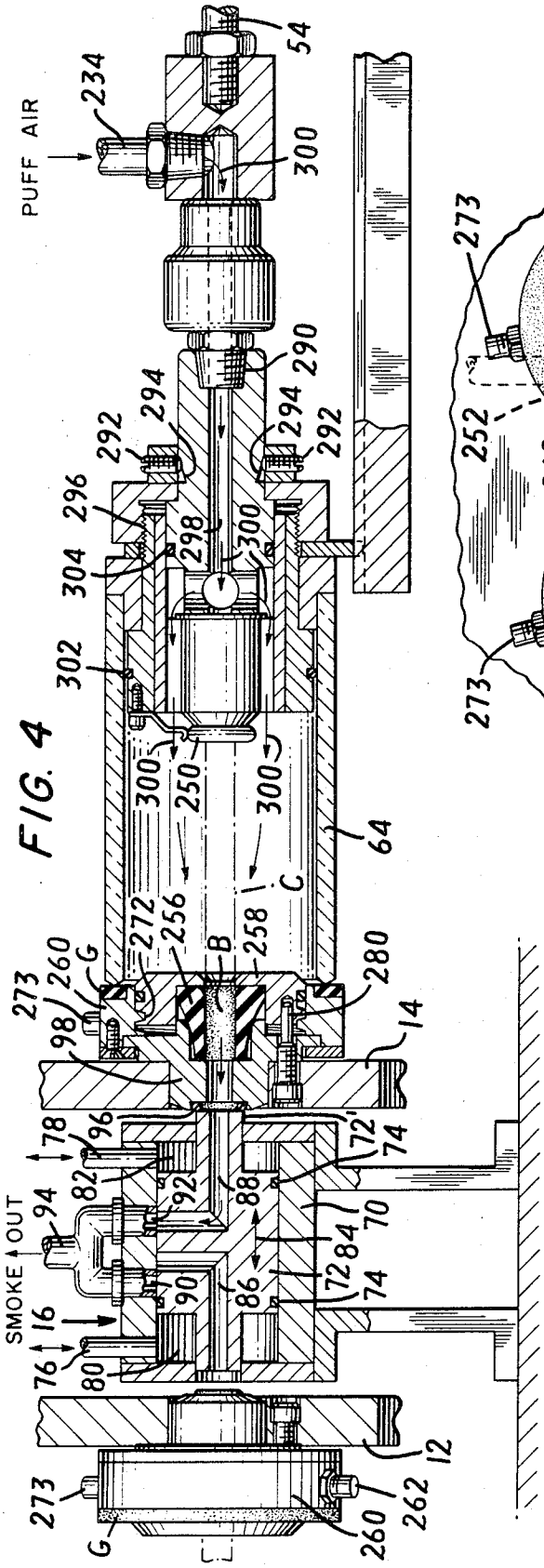

PUFF AIR
SMOKE OUT
234
54
300
290
294
292
296
304
298
302
250
64
272
256
258
B
C
260
G
273
98
280
14
78
96
72
74
82
92
88
70
94
84
90
86
16
76
80
12
262

