Feb. 11, 1969 C. S. McARTHUR ET AL 3,426,582

CIGARETTE INSPECTION APPARATUS

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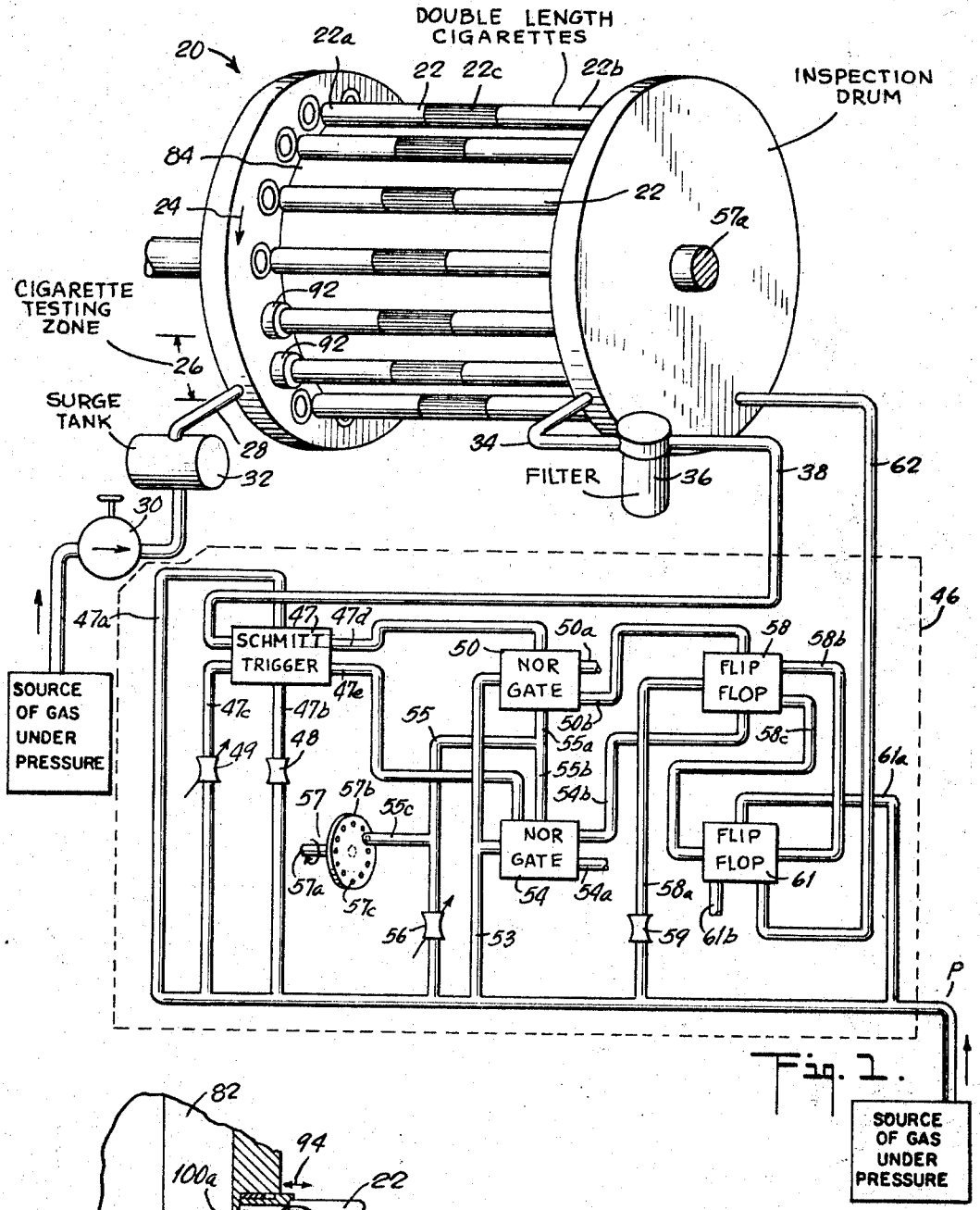


Fig. 1.

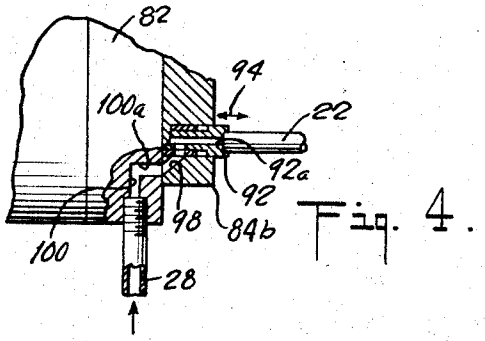


Fig. 4.

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Fig. 2.

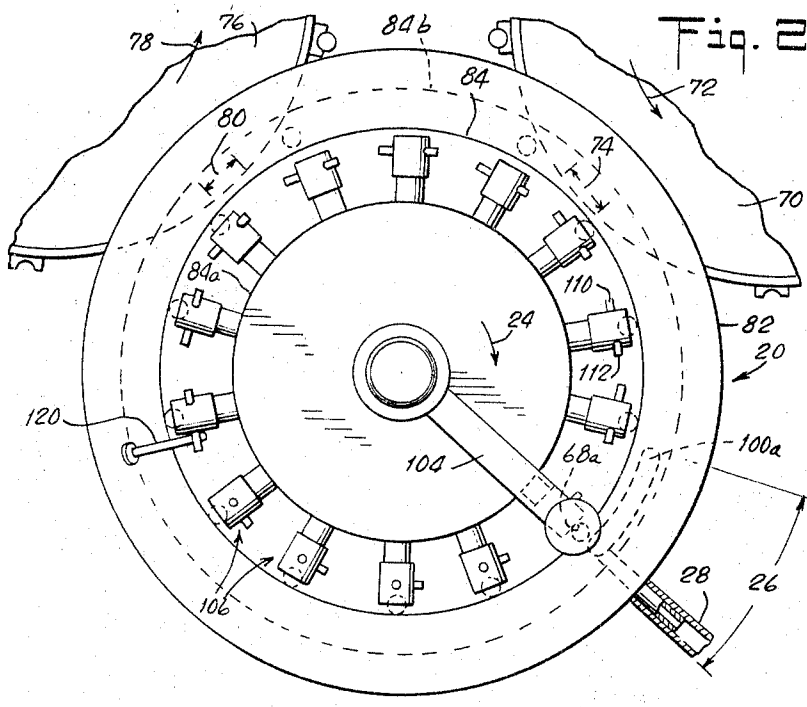


Fig. 5.