FIG. 4

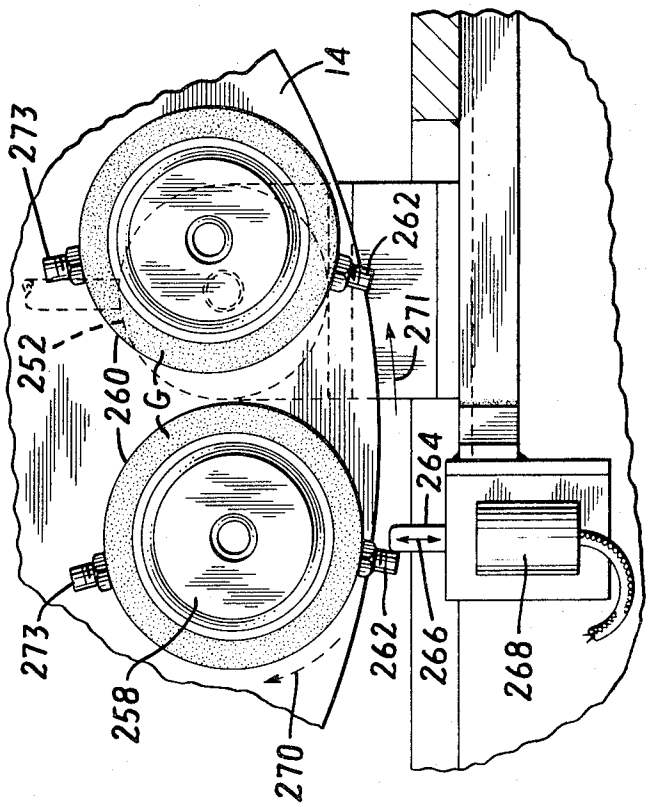

14
273
262
271
252
260
G
264
273
258
262
266
268
270

FIG. 5

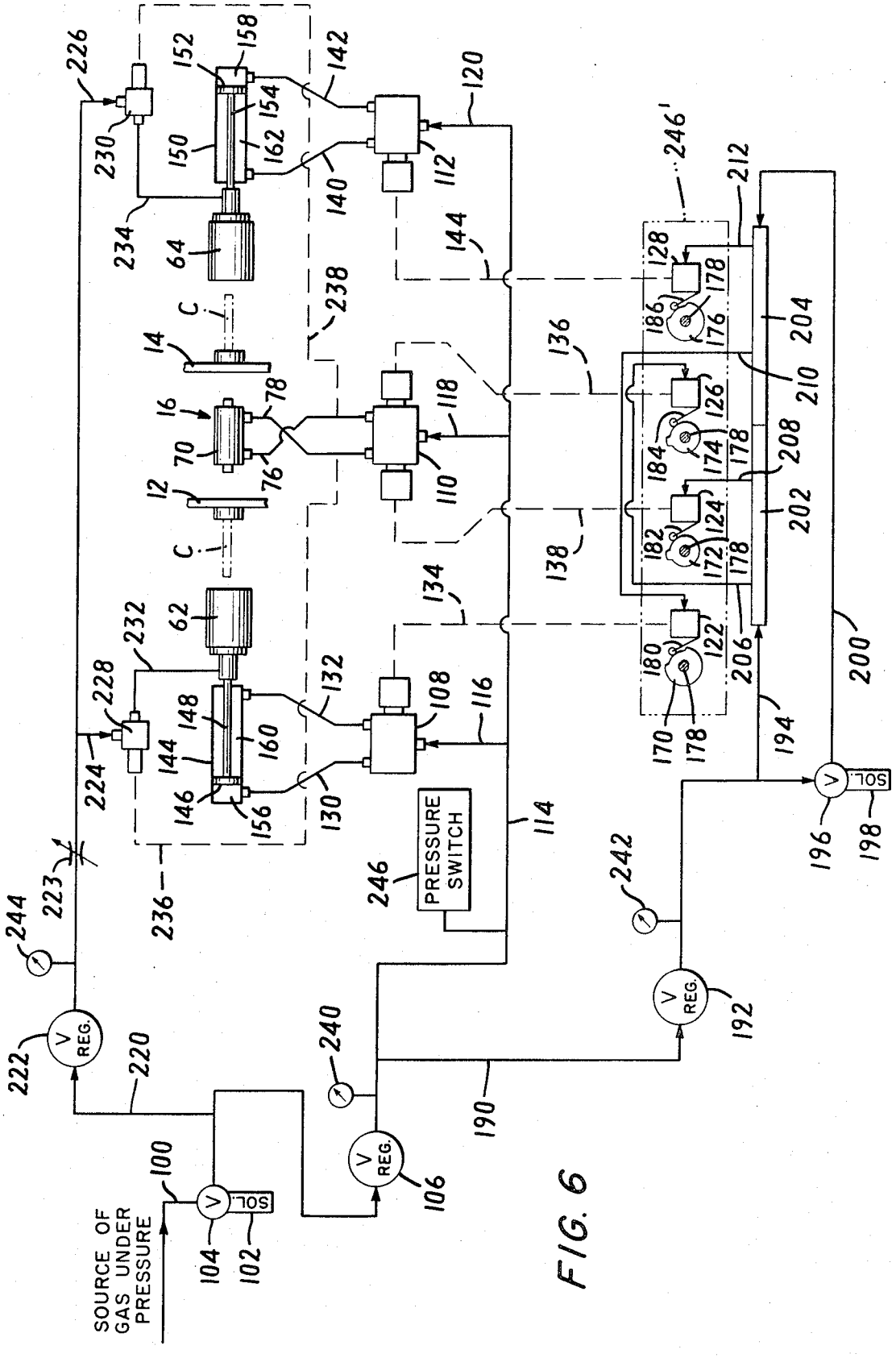


FIG. 6

SMOKING MACHINE

BACKGROUND OF THE INVENTION

This invention relates to smoking machines and, more particularly, to a novel and highly-effective smoking machine which will generate a continuous or intermittent stream of smoke under standardized conditions.