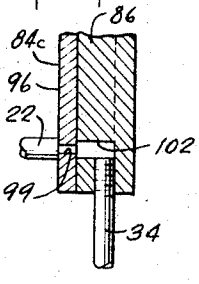
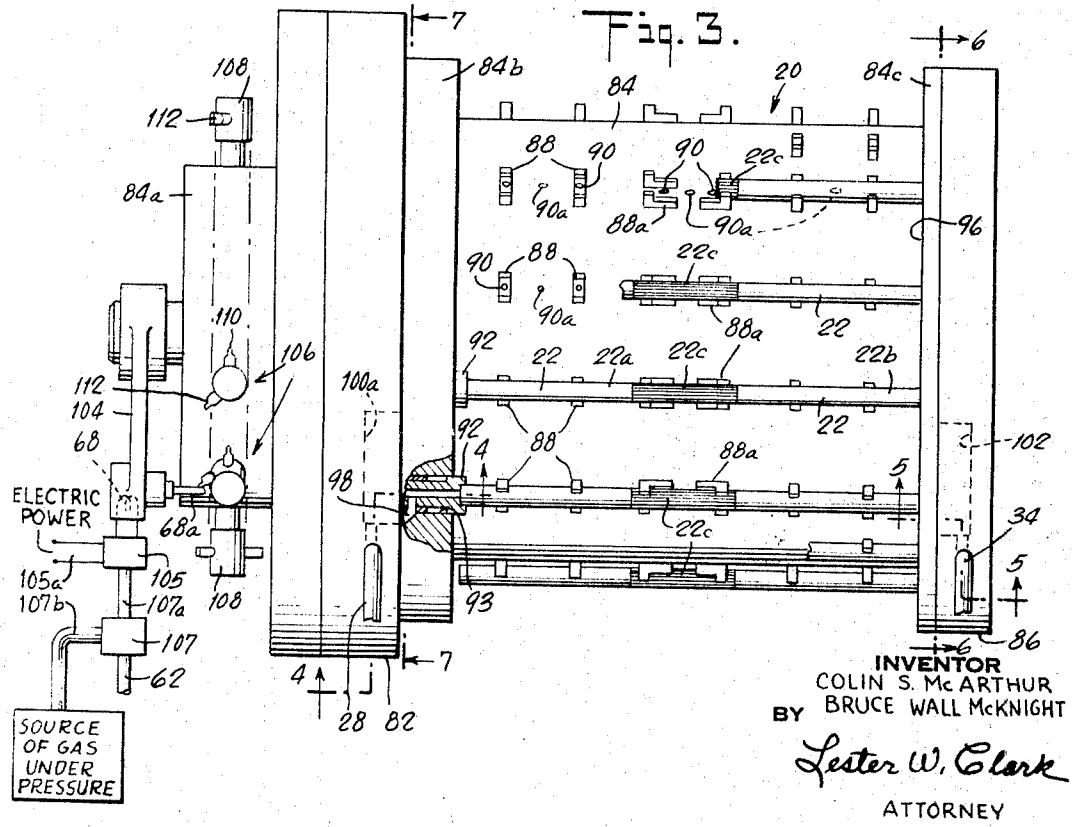


Fig. 3.



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Fig. 6.

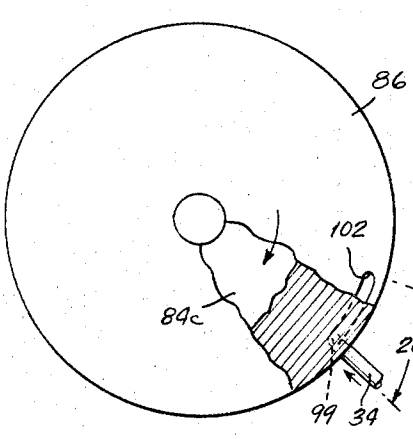
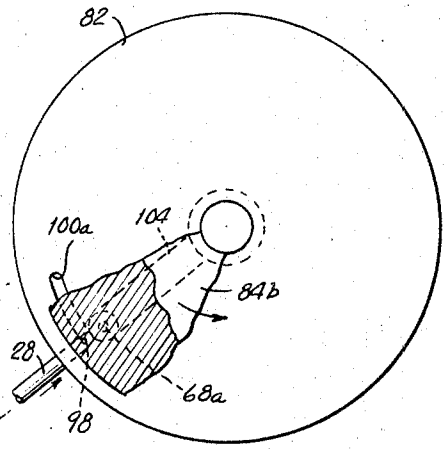


Fig. 7.



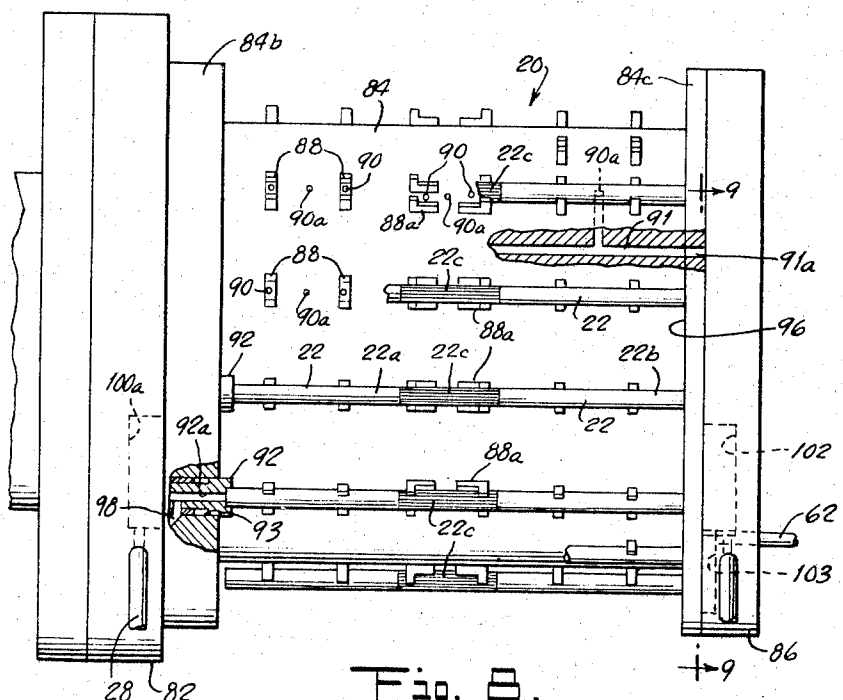


Fig. 8.

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Fig. 9.

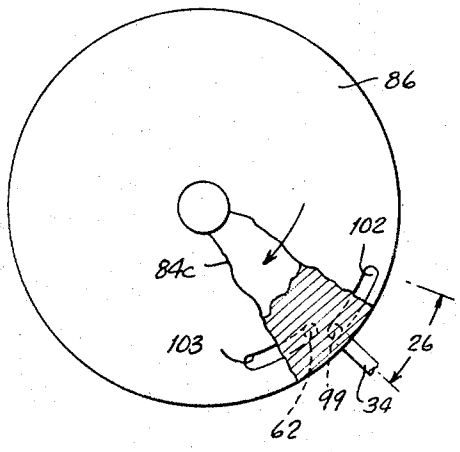
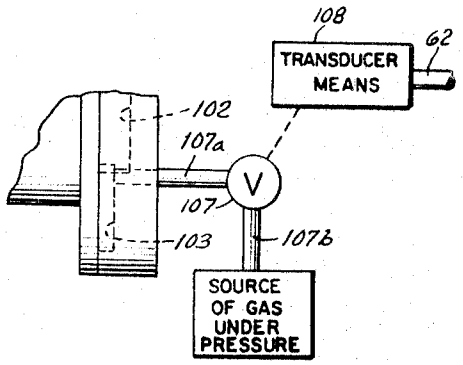


Fig. 10.



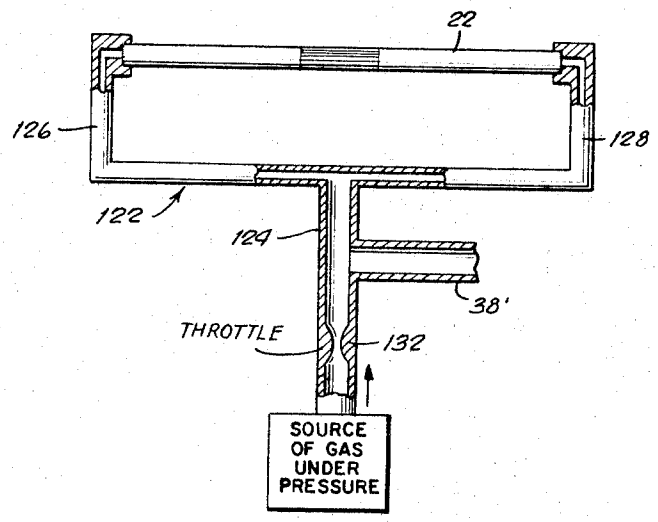


Fig. 11.

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United States Patent Office 3,426,582
Patented Feb. 11, 1969

3,426,582

CIGARETTE INSPECTION APPARATUS

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Filed May 18, 1966, Ser. No. 551,162
U.S. Cl. 73—45.1 12 Claims
Int. Cl. G01m 3/04

ABSTRACT OF THE DISCLOSURE

Inspection apparatus for filter cigarettes, in which the interior of the cigarette is subjected to a pressure differing from the external atmospheric pressure, and the internal pressure is utilized to control a bistable fluid amplifier, which in turn actuates an ejecting mechanism if the internal pressure in the cigarette indicates that the cover of the cigarette is leaky. The inspection and ejection of faulty cigarettes takes place at a single station on the periphery of a rotating drum. The peripheral length of that station on the drum surface is substantially equal to the spacing between cigarettes on the drum. The pressure is applied to the cigarette throughout the length of its passage through the station. Synchronizing means is provided so that the ejection apparatus operates only during the latter part of the passage of a cigarette through the station, thereby ensuring that the pressure condition in the cigarette is stabilized before the ejection apparatus is actuated, and also ensuring that only the cigarette under test is ejected if an indication of a leak is found.

This invention relates to the inspection of cigarettes, and more particularly relates to the inspection of cigarettes for imperfections causing air leaks therein.

Sherrill Patent No. 2,951,364 shows an apparatus for inspecting cigarettes for air leaks by passing a flow of air through each cigarette. A mechanical sensing device incorporating a movable member responds to an abnormal air flow, thereby indicating a leak in the particular cigarette under inspection. In response to movement of the movable member, an ejector mechanism is actuated to eject the defective cigarette. Although mechanical sensing arrangements for detecting abnormal air flow conditions have been suitab'e in the past, they are slow as compared to the speeds available in present cigarette-making machines and the even greater speeds expected in future machines. It is therefore desirable to have an inspection arrangement for leak detection that can handle cigarettes at the fast rate at which they may now be produced.

It is an object of the present invention to provide an apparatus for the improved inspection of cigarettes for leaks.

Another object of the present invention is to provide for the high speed inspection of cigarettes for leaks.

Another object of the invention is to provide an apparatus for the inspection of cigarettes for leaks employing fluid principles to achieve high speed response of a rejection mechanism to an inspection mechanism.

These and other objects and advantages of the invention will be more apparent as the detailed description of one presently preferred but merely illustrative embodiment of the invention proceeds, with reference to the drawings, in which:

FIG. 1 illustrates an inspection apparatus embodying the invention, having mechanical parts shown in a simplified perspective view and fluid amplifier means parts shown in a simplified diagrammatic view;

FIG. 2 is an end view of a cigarette-conveying apparatus incorporating one form of means for subjecting the cigarettes to a source of gas for inspection for leaks and one form of cigarette rejection means;

FIG. 3 is a side view of the apparatus of FIG. 2;

FIGS. 4, 5, 6, and 7 are sectional views of portions of the apparatus shown in FIG. 3, taken along the section lines 4—4, 5—5, 6—6, and 7—7 of FIG. 3 and looking in the directions of the corresponding arrows in that figure;

FIG. 8 is a side view of a cigarette-conveying apparatus such as shown in FIG. 3 incorporating a second form of cigarette rejection means responsive to the fluid amplifier means;

FIG. 9 is a sectional view of a portion of the apparatus shown in FIG. 8, taken along section line 9—9 of FIG. 8 and looking in the direction of the arrows;

FIG. 10 is a partial detail view showing a variation on the second form of rejection means; and

FIG. 11 is a simplified view of a second form of means for subjecting the cigarettes to a source of gas for inspection.

As employed herein, the term "cigarette" is a generic term inclusive of a filter cigarette or a non-filter cigarette, as well as a single length or multiple length cigarette. The term is also intended to include any self-contained smoking article, such as a cigar, which may be tested in accordance with the invention.

Briefly, the present invention provides a leak inspection system wherein gas at an elevated or reduced pressure is applied to each of a succession of cigarettes, and the change in pressure attributable to leaks in the cigarette controls fluid amplifier means so as to divert the output of said means from a first outlet to a second outlet, said second outlet being arranged to actuate means for ejecting the leaky cigarette in question.

The apparatus according to the invention provides very fast response between testing and ejection. This is important because with present day cigarette-making machines approximately 1000 dual cigarettes per minute, or 17 dual cigarettes per second, are handled. This means that the testing and ejection mechanism has to be extremely rapid, e.g. it must test about 17 dual cigarettes per second and reject the leaky ones. Because of this rapid cigarette handling rate, the apparatus must also be extremely reliable, because in even a momentary mechanical break-down a rapid build-up of untested cigarettes or cigarettes which have been incorrectly rejected would occur. The apparatus according to the invention meets the felt need, because, operating upon fluid principles, it is extremely rapid in response and it is extremely reliable, both principally because there is no inertia involved except that of the fluid, which being a gas typically, is extremely low in mass and accordingly in inertia.

Referring to FIG. 1, a conveyor such as a drum assembly **20** is shown carrying a plurality of double length cigarettes **22** thereon, each of which is to be inspected for leaks. Each dual cigarette typically comprises tobacco-filled portions **22***a* and **22***b* at the ends thereof separated by a double length filter section **22***c* in the middle thereof and fastened together by means of tipping paper and adhesive. Subsequently, each double length cigarette is cut in the middle of filter section **22***c* to produce two standard filter-type cigarettes. The cigarettes are applied to, carried by, and removed from the drum assembly **20** by means presently to be described. The drum assembly **20** is represented only diagrammatically in FIG. 1; it is shown in more detail in the other figures.

The drum assembly rotates as shown by arrow **24**. As each cigarette carried on the drum assembly passes through a testing zone **26**, gas (typically air) under constant pressure greater than ambient pressure is applied to

the cigarette from a conduit **28**. It is possible, but not preferred, to use a constant vacuum system instead of an elevated pressure system. With a vacuum the leak pressure-pulse is positive-going, but with an elevated pressure (as illustrated) it is negative-going. In one form of the invention, the conduit **28** is connected to a source of gas under pressure (not shown) through a regulator **30** and a surge tank **32** to maintain the flow of gas constant. A slip ring arrangement described in detail in connection with FIGS. 2 and 3 couples the conduit **28** to each cigarette as it passes through the testing zone **26**.

Gas flows through the cigarette in the testing zone and out of the cigarette and into an outlet conduit **34** connected to a filter **36**. The filter filters out any tobacco that may be present in the gas. The gas is then led, by a conduit **38**, to fluid amplifier means shown in the lower half of FIG. 1 within the broken line envelope **46**. Means **46** operates on fluid amplifier principles, that is to say, the fluid input from conduit **38** controls the fluid output from means **46**, so that the output is diverted to a first destination or a second destination, depending upon the level of fluid input pressure at conduit **38**. One of the two destinations controls the rejection means for the cigarettes, and the other destination is an exhaust.

The fluid amplifier means **46** comprises a Schmitt trigger **47** responsive to the input of conduit **38** and controlling a pair of NOR gates **50**, **54**, which in turn control a control flip flop **58**. An output flip flop **61** having a greater output than control flip flop **58**, is controlled thereby, and either exhausts its output or applies it to conduit **62** which is connected to cigarette rejection means associated with the inspection drum. Fluid power is supplied to fluid amplifier means **46** from power source conduit P, and in the illustrated embodiment 12.5 p.s.i.g. gas pressure is applied at conduit P.