The need has arisen during research on smoking and health for a quiet, trouble-free, inexpensive, universally-accepted smoking machine that is standardized yet sufficiently flexible or adaptable to provide variable puff characteristics and generally to simulate the smoking activities of a human being. Smoking machines are known, but they have not heretofore adequately filled this need.

SUMMARY OF THE INVENTION

An object of the invention is to fill the need indicated above. In particular, an object of the invention is to provide a standardized yet flexible or adaptable smoking machine for use with animals, filters, or other agents intended to be exposed to smoke from cigarettes and the like, in order to advance research on the relation of smoking to health.

The foregoing and other objects are attained in accordance with the invention by the provision of a smoking machine which in a preferred embodiment comprises a pair of disks each rotatable about an axis, a plurality of holders on each of the disks, the holders being adapted to hold smokable articles such as cigarettes and being spaced apart at equal intervals in a circular path centered on the disk axis, and a valve mounted at a smoking station adjacent to each of the disks to receive smoke from the smokable articles and channel it to a desired location.

A shuttle is provided for shuttling the valve to form seals around the butt ends of the smokable articles alternately on one of the disks and on the other of the disks at the smoking station. Indexing means is provided for rotating the disks stepwise and alternately about their respective axes to bring successive ones of the holders on each of the disks to the smoking station.

A pair of pressure chambers is also provided, together with reciprocating means for moving the pressure chambers alternately to positions respectively surrounding one of the smokable articles on each of the disks at the smoking station and respectively forming seals around the lighted ends of the smokable articles and to positions respectively spaced apart from the disks and the smokable articles to permit indexing of the disks.

An air supply alternately elevates the air pressure within the pressure chambers to a level above atmospheric pressure to cause air to flow through the smokable articles at the smoking station. The actuation of the reciprocating means to form the seal on one of the disks is in conjunction with actuation of the air supply to raise the air pressure in the corresponding pressure chamber, and the actuation of the reciprocating means to form the seal on the other of the disks is in conjunction with the actuation of the air supply to raise the air pressure in the other pressure chamber. The actuation of the reciprocating means to break the seals is prior to the actuation of the indexing means.

The smokable articles are thus sequentially indexed to the smoking station and puffed in a manner that is flexible and adapted to simulate the smoking activities of a human being, and substantially all of the smoke passing through the smokable articles is delivered to the desired location.

In the typical case where the smokable articles are cigarettes, each of the holders is formed with a bore into which the butt end of the associated cigarette extends, and the bore is horizontal so that the cigarette extends in a horizontal direction.

Preferably, there are substantially 15 of the holders on each of the disks and each of the smokable articles is given a puff having a volume of substantially 35 ml., a duration of substantially 2 seconds, and a repetition rate of substantially one per minute.

The stepwise indexing is preferably effected by means comprising a pair of geneva movements.

The shuttle preferably comprises a double-acting piston-cylinder assembly.

The reciprocating means preferably comprises a pair of double-acting piston-cylinder assemblies one of which moves one of the pressure chambers and the other of which moves the other of the pressure chambers.

Control valve means is preferably provided for controlling the piston-cylinder assemblies, together with cam means for controlling the control valve means and motive means for powering the cam means.

The motive means also powers the indexing means, so that all movements of the machine are controlled by a single source, whereby they are readily maintained in synchronism.

BRIEF DESCRIPTION OF THE DRAWING

An understanding of other aspects of the invention can be gained from a consideration of the following detailed description of the preferred embodiment thereof, in conjunction with the appended figures of the drawing, wherein:

FIG. 1 is a top plan view of a preferred embodiment of a smoking machine in accordance with the invention;

FIG. 2 is a front elevational view of the machine;

FIG. 3 is a side elevational view along the line 3—3 of FIG. 1;

FIG. 4 is a sectional view on a larger scale along the line 4—4 of FIG. 1;

FIG. 5 is a fragmentary side elevational view on a larger scale of a portion of the machine; and

FIG. 6 is a schematic diagram of a pneumatic system according to the invention for controlling the movements of the machine.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIGS. 1–3 show a smoking machine 10 constructed in accordance with the invention. The machine 10 includes a pair of disks 12, 14 each rotatable about an axis A. The axes of the two disks are preferably identical, but it is within the scope of the invention to mount the disks for rotation about separate axes.