The Schmitt trigger **47** is a known all-fluid amplifier circuit having the characteristic that the output thereof is switched from its normal output port to the other output port in response to, and for the duration of, change in a monitored input pressure exceeding a predetermined level. In the circuit of fluid amplifier means **46**, Schmitt trigger **47** accordingly acts as a detector which produces a pulse in one of the output ports in response to a pressure signal at conduit **38** exceeding said predetermined level. Schmitt trigger **47** is powered from power source conduit P by a conduit **47***a* supplying the full 12.5 p.s.i.g. together with a conduit **47***b* having a fixed restrictor **48** to apply a lower pressure, and a conduit **47***c* having a variable restrictor **49** to apply a lower variable pressure adapted to set the aforesaid predetermined level.

The output port conduits **47***d*, **47***e* of Schmitt trigger **47** are applied respectively to NOR gates **50**, **54**. A second control input is applied to NOR gates **50**, **54** by a timing pulse conduit circuit **55**, which conduit is connected to power source conduit P through variable restrictor **56** so as to supply an input signal at branches **55***a*, **55***b* to NOR gates **50**, **54** respectively. Conduit **55** includes a side branch **55***c* which is open ended. An apertured disc assembly **57** is arranged to alternately block and unblock side branch **55***c*. Apertured disc assembly **57** includes a shaft **57***a* carrying a disc **57***b* having a plurality of peripherally located apertures **57***c* spaced circumferentially on a constant radius. Side branch **55***c* abuts the circumference traced out by the apertures **57***c* during rotation of disc **57***b* with shaft **57***a*.

As disc **57***b* is rotated thereby bringing the plurality of apertures **57***c* successively into coincidence with the open end of side branch **55***c*, the pressure in conduit **55** is repeatedly allowed to exhaust each time an aperture **57***c* comes into such coincidence. The arrangement is such that the period between adjacent apertures **57***c* exactly equals the period between consecutive cigarettes **22** reaching the mid-point of testing zone **26**. To accomplish this, shaft **57***a* may actually be the same shaft upon which the inspection drum is mounted, as is illustrated in FIG. 1. Alternatively shaft **57***a* can be separate from but driven in exact synchronization with the inspection drum and its shaft, e.g. by gearing. In either case the number of apertures **57***c* will equal the number of cigarette positions on the inspection drum. It is also possible to employ fewer or more apertures, spaced at greater or lesser angular amounts, provided that the shaft on which disc **57***b* is mounted is driven at the correct proportion of the speed of the inspecion drum shaft to keep the period between apertures **57***c* equal to the period between cigarettes **22**. In any event, branch **55***c* is positioned angularly so that the rotation of disc **57***b* causes a series of negative-going pressure pulses, dropping to zero, corresponding to the coincidence of successive apertures **57***c* with branch **55***c*, which pulses provide an input at conduit branches **55***a* **55***b* to NOR gates **50**, **54** synchronized with the arrival of the respectively associated cigarettes **22** at the mid-point of the testing zone. Power is applied to NOR gates **50**, **54** from conduit **53** which is connected to power source conduit P.

NOR gates are fluid amplifier devices that attain one state when neither of the two input ports receive a pressure signal, and attain another state when either or both input ports do receive a pressure signal. With respect to NOR gates **50**, **54** this means that when a pressure signal is received at either or both of input conduits **47***d*, **55***a* of NOR gate **50**, the output of that NOR gate will be directed to exhaust port **50***a*. Similarly, when either or both of input conduits **47***e*, **55***b* carries a fluid pressure signal to NOR gate **54**, the output of that NOR gate will be directed to exhaust port **54***a*. On the other hand, when there is no signal on input conduits **47***d*, **55***a*, then NOR gate **50** will direct its output to output conduit **50***b* which forms a first input for control flip flop **58**. When no signal appears at input conduits **47***e*, **55***b*, NOR gate **54** will direct its output to conduit **54***b* which forms a second input for flip flop **58**.

A flip flop is a fluid amplifier device which is bistable, i.e. has an output flow which exists substantially totally in either of two output channels, until positively switched to the other channel by an appropriate input signal. A common example of a fluid amplifier flip flop is the usual bistable fluid amplifier wherein the output flow adheres to the wall of a chamber leading to one output channel until a properly directed input pressure signal snaps it off that wall and across the chamber to lock onto an opposite wall leading to the other output channel.

Flip flops **58**, **61** derive their power stream from power source conduit P by conduits **58***a*, **61***a* respectively. Conduit **58***a* is provided with a fixed restrictor **59** to provide a reduced pressure power stream therefor, so that flip flop **61** has a correspondingly greater power output than flip flop **58**. The output stream of flip flop **58** is switched into output conduit **58***b* when the pressure at input conduit **54***b* exceeds that at input conduit **50***b* by a predetermined amount. Conversely, the output stream of flip flop **58** is switched into output conduit **58***c* when the pressure at input conduit **50***b* exceeds that at input conduit **54***b* by a predetermined amount. The output stream from flip flop **61** is switched into exhaust port **61***b* when the input pressure from conduit **58***b* exceeds the input pressure from conduit **58***c* by a predetermined amount. Conversely, the output stream of flip flop **61** is switched into output conduit **62** when the input pressure from conduit **58***c* exceeds the input pressure from conduit **58***b* by a predetermined amount. As aforesaid, the output conduit **62** leads to the inspection drum where it is connected to the ejection mechanism, so that when an output appears in conduit **62** the leaky cigarette will be ejected.

Viewed at its terminals therefore, fluid amplifier means **46** has a power stream introduced from power conduit P, and this power stream is controlled by the pressure signals arriving at input conduit **38** from cigarettes under test. The testing of a leaky or an acceptable cigarette will be represented by the pressure in input conduit **38** and will,

respectively, cause bistable switching of the power stream derived from power source conduit P into conduit **62** to eject that cigarette, or into exhaust to leave that cigarette as is.

The specific means shown in FIG. 1 as an example of fluid amplifier means **46** achieves the aforesaid bistable fluid amplifier terminal characteristics by cooperation of the various circuit elements within fluid amplifier means **46**, as follows. Schmitt trigger **47** discriminates between input pressure signals at conduit **38** which do not meet the aforesaid predetermined level, and those that do. The output of Schmitt trigger **47** is directed to conduit **47***d* at all times when the signal at input conduit **38** does not meet the aforesaid predetermined level. As soon as the signal at conduit **38** meets the aforesaid predetermined level, the output of Schmitt trigger **47** is switched in response thereto from conduit **47***d* to conduit **47***e*. By adjustment of variable restrictor **49**, the point at which this switching takes place can be adjusted, i.e. the aforesaid predetermined level can be set. It may be desirable to set the aforesaid predetermined level at any of a range of values depending upon what quality standards as regards leaky cigarettes the user of the apparatus desires to erect.

The signal at conduit **38** is of course inversely proportional to the leak rate of the cigarette **22** in question, i.e. a higher leak rate at the cigarette **22** produces a lower pressure at conduit **38**. The input signal which causes Schmitt trigger **47** to switch from conduit **47***d* to **47***e* is therefore a negative-going pressure waveform. On the other hand, the signal produced at conduit **47***d* by Schmitt trigger **47**, and switched as aforesaid to channel **47***e*, is a positive-going pressure signal. That signal is switched to conduit **47***e* only so long as the input signal which caused the switch appears at conduit **38**. The output of Schmitt trigger **47** returns to conduit **47***d* as soon as that input signal returns above the aforesaid predetermined level, so that conduit **47***e* receives a pulse of output from Schmitt trigger **47** in response to and for the duration of time that the input signal at conduit **38** meets the aforesaid predetermined level. In effect, this means that as long as the leaky cigarette is under test, the Schmitt trigger **47** will direct its output into conduit **47***e*.

For purposes of the following discussion, reference to the existence of a signal at either of conduits **47***d* or **47***e* means that the positive pressure output of Schmitt trigger **47** is present in that particular conduit, and reference to no signal being in either of these output conduits means that the output of Schmitt trigger **47** is present in the other one of these output conduits. Reference to no signal being at conduit branches **55***a* or **55***b* means that branch conduit **55***c* has aligned with one of apertures **57***c* so that the pressure in conduit **55** has dropped to zero. Conversely, reference to a signal being at either of conduits **55***a* or **55***b* means that branch conduit **55***c* does not coincide with an aperture **57***c* and the pressure in conduit **55** is at an elevated value. Hereinafter when no signal is impressed at each of the input conduits to a NOR gate, that will be referred to as no signal-no signal. Similarly, when a signal is applied to one input conduit to a NOR gate and no signal is applied to the other input conduit, that will be referred to as signal-no signal. Finally when a signal is applied to each input conduit of a NOR gate, that will be referred to as signal-signal.

NOR gate **50** constitutes the rejection NOR gate, in that when conduit **50***b* is energized with the output thereof it triggers the rejection of the leaky cigarette, by changing the state of the flip flops **58**, **61** to their rejection state, as will be explained presently. NOR gate **54** constitutes the restoring NOR gate, in that when conduit **54***b* is energized with the output thereof it restores flip flops **58**, **61** to their non-rejection state.

In accordance with the aforesaid rules, a leaky cigarette produces a switch of the output of Schmitt trigger **47** from conduit **47***d* to conduit **47***e*, thereby producing a no signal-no signal condition at NOR gate **50**, and a signal-no signal condition at NOR gate **54**. This means that NOR gate **50** must flip to or remain at the output state wherein the rejection output conduit **50***b* receives the output stream, and the NOR gate **54** must flip to or remain at the condition wherein the exhaust port **54***a* receives the output stream. Thus conduit **50***b* is energized and conduit **54***b* is de-energized, causing the power stream of flip flop **58** to switch into output conduit **58***c* from output conduit **58***b*, or to remain at output conduit **58***c* if it is already there. Flip flop **58**, having fluid pressure in output conduit **58***c*, and an absence of fluid pressure in output conduit **58***b*, causes flip flop **61** to switch the power stream thereof from exhaust port **61***b* to the output conduit **62**, or to remain at output conduit **62**, as the case may be.

Thus the overall rejection sequence in response to a leaky cigarette is that a negative-going pulse at input conduit **38**, meeting the aforesaid predetermined level, causes an output flow in conduit **62** which is employed as hereinafter described to reject the very cigarette which caused that flow. It will be remembered that the fluid flow in output conduit **62** is commenced only when the synchronization assembly **57** produces a pulse indicating that the center of the testing arc **26** of the cigarette **22** in question has been reached. It is thus guaranteed that the correct cigarette is ejected in response to the testing measurement. As will be explained hereinbelow, the output flow in conduit **62** persists, due to the bistable nature of flip-flops **58**, **61** until the center of the testing zone **26** is reached by the next consecutive cigarette **22**, i.e. until the next consecutive aperture **57***c* coincides with branch conduit **55***c*. At that latter event, the flow in output conduit **62** is either continued (rejecting the new cigarette) or switched into exhaust port **61***b* (accepting the new cigarette) depending upon the new input signal at input conduit **38**. The output flow in response to any single test is therefore in the form of a pulse whose period is determined by the incidence of successive apertures **57***c* at branch conduit **55***c*, i.e. by the period of traverse from the test cigarette being at the mid-point of testing zone **26** to the next successive cigarette being at that mid-point. The pulse period will be multiple if successive cigarettes are leaky, as will appear hereinafter.

The resetting of flip flops **58**, **61** so that the power stream of flip flop **61** is switched from output conduit **62** to exhaust port **61***b*, results when an acceptable cigarette follows a leaky cigarette, as just mentioned. This occurs as follows. As the inspection drum turns so that the next cigarette **22** is brought into the testing zone **26**, the apertured disc **57***b* will also turn so that the open end of branch conduit **55***c* will move from one aperture **57***c* to the next. While between apertures, the branch conduit **55***c* is closed off by disc **57***b*, so that the pressure in conduit **55** is elevated to yield a signal at conduit branches **55***a*, **55***b* to NOR gates **50**, **54**. The presence of a signal during that interval at each of NOR gates **50**, **54** means that each of the NOR gates switches its output flow to its exhaust port. Since flip flops **58**, **61** remain locked in their state until positively restored, this action does not affect the rejection state of flip flop **61**. However when the next aperture **57***c* coincides with the open end of branch conduit **55***c*, no signal is again imposed on each of NOR gates **50**, **54** at the branch conduits **55***a*, **55***b* respectively. Assuming that the cigarette corresponding to this next aperture is not leaky, no signal will appear in conduit **47***e* applied to NOR gate **54**, but the normal signal output of Schmitt trigger **47** will appear in conduit **47***d* to NOR gate **50**. The signal-no signal condition on NOR gate **50** will flip the output thereof from the output conduit **50***b* to the exhaust port **50***a*. The no signal-no signal condition on NOR gate **54** will flip the output thereof from exhaust port **54***a* to output conduit **54***b*. The presence of fluid pressure in conduit **54***b* and the absence thereof in conduit **50***b* switches the output of flip flop **58** from conduit **58***c* to conduit **58***b*. This in turn switches

the output of flip flop 61 from rejection output conduit 62 to the exhaust port 61*b*. The acceptable cigarette following a leaky cigarette thus itself causes the resetting of flip flops 58, 61 so that the rejection flow pulse in conduit 62 ceases, and that cigarette is not rejected.

After the flip flops have been restored to the condition just described wherein there is no output in rejection conduit 62, rejection can be practiced again at the next aperture 57*c* if the output signal from Schmitt trigger 47 is switched from its normal output conduit 47*d* to output conduit 47*e*, as has already been explained. If two or more leaky cigarettes appear consecutively under test, the repeated presence of a signal from Schmitt trigger 47 to output conduit 47*e* will mean a repeated no signal-no signal condition on NOR gate 50, and a repeated signal-no signal condition at NOR gate 54. The rejection state of flip flops 58, 61 is thus continued for the second consecutive leaky cigarette. Similarly, if two or more acceptable cigarettes occur in a row the normal output of Schmitt trigger 47 into conduit 47*d* will persist, thus repeating a signal-no signal condition at NOR gate 50 and a no signal-no signal condition at NOR gate 54. This means that the output of NOR gate 50 will remain at its exhaust port 50*a*, and the output of NOR gate 54 will remain at its restoring output conduit 54*b*. The flip flops 58, 61 accordingly will not change from their state wherein the output of flip flop 61 is directed to exhaust port 61*b*.

The various fluid switching actions just described at the components within fluid amplifier means 46 occur very rapidly, and without the intervention of mechanical moving parts with the exception of disc 57*b* which may be positively connected to or geared to the inspection drum and is accordingly virtually fool-proof. While disc 57*b* is mechanical, that detracts in no way from the totally fluid principles of the fluid amplifier means 46. This is because the disc 57*b* rotates faster or slower together with the inspection drum. It introduces no inertia considerations. The disc 57*b* is merely a fluid pulse generator whose frequency is controlled by the inspection drum, and need not be mechanical at all. No mechanical element must respond to the fluid pressure signal, i.e. no mechanical element is in the chain of elements responding to the input signal. The system is easily capable of testing and producing a rejection signal or not at the aforesaid 17 dual length cigarettes per second rate, and moreover is so reliable that production stoppages because of break-downs is virtually non-existent. This is an important advance in an art wherein a number of cigarette-making machines may all be operated at the same time each producing 17 dual length cigarettes per second, or more.