A plurality of holding means is provided on the disks, there being about 15 holders on the disk 12 and about 15 holders on the disk 14. By way of a specific example, the drawings show 13 holders H–1 through H–13 on the disk 12 and 13 holders H–14 through H–26 on the disk

14. A reason for employing roughly 15 holders on each disk or about 30 holders altogether is that this permits a two-second puff on each of 30 cigarettes in each minute, which means that each cigarette is smoked at a rate which is substantially the same as the rate at which a person might smoke a cigarette.

The holding means H–1, H–2, H–3, . . . H–*n* are adapted to hold smokable articles such as cigarettes in a horizontal position approximating the position in which they are held by a person when smoking. Representative cigarettes C are shown in phantom outline in FIGS. 1, 2, 4, and 6. It is of course within the scope of the invention to insert other smokable articles such as cigars in the holding means H–1 through H–*n*. It is even possible in principle to insert articles such as pipes in the holding means, provided only that the holding means have apertures adapted to form seals around the pipe stems, which are generally not cylindrical but considerably flattened as compared to cigarettes and cigars.

The holding means H–1 through H–13 are spaced apart at equal intervals on the disk 12 in a circular path centered on the axis A, and the holding means H–14 through H–26 are spaced apart at equal intervals on the disk 14 in a circular path also centered on the axis A. While the disks 12 and 14 are rotatable about a common axis A, they are physically on separate axles 15. They are indexed in rotation stepwise and alternately in a manner described in detail below.

In accordance with the invention, "reverse puffing" is preferably employed: i.e., instead of creating a partial vacuum at the butt ends of the cigarettes or other articles inserted in the holders H–1 through H–n in order to take a puff, a pressure greater than atmospheric is created around the lighted ends. The smoke flowing through the cigarettes or other articles is therefore delivered at atmospheric pressure, which offers certain advantages.

The smoke must be received and channeled to a desired location, at which there may be for example a holder in which an experimental animal is placed, and, to serve this purpose, a shuttle valve arrangement is provided. A valve 16 is mounted between the disks 12 and 14 at a smoking station S, together with shuttle means for shuttling the valve 16 to form seals around the butt ends of the smokable articles alternately on one of the disks, for example the disk 12, and on the other of the disks, for example the disk 14, at the smoking station S. The shuttle means for shuttling the valve back and forth between the disks 12 and 14 comprises a piston-cylinder assembly and a pneumatic system for actuating it. This is illustrated in FIGS. 4 and 6 and described in detail below.

Indexing means 18 (see especially FIG. 3) is provided for rotating the disks 12 and 14 stepwise and alternately about the axis A to bring successive ones of the holding means H–1 through H–*n* on each of the disks 12 and 14 to the smoking station S. The indexing means 18 preferably comprises two geneva movements 56, 180° out of phase, as shown in FIGS. 1 and 3.

The geneva movement is characterized by dependability, accuracy of positioning and timing, ruggedness, low maintenance cost, and smoothness of operation. It comprises a star wheel 20 (see especially FIG. 3) with four slots 22 separated by four concave surfaces 24. A drive wheel 26 is formed with a circular shoulder 28 complemental to the concave surfaces 24 and adapted to hold the star wheel 20 stationary as the wheel 26 rotates in the direction indicated by an arrow 32. The drive wheel 26 is also formed with a pin 34 in line with a concave shoulder portion 30 and the axis of rotation 36 of the drive wheel. When the pin 34 enters one of the slots 22 the shoulder 28 is out of contact with the adjacent surfaces 24, and the concave portion 30 permits rotation of the star wheel 20 in a direction indicated by an arrow 38 through an angle of 90°, whereupon the pin 34 leaves the slot 22 and the surface 28 engages the succeeding surface 24 on the star wheel 20 and holds the star wheel against rotation until the next revolution of the wheel 26.

The star wheels 20 at opposite ends of the shaft 58 (FIG. 1) thus make one revolution, in stepwise increments of 90° each, for every four revolutions of the drive wheels 26. Because the pins 34 are 180° out of phase (FIG. 1), the stepwise movements of one star wheel alternate with those of the other. This imparts alternate stepwise indexing movements to the disks 12 and 14, which bring the cigarettes C or other smokable articles on the two disks alternately to the smoking station S. As FIG. 1 shows, two notched timing belts 40 are provided, one for each of the disks 12 and 14, so that they rotate alternately, which they are adapted to do since they are mounted on separate axles 15. The drive wheels 26 are mounted on, and turn with, the shaft 54, which is powered by motive means including a synchronous electric motor 50 and a gear train 52. The shaft 54 through identical gear trains 56 near opposite ends thereof turns shafts 58 (FIG. 1) at the same speed and in the same direction. The sprockets 42 are mounted on the shafts 58 so that the timing belts 40, the sprockets 44 and hence the disks 12 and 14 on opposite sides of the machine are maintained in synchronism, through 180° out of phase.