FIGS. 2–7 show in greater detail the construction of a first form of the drum assembly 20 shown in diagrammatic form in FIG. 1. This first form employs valves to eject the rejected cigarettes by the valving on of positive air pressure, the values being turned to the "on" condition by a pressure switch operated by output conduit 62. In FIG. 2, the drum assembly 20 is adapted to receive a series of cigarettes from a drum assembly 70. The drum assembly 20 rotates clockwise, as shown by arrow 24, while the drum assembly 70 rotates counterclockwise, as shown by arrow 72. The surfaces of the drum assemblies pass tangentially adjacent to each other at a cigarette transfer zone 74, and cigarettes are transferred from the drum assembly 70 to the drum assembly 20, as described in greater detail below. The cigarettes transferred to the drum assembly 20 are thereafter tested as they pass through the testing zone 26 and are either rejected as being defective or are retained on the drum. Those cigarettes retained on the drum are thereafter transferred to a further drum assembly 76 which rotates counterclockwise as shown by arrow 78. Cigarettes are transferred to the drum assembly 76 in transfer zone 80, as described below.

As shown in FIG. 3, the drum assembly 20 comprises a fixed head 82 which serves to mount the drum assembly to a frame (not shown). Journalled within the head 82 is a rotatable drum 84 which extends at one end through the fixed head 82 as a reduced diameter portion 84*a*. The drum 84 also includes an intermediate stepped portion 84*b* and an end flange 84*c*. Another fixed head 86 abuts the end flange 84*c*.

The drum 84 carries a plurality of rows of cradles 88 thereon, the rows being arranged around the circumference of the drum upon its outer surface. Each cradle 88 is advantageously concave and semicylindrical so as to cradle a portion of the cylindrical surface of one of the cigarettes 22 carried on the drum. The central pair of cradles 88*a* in each row receive the cylindrical surface of substantially the entire filter portion 22*c* of the double length cigarette in the row.

Each cradle 88 has a central orifice 90 opening underneath the cigarette in the cradle. Each of the central elongated cradles 88*a* has a pair of such orifices. Orifices 90*a* are also included in the drum 84 in each row of orifices 90. Internal passageways (not shown) within the drum 84 selectively connect (by appropriate valve action) the orifices 90*a* to a positive source of gas (typically air) pressure and the orifices 90 to a source of vacuum. Thus each cigarette 22 on the surface of the drum 84 is either ejected from the cradles 88 by positive gas pressure applied to the orifices 90*a* or retained on the cradles by vacuum applied to orifices 90.

In this regard, the surfaces of the drum assemblies 70 and 76 are similarly formed with cradles and orifices to retain the cigarettes on or eject the cigarettes from the cradles. In the system of FIG. 2, as each cigarette on the drum 70 enters into the transfer zone 74, it is subjected to a positive gas pressure ejecting that cigarette from the cradles on that drum onto the cradles of the drum 84. At the same time, the orifices 90 in the cradles 88 on the drum 84 within the transfer zone 74 are subjected to a vacuum to receive the cigarette from the drum 70 and to retain the transferred cigarette on the surface of the drum 84. In like fashion, orifices 90*a* on the drum 84 when in the transfer zone 80 are subjected to positive gas pressure and the orifices in the cradles on the drum 76 are subjected to vacuum to transfer cigarettes from the drum 84 to the drum 76.

As shown in FIGS. 3 and 4, the intermediate stepped portion 84*b* of the drum 84 includes a plurality of holders 92. Each holder is mounted within a corresponding passage 93 and may be reciprocated in the directions indicated by arrow 94 (FIG. 4) by a driving mechanism (not shown) in the drum 84. When a cigarette is transferred from the drum 70 to the drum 84 as described above, the holder 92 on the drum 84 positioned in the transfer zone 74 is in a retracted position within the drum portion 84*b*. After the cigarette is transferred to the drum 84, the holder 92 is moved outwardly to the position shown in FIGS. 3 and 4 to engage one end of the cigarette 22 transferred to the drum 84. In so engaging the cigarette end, the cigarette is moved slightly to the right with respect to FIG. 3 so that the other end thereof is firmly engaged by surface 96 of the drum flange 84*c* (FIG. 5).

As shown in FIGS. 3 and 4, each cigarette holder 92 includes a passage 92*a* therein that communicates with a passage 98 in the drum portion 84*b*. Similarly, each contact area of the drum flange 84*c* (FIG. 5) engaging an end of a cigarette communicates with a passage 99 in the drum flange. It will be noted, then, that the passages 98 and 92*a* communicate with one end of the cigarette, and the passage 99 communicates with the other end of the cigarette. These passages are provided for subjecting the cigarette to a flow of gas for leak testing as described immediately below.

Gas input conduit 28 is shown in FIG. 3 as mounted on the fixed head 82. FIG. 4 shows that conduit 28 communicates with a passage 100 within the fixed head

82. The passage 100 terminates in a portion 100*a* that is shown in FIG. 7 as subtending an angle of roughly 25° of rotation of the drum 84. The angular extent of the passage 100*a* defines the extent of the cigarette testing zone 26. At the other end of the drum 84, as shown at the righthand side of FIG. 3, the gas outlet conduit 34 is connected to the fixed head 86. As shown in FIG. 5, the outlet conduit 34 communicates with a passage 102 in the fixed head. As will be noted from FIG. 6, the passage 102 subtends the same angle as the passage 100*a* and is located directly opposite the passage 100*a*.

The passages 100*a* and 102 in the fixed heads 82 and 86 are positioned so as to communicate with the passages 98 and 99 in the drum portions 84*b* and 84*c*. Hence, during the portion of the revolution of the drum 84 in which the passage 98 leading to a particular cigarette holder 92 communicates with the passage 100*a*, gas under pressure is provided via the passages 28 and 98 to that cigarette. The gas flows through the cigarette and into the associated passage 99 in the flange 84*c* at the other end of the drum, and flows out of that passage into the passage 102 and thence into the outlet conduit 34 to the filter 36 and fluid amplifier means 46 shown in FIG. 1.

Thus as each cigarette passes through the testing zone 26, it is subjected to a flow of gas therethrough. If the cigarettes are all of uniform draft, both the flow of gas and the pressure thereof will be constant. However, if any one of the cigarettes has a leak therein, the gas flow will leak out, thereby producing the aforesaid negative-going pressure signal for the duration of testing of that cigarette. In accordance with the presently discussed form of rejection means, the resultant flow in output conduit 62 will actuate relay 68 (FIG. 3), ejecting the leaky cigarette.

With respect to FIG. 2, the angular extent of the testing zone 26 is preferably slightly less than the angular separation of adjacent rows of cradles 88 on the drum 84, so that after each cigarette passes out of the testing zone, there is a short period of time before the next cigarette enters the testing zone. Also, the synchronization pulse from conduit 55 (FIG. 1) occurs at the mid-point of testing zone 26, so that the arm 10 (FIG. 2) is preferably located at the extreme latter end of the movement of the cigarette within the testing zone 26, as illustrated. There is thus provided one-half the zone 26 for the relay 68 to react to eject the leaky cigarette. This is fully ample, even at the contemplated ultra-high cigarette rate, and the mechanical nature of the relay and its switch does not comprise that rate significantly. The angular extent of the testing zone 26 may alternatively be the same as or slightly greater than the angular separation of adjacent rows of cradles 88 on the drum 84. However, the angular extent of the testing zone 26 should not exceed one and one-half times the angular separation of adjacent rows of cradles 88, if the synchronization pulse is to occur one-half the aforesaid angular separation before the position of arm 104.