In this way, the two disks 12 and 14 are rotated stepwise and alternately about their respective axes A to bring successive ones of the holding means on alternate disks to the smoking station S. The operation and timing of the indexing means is also synchronized with the operation of the pneumatic structure shown schematically in FIG. 6 and described in detail below.

In order to puff the cigarettes or other smokable articles at the smoking station S, a pair of pressure chambers 62 and 64 is provided. The pressure chambers 62 and 64 are adapted to be reciprocated as shown by double-headed arrows 66 in FIGS. 1 and 2 so that they are respectively placed over the two cigarettes C or other smokable articles at the smoking station S. The chambers 62 and 64 thus are moved alternately to positions respectively surrounding one of the smokable articles on each of the disks 12 and 14 at the smoking station S and respectively forming seals around the lighted ends of the cigarettes and to positions respectively spaced apart from the disks 12 and 14 and the smokable articles to permit indexing of the disks 12 and 14. The reciprocating means for moving the chambers 62 and 64 as described above is illustrated schematically in FIG. 6 and described in detail below. A pneumatic system is employed, since a rather long stroke is necessary to position a chamber over a cigarette, and for positive action and speed of response the stroke is powered in two directions.

Air-supply means is provided for alternately elevating the air pressure within the pressure chambers 62 and 64 when they thus enclose the cigarettes to a level

above atmospheric pressure to cause air to flow through the cigarettes or other smokable articles at the smoking station S.

FIGS. 4 and 6 show how the reciprocating means for the pressure chambers 62 and 64 and the shuttle means for the valve 16 are actuated to form seals with respect to one of the disks in conjunction with actuation of the air supply means to raise the air pressure in the corresponding pressure chamber and are actuated to form seals with respect to the other of the disks in conjunction with actuation of the air supply means to raise the air pressure in the other pressure chamber and how the reciprocating means is actuated to break the seals prior to actuation of the indexing means.

As FIG. 4 shows, the valve 16 includes a cylinder 70, a piston 72 slidable within the cylinder 70 and sealed thereto by 0-rings 74, and lines 76 and 78 for supplying air to annular spaces 80 and 82 at opposite ends of the piston 72. By supplying air to the chamber 80 or 82 through the line 76 or 78 and exhausting air from the other space 82 or 80, the piston 72 can be made to move in either direction as indicated by a double-headed arrow 84. In this way, one or another of flow passages 86 and 88 is brought into communication with a passage 90 or 92 of a smoke delivery pipe 94 which communicates with a chamber, for example, in which is placed a holder for an experimental animal (not shown). At the same time, the flow passage in question (the passage 88, as illustrated by way of example in FIG. 4) is brought into communication with the (horizontal) bore B in which the cigarette C is inserted. An extension 72′ forms a seal with an 0-ring 96 held in a recess in a holder base portion 98.

As FIG. 6 shows, a source 100 supplys a gas such as air under pressure to the pneumatic system when a solenoid 102 is energized to open an associated valve 104. The air pressure is regulated by a pressure regulator 106 and the air is supplied to three operating valves 108, 110 and 112 through a supply line 114 and branches 116, 118 and 120 respectively. The operating valve 108 is controlled by a control valve 122; the operating valve 110 is controlled by control valves 124 and 126; and the operating valve 112 is controlled by a control valve 128. More particularly, the valve 108 supplies air under pressure through a line 130 or 132 depending on whether or not air is supplied to the valve 108 through a line 134; the valve 110 supplies air under pressure through the line 76 or 78 depending on whether air is supplied to the valve 110 through a control line 136 or 138; and the valve 112 supplies air under pressure through a line 140 or 142 depending on whether or not air is supplied to the valve 112 through a control line 144.