Referring to FIG. 3, the relay 68 is carried within a housing in arm 104. The relay controls a plunger 68*a* which, when the relay is energized, may actuate that one of a plurality of valve operators 106 which happens to be passing plunger 68*a* on the rotating drum portion 84*a*. The valve operators 106 control the application of vacuum to the orifices 90 and pressure to the orifices 90*a* so as to cause the cigarettes in the cradles to be retained upon the drum or to be ejected therefrom. Each of the valve operators 106 is associated with a corresponding one of the rows of cradles 88, and is rotatable on its own longitudinal axis. Each valve operator includes a spindle 108 to which are attached a pair of radial fingers 110 and 112.

The relay housing of arm 104 is so positioned and the relay plunger 68*a* has an axial movement of sufficient length so as to intercept any finger 112 passing by when the plunger 68*a* is in its extended position, but adapted to clear any finger 112 passing by when the plunger is in a retracted position. The setting of the valve operators 106 is undisturbed as the drum 84 rotates until an electrical signal to the relay 68 causes the plunger to be extended, as shown in FIG. 3, so as to intercept the finger 112 then in proximity to or next coming into proximity to the plunger 68*a*, thereby to rotate 90° the valve operator 106. The valving action of the valve operator 106 is such that the 90° turn thereof acts to switch the orifices 90 associated therewith from a normal gas vacuum condition and to apply a positive gas pressure to the associated orifices 90*a*. This action tends to eject the associated cigarette from the cradles 88.

It will be noted from FIG. 7 that the relay plunger 68*a* is positioned at the bottom region of the testing zone 26. Hence each cigarette tested in the zone and detected as leaking, thereby causing the relay 68 to be actuated, is ejected from the surface of the drum 84 with gravity assisting air pressure. It should be noted in this connection that each of the cigarette holders 92 is moved to its retracted position after the cigarette has passed through the testing zone 26 so that the associated cigarette may be ejected following the test or may, if found acceptable, be transferred to the drum 76 as explained below.

Referring again to FIG. 2, a finger 120 is fixed to the head 82. The finger is adapted to intercept the finger 110 on any valve operator 106 that is not in the vacuum position. Hence each of the valve operators which has been actuated by the relay plunger 68*a* to eject its associated cigarette is moved to the vacuum position for proper operation in the next cycle of operation when a cigarette is again received from the drum 70 for testing.

Those cigarettes passing through the testing zone 26 and not ejected from the surface of the drum 84 continue to be retained on the drum until they reach the transfer zone 80 (FIG. 2). In the transfer zone 80, the vacuum supplied to the orifices 90 in the cradles 88 is temporarily removed by means of a valving arrangement (not shown) so that the cigarettes may be transferred to the drum 76.

When the form of apparatus including arm 104 and relay 68 is employed, the aforesaid output pulse of air in output conduit 62 is advantageously employed (FIG. 3) to actuate relay 68 to eject the leaky cigarette. In one form, a pneumatic switch 105, preferably of the diaphragm type, is directly actuated (not shown) by the pressure pulse from conduit 62 and thereby closes electrical contacts for the duration of that pulse, connecting electrical power leads 105*a* to relay 68. In general, fluid back-up pressure is not a problem with the output flip flop 61 of means 46, because the alternative output is exhaust 61*b*. Therefore, conduit 62 can be connected directly to switch 105. To avoid back-up however, or to employ a higher pressure rated switch 105, which may have better operating characteristics, a pneumatic relay 107 may be employed to receive the pulse from conduit 62 and supply a separate, and stronger, pulse to switch 105 via conduit 107*a*, as illustrated. Pneumatic relay 107 may be a diaphragm operated needle valve, the diaphragm of which responds to the pressure in conduit 62, and the power circuit of which runs from a pneumatic supply conduit 107*b* to conduit 107*a*. The pressure at 107*b* can be whatever is necessary and suitable. As another alternative (not shown), the pneumatic pressure of pneumatic relay 107 can actuate member 68*a* via a pneumatic cylinder (not shown) rather than by electrical means, although this is not preferred. Although these various approaches each introduce electrical and mechanical inertia into the rejection system, the improvement contributed by use of fluid amplifier means 46 in detection and pulse generation is so superior that this can be tolerated, especially in adapting pre-existing machines having a relay 68 and valve operators 106 to the present invention. Moreover, the amplification of the leak pulse by means 46 allows

faster and more rugged mechanical or electrical rejection means to be employed.

However, the system also can operate with a totally fluid rejection means, thus introducing no mechanical or electrical inertia anywhere, by practicing the alternative form shown in FIGS. 8–10. In that form, the arm **104**, relay **68**, and valve operators **106** are omitted. The positive pressure orifices **90***a* are retained, but they are no longer controlled by valve operator **106**. Instead, a passage **103** (FIG. 9) appears in fixed head **86**, and each row of positive pressure orifices **90***a* is fed positive pressure by a passage **91**, one of which is shown in FIG. 8. Each such passage **91** is located circumferentially midway between the row of orifices **90***a* to which it is connected and the row immediately in advance thereof on drum **20**, i.e., in the direction of rotation of drum **20**. Each passage **91** terminates at an open end **91***a* abutting, and normally closed by, fixed head **86**. Ends **91***a* are on a common radius with passage **103** in fixed head **86**. Passage **103** commences at the circumferential terminal point of passage **102**, and continues for about the angular space between adjacent cigarettes **22**. Because each passage **91** is one-half that distance in advance of its orifices **90***a*, the sequencing is such that positive pressure, if applied, commences at the mid-point of testing.

Since ends **91***a* are normally abutted with head **86**, no pressure normally emanates therefrom. But when a passage **91** moves with drum **20** until its end **91***a* communicates with passage **103**, any positive pressure introduced into passage **103** from output conduit **62** will emanate from the line of orifices **90***a* associated with that particular passage **91**. The positive pressure force exerted on the cigarette **22** at orifices **90***a* can be equal to, greater than, or less than, the vacuum force exerted thereon at orifices **90**. If it is greater than the vacuum force, clearly the cigarette will be ejected. But it will be remembered that there is centrifugal force on each cigarette, and that there is effective gravity force at the bottom portion of drum **20**. Consequently in practice a postive pressure force equal to or even somewhat less than, the vacuum force, can also cause ejection of that cigarette. Where a high vacuum is employed, a pressure booster can be employed on conduit **62** to overcome same. This is shown in FIG. 10 where the pneumatic relay **107** already described with reference to FIG. 3 is shown supplying higher pressure to passage **103** in response to a pulse on conduit **62**. The positive pressure pulse, from conduit **62** directly or from conduit **107***a*, can alternatively be applied (not shown) directly to vacuum orifices **90** to negate or substantially negate the vacuum force thereat, rather than being applied to separate orifices **90***a* as shown.

Relay **107** may be a valve, as mentioned above, and may be actuated by a suitable pressure sensitive transducer means **108**, as shown. Transducer means **108** may be a pressure sensitive switch.

As described above, the system of FIGS. 1–10 provides for a flow of gas through each cigarette. The fluid amplifier means **46** monitors the outlet line, and hence requires a filter to remove tobacco from the gas. It may be desirable, however, not to sense "dirty" gas that has passed through a cigarette, and the alternative embodiments of FIG. 11 are intended to operate by sensing "clean" gas prior to its application to the cigarette under test.