The operating valves 108 and 112 control the reciprocating movement of the pressure chambers 62 and 64 respectively. A stationary cylinder 144 carries a movable piston 146 slidable in sealed relation thereto, and the piston 146 is connected by a rod 148 to the pressure chamber 62. Similarly, a stationary cylinder 150 carries a movable piston 152 slidable in sealed relation thereto which in turn is connected by a rod 154 to the pressure chamber 64. Air introduced into the space 156 or 158 by the line 130 or 142 causes the piston 146, rod 148 and pressure chamber 62 to move to the right or the piston 152, rod 154 and pressure chamber 64 to move to the left as seen in FIG. 6, while air introduced into the space 160 or 162 through the line 132 or 140 causes the piston 146, rod 148 and pressure chamber 62 to move to the left or the piston 158, rod 154 and pressure chamber 64 to move to the right as seen in FIG. 6.

The control valves 122, 124, 126 and 128, which control the operating valves, are in turn respectively controlled by cams 170, 172, 174 and 176 mounted on a common shaft 178 so that the cams turn in synchronism. The shaft 178 is driven by a gear train 179 from the shaft 54 (FIG. 1), which, as indicated above, is driven by motive means including the motor 50 and gear train 52. Cam followers 180, 182, 184 and 186 thus respectively actuate the valves 122, 124, 126 and 128 in timed sequence.

The air for the control valves is supplied from the source of gas 100 through the valve 104 and pressure regulator 106, a line 190. a pressure regulator 192, a line 194 and, when a valve 196 is opened by energizing of a solenoid 198, through a line 200. The lines 194 and 200 communicate with opposite ends of chambers 202 and 204. The chamber 202 is connected to the control valve 126 by a line 206 and with the control valve 124 by a line 208. The chamber 204 is connected to the control valve 122 by a line 210 and to the control valve 128 by a line 212. The control valves 122, 124, 126 and 128 thus supply air under pressure to the control lines 134, 136, 138 and 144 depending on the positions of cams 170, 172, 174 and 176.

Air is supplied from the source of gas 100 through a line 220, a pressure regulator 222, an adjustable orifice 223 (which assures proper puff characteristics), and branch lines 224 and 226 to puff valves 228 and 230, respectively. Puff air is supplied to the pressure chambers 62 and 64 through lines 232 and 234 in accordance with the conditions of the valves 228 and 230. The valves 228 and 230 are controlled by the delivery of air through control lines 236 and 238 which communicate respectively with the lines 78 and 76. Accordingly, when air is supplied through the line 76 to the left end of the cylinder 70 (FIG. 4) to force the piston 72 to the right to form a seal with respect to the disk 14, control air is also supplied to the valve 230 through the line 238 (which is connected to the line 76) to actuate the valve 230 to permit puff air to be supplied through the line 226 and through the line 234 to the pressure chamber 64 to puff the cigarette C shown at the right of FIG. 6. Similarly, when air is supplied through the line 78 to the right end of the cylinder 70 to force the piston to form a seal with respect to the disk 12, control air is also supplied over the line 236 (which is connected to the line 78) to the valve 228 to actuate the valve 228 to permit puff air to be supplied through the line 232 to the pressure chamber 62 to puff the cigarette shown at the left of FIG. 6.

The adjustable orifice 223 is preferably set, in many experiments, to permit a flow of 17.5 cc/sec, so that a two-second puff has the desired 35 cc volume.

Gauges 240, 242 and 244 respectively downstream of the pressure regulators 106, 192 and 222 permit monitoring of the pressures at those points to ascertain that the pneumatic system is functioning properly. A pressure switch 246 is connected to the line 114 and produces an electrical output adapted to shut down the electric motor 50 (FIG. 1) in case the pressure in the system drops below a safe operating level or increases above a safe operating level.

The electrical and pneumatic programmer **246'** shown in FIG. **6** is also shown in FIG. **1.** The electrical part of the programmer is conventional and hence is not described in detail. It controls electrical functions including the operation of various ones of the solenoids employed in the apparatus.

Provision is made in accordance with the invention for automatic locking and lighting of the cigarettes manually or otherwise inserted in the holders and ejection of them therefrom after they are smoked. Lighting is effected by means of an electrical lighter **250** (FIG. **4**) in the pressure chamber **64** and another lighter (not shown) in the pressure chamber **62.** The lighter **250** lights the cigarettes mounted in holders on the disk **14** and the other lighter lights the cigarettes mounted in holders on the disk **12.** The lighter **250** is a modified **12**-volt device similar to lighters used in automobiles and hence is not described in detail. The lighter remains in a position fixed with respect to the pressure chamber **64** but makes contact with the end of each cigarette C only for purposes of lighting the cigarette; the next time the cigarette is indexed to the smoking station it has burned down enough that it does not touch the lighter.

Ejection of the cigarettes is effected by an ejector **252** (FIG. **1**) which comprises a pneumatic piston-cylinder assembly **253** supporting a probe (not shown) at each end of the piston adapted to push on the butt ends of the cigarettes and eject the cigarettes from their respective holders after they have been smoked to the desired extent (as determined, for example, by counting the number of rotations of the disks **12** and **14**). From FIG. **1,** a holder such as **H–1,** in the disc **12,** shown in alignment with the assembly **253** would have a spent cigarette ejected axially therefrom if and when the piston moves to the left as illustrated therein, and the probe extending toward the left therefrom, would enter the central passage in the member **98** as seen in FIG. **4,** and push the spent cigarette out of the insert member **256** which is adapted to free the same in a manner described below. An ash bin **254** (FIG. **3**) collects the cigarette butts.

The cigarettes are locked in position in the holders and freed for ejection when they have been smoked to a desired extent in the following manner: The cigarettes are normally gripped by a sealing means such as a molded rubber annular insert **256** (FIG. **4**) held by a holding ring **258** that moves axially to and fro in response to rotation of an outer control ring **260.** The outer ring **260** carries a gasket G against which the puff chamber **64** forms a seal, and the ring **260** can be moved in rotation by abutment of a lug **262** (FIG. **5**) against a movable lug **264.** The movable lug **264** is moved in either direction indicated by a double-headed arrow **266** in response to the energizing or deenergizing of a solenoid **268.** A clockwise rotation is imparted to the outer ring **260** as indicated by an arrow **270** in FIG. **5** when the movable lug **264** is extended and engages the lug **262** upon rotation of the disk **14** in the direction indicated by an arrow **271.** The outer ring **260** engages the inner ring **258** by means of a helical thread **272.** A pin **280** prevents the inner ring **258** from rotating when the outer ring **260** is rotated, so that the ring **258** moves axially instead of in rotation in response to a relative screwing and unscrewing of the threaded connection **272.** When the inner ring **258** is moved to the right as seen in FIG. **4,** this reduces the compression of the rubber annular seal **256** and permits the cigarette to be ejected by the ejector probe when the cigarette reaches the ejector **252** (FIG. **1**).

When fresh cigarettes are inserted in the holders the outer rings **260** can be rotated counterclockwise as seen in FIGS. **3** and **5** by engagement of lugs **273** with movable lugs **274** that can move in either direction indicated by a double-headed arrow **276** (FIG. **3**) in response to the energizing or deenergizing of a solenoid **278.**

Normally, both of the movable lugs **264** and **274** are retracted, so that the outer rings **260** are not rotated as the disks **12** and **14** are indexed. However, when a fresh supply of cigarettes is inserted, the movable lug **274** is advanced so that the cigarettes are tightened in the holders, and, when the cigarettes have been smoked to the desired extend, the lug **264** is advanced so that the cigarettes are loosened for ejection.

FIGS. **1** and **2** best show the control panel P of the smoking machine. The left hand panel P–L comprises electrical controls, including on-off switch, fuse, pilot light and individual controls to index the cigarette holders and to start and stop the puff cycle. There are limit switches actuated by the puff chambers, which ensure that the index drive will not operate while a puff cylinder is in the smoking position. Additionally, there is a lighter switch which is timed for automatic cut-off and a puff counter which will stop the smoking cycle after a predetermined number of puffs have been taken.

The right hand panel P–R contains the pneumatic controls for the three air supplies.

The puff chambers are provided with quick-connect fittings to make them readily detachable for inspection and cleaning. A threaded connection **290** is easily unscrewed, and, upon loosening of set screws **292** to withdraw them from an annular recess **294,** a threaded connection **296** can be unscrewed. When the device is assembled as shown in FIG. **4,** puff air flowing through the line **234** and passages **298** as shown by arrows **300** is prevented from leading in the reverse direction from the puff chamber by **0**-rings **302** and **304.**

Thus there is provided in accordance with the invention a novel and highly-effective smoking machine which can be used not only for reverse puffing in the manner set forth above but also for conventional vacuum puffing, in which case the nearly instantaneous reaction time of the shuttle valve provides a smoke stream which is for all practical purposes uninterrupted. A single timing source for all functions is employed, precluding loss of synchronization. An efficient system of interlocks prevents damage and ensures that the system, if not in proper operating condition, will not operate at all.

For analytical smoking, the reverse puff chambers may or may not be used, according to the design of the experiment. If they are not used, the shuttle valve may be dispensed with. Individual analytical filters may then be installed at the rear of the mouthpieces.

Many modifications of the representative embodiment of the invention disclosed herein will readily occur to those skilled in the art. Accordingly, the invention is to be construed as including all of the modifications thereof within the scope of the appended claims.

We claim:

1. A smoking machine comprising:

a pair of disk means each rotatable about an axis;

a plurality of holding means on each of said disk means, said holding means being adapted to hold lit smokable articles such as cigarettes and being spaced apart at equal intervals in a circular path centered on said axis;

valve means mounted at a smoking station adjacent to each of said disk means to receive smoke from said smokable articles and channel it to a desired location;

shuttle means for shuttling said valve means to form seals around the butt ends of said smokable articles alternately on one of said disk means and on the other of said disk means at said smoking station;

indexing means for rotating both of said disk means stepwise about their respective axes to bring successive ones of said holding means on each of said disk means to said smoking station;

a pair of pressure-chamber means;

reciprocating means for moving said pressure-chamber means alternately to positions respectively surrounding one of said smokable articles on each of said disk means at said smoking station and respectively forming seals around the lighted ends of said smokable articles and to positions respectively spaced apart from said disk means and said smokable articles to permit indexing of said disk means; and

air-supply means for alternately elevating the air pressure within said pressure-chamber means to a level above atmospheric pressure to cause air to flow through said smokable articles at said smoking station;

the actuation of said reciprocating means to form said seal with respect to one of said disk means being in conjunction with the actuation of said air-supply means to raise the air pressure in the corresponding pressure-chamber means, the actuation of said reciprocating means to form said seal with respect to the other of said disk means being in conjunction with the actuation of said air supply means to raise the air pressure in the other pressure-chamber means, and the actuation of said reciprocating means to break said seals being prior to the actuation of said indexing means;

whereby said smokable articles are sequentially indexed to said smoking station and puffed in a manner that is adapted to simulate the smoking activities of a human being, and substantially all of the smoke passing through said smokable articles is delivered to said desired location.

2. A smoking machine according to claim **1** wherein said smokable articles are cigarettes and each of said holding means is formed with a bore into which the butt end of the associated cigarette extends, said bore being horizontal so that said cigarette extends in a horizontal direction.

3. A smoking machine according to claim **1** wherein there are substantially 15 of said holding means on each of said disk means and each of said smokable articles is given a puff having a volume of substantially 35 ml., a duration of substantially 2 seconds, and a repetition rate of substantially one per minute.

4. A smoking machine according to claim **1** wherein said indexing means comprises a pair of geneva movements 180° out of phase.

5. A smoking machine according to claim **1** wherein said shuttle means comprises a double-acting piston-cylinder assembly.

6. A smoking machine according to claim **1** wherein said reciprocating means comprises a pair of double-acting piston-cylinder assemblies one of which moves one of said pressure-chamber means and the other of which moves the other of said pressure-chamber means.

7. A smoking machine according to claim **1** wherein said shuttle means comprises a double-acting piston-cylinder assembly and said reciprocating means comprises a pair of double-acting piston-cylinder assemblies one of which moves one of said pressure-chamber means and the other of which moves the other of said pressure-chamber means, further comprising control valve means for controlling said piston-cylinder assemblies, cam means for controlling said control valve means, and motive means for powering said cam means.

8. A smoking machine according to claim **7** wherein said motive means also includes means for driving said indexing means.

9. In a smoking machine for smoking a plurality of cigarettes by puffing them sequentially, the improvement comprising a holder for each cigarette, each holder comprising an annular seal for holding the butt end of the cigarette, a rotatable control ring, a holding ring movable axially to and fro in response to rotation of said control ring and pressing against said annular seal, and means cooperating with said control ring for selectively imparting a rotation thereto, said annular seal in response to increased pressure of said holding ring gripping said cigarette securely and in response to reduced pressure of said control ring loosening its grip on said cigarette.

10. A smoking machine according to claim **9** comprising a threaded connection between said control ring and said holding ring and pin means preventing rotation of said holding ring upon rotation of said control ring, the axial to-and-fro movement of said holding ring being effected by a relative screwing and unscrewing of said threaded connection.

11. A smoking machine according to claim **9** wherein said means cooperating with said control ring for selectively imparting a rotation thereto comprises a movable lug and a solenoid for moving said movable lug selectively between a position in which it interacts with said control ring to impart a rotation thereto and a position in which it avoids said control ring.

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