Referring to FIG. 11, gas under constant pressure is applied to a branched conduit **122**. The common leg **124** of the conduit is connected to input conduit **38'** which leads to fluid amplifier **46**, while legs **126** and **128** are coupled to opposite ends of cigarette **22**. Depending upon the imperiousness of the cigarette paper to the flow of gas therethrough, little or no pressure drop occurs at the comman conduit leg **124** unless there is a leak in the cigarette. When there is a leak however, the negative-going pressure pulse is reflected at the input to the cigarettes at conduit **124**, and accordingly is monitored by input conduit **38'** to operate means **46** in the same manner as has already been described. The chief difference is that with the arrangement of FIG. 11, which may be practiced with any of the preceding forms of apparatus according to the invention, the gas fed to Schmitt trigger **47** is clean initially, so that a filter is not needed.

What has been described is a fluid amplifier cigarette inspection and rejection system that is very fast, being almost entirely without inertia, very reliable, being entirely or almost entirely without moving parts or friction, and adaptable to a wide range of inspection rates during operation of a given machine. The bistable nature of the illustrated apparatus is very advantageous in that it divides cigarettes into clearly acceptable and clearly rejected categories depending only upon what side of the arbitrary rejection line they fall, not how far above or below that line they fall. This gives precision to the division, which is advantageous especially in those situations where the accepted cigarettes must be guaranteed to meet a precise minimum fixed standard. Where the division can be rougher, this attribute will weigh less heavily.

The invention has been described with reference to a number of forms, but this was for illustration, not delineation. The illustrative apparatus can be varied in numerous ways within the scope of the invention. All embodiments, illustrated or not, that incorporate the principles of the invention are included within the claimed scope thereof.

What is claimed is:

1. Apparatus for inspecting cigarettes for leaks, comprising:

(a) gas pressure means for subjecting the interior of one of said cigarettes to gas under a pressure different from the pressure outside the cigarette;

(b) monitoring means for monitoring the leakiness of said cigarette as represented by the gas pressure in the interior of said cigarette, comprising fluid amplifier means having a power stream, first and second output channels, and a control input communicating with the gas pressure in the interior of said cigarette and effective to divert said power stream from said first output channel to said second output channel only when said gas pressure is outside a predetermined range;

(c) means responsive to a flow in said second output channel for rejecting said cigarette while it is being tested by said monitoring means;

(d) said gas pressure means including:

(1) conduit means communicating with said cigarette at both ends thereof; and

(2) a source of gas under pressure connected to said conduit means; and

(e) said control input communicates with the gas pressure in said conduit means between said gas pressure source and the ends of said cigarettes.

2. Apparatus for inspecting cigarettes for leaks, comprising:

(a) a testing station;

(b) motive means for moving cigarettes through said testing station sequentially and in a predetermined spaced relation along a normal conveying path, said testing station extending along said path for no more than one and one-half times said predetermined spaced relation;

(c) gas pressure means for subjecting the interior of a cigarette passing through said testing station to gas under a pressure different from the pressure outside the cigarette;

(d) monitoring means for monitoring the leakiness at any cigarette subjected to said gas pressure means in said testing station as represented by the gas pressure in the interior of said cigarette, comprising bistable fluid amplifier means having a power stream, first and second output channels, and a control input communicating with the gas pressure in the interior

of said cigarette and effective to switch said power stream from a stable state in said first output channel to a stable state in said second output channel when said gas pressure is outside of a predetermined range and thereby indicates a leak in the cigarette and;

(e) means responsive to output in said second output channel for ejecting any said cigarette from said normal path before said cigarette leaves said testing station.

3. Cigarette inspecting apparatus according to claim 2, further including means for resetting the output of said fluid amplifier means from said second output channel to said first output channel when the cigarette following a leaky cigarette is not leaky.

4. Cigarette inspecting apparatus according to claim 2, further including synchronizing means allowing said power stream to be switched to said second output channel only after the cigarette under test has reached a predetermined point within said testing station, spaced from the end of the testing station by a distance smaller than the spacing of the cigarettes on said motive means, to ensure that the preceding cigarette has passed beyond the station before the power stream may be so switched.

5. Cigarette inspecting apparatus according to claim 2, wherein said means responsive to output in said second output channel comprises, a passage leading to an orifice under any cigarette in said testing station, said passage being connected to said second output channel.

6. Cigarette inspecting apparatus according to claim 2, wherein said means responsive to output in said second output channel comprises, a passage leading to an orifice under any cigarette in said testing station, a gas pressure source, and means including a normally closed pressure controlled valve connected between said source and said passage, said pressure controlled valve being responsive to the pressure in said second output channel.

7. Apparatus for inspecting cigarettes for leaks, comprising:

(a) a testing station;

(b) motive means for supplying cigarettes sequentially to and removing cigarettes sequentially from said testing station in a normal conveying path;

(c) gas pressure means for subjecting the interior of any said cigarette in said testing station to gas under a pressure different from the pressure outside the outside the cigarette in response to movement of that cigarette into said testing station;

(d) monitoring means for monitoring the leakiness of any cigarette subjected to said gas pressure means in said testing station as represented by the air pressure in the interior of said cigarette, comprising a fluid trigger having a control input communicating with the gas pressure in the interior of said cigarette and effective to switch the output thereof from a normal channel to an alternate channel in response to and for as long as said gas pressure at said control input is outside of a predetermined range and thereby indicates a leak in the cigarette, a fluid pulse generator adapted to generate a pulse each time an entering cigarette reaches a certain point within said testing station, an output flip flop fluid amplifier having first and second output channels and first and second control inputs, and sampling means for sampling said trigger alternate output channel each time said pulse generator produces a pulse and controlling said output flip flop to produce output in said second output channel in response to coexistence of said pulse and output in said alternate channel and until the next said pulse; and

(e) means responsive to output in said output flip flop second output channel for ejecting any said cigarette in said testing station from said normal path to a rejection path.

8. Cigarette inspecting apparatus according to claim 7, wherein said sampling means comprises a control flip flop having the two output channels thereof connected respectively to said first and second output flip flop control inputs, and a pair of NOR gates, one sampling said trigger normal output channel to constitute the rejection NOR gate, and the other sampling said trigger alternate output channel to constitute the restoring NOR gate, each said NOR gate sampling the output of said fluid pulse generator, an alternate output channel of one NOR gate being connected to one control input of said control flip flop, and an alternate output channel of the other NOR gate being connected to the other control input of said control flip flop.

9. Cigarette inspecting apparatus according to claim 7, wherein said fluid pulse generator comprises a source of gas under pressure, a conduit supplied with gas from said source, a restriction in said conduit, and means positively driven in synchronism with movement of said motive means for venting said conduit at a point downstream from said restriction each time said motive means moves so that any cigarette within said testing station reaches a predetermined point therein.

10. Apparatus for testing hollow articles for leaks, comprising:

(a) conveyor means for moving successive holllow articles in a predetermined spaced relation along a normal path through a testing zone having a length in the direction of movement no greater than one and one-half times the spacing between successive articles;

(b) means for connecting the interior of each article in the testing zone to a source of fluid under a pressure having a predetermined difference from the ambient pressure outside said article;

(c) means for sensing the interior pressure of each article as it moves through the testing zone; and

(d) means for ejecting from said normal path each article whose interior pressure is outside of a predetermined range of pressures and thereby indicates a leak in said article;

wherein the improvement comprises:

(e) first bistable fluid amplifier means operatively connected to said ejecting means and shiftable between a normal condition in which it does not actuate the ejecting means and a reject condition in which it does actuate the ejecting means;

(f) second bistable fluid amplifier means in said sensing means to produce a normal output signal only when the interior pressure of an article is within said predetermined range and a contrasting output signal when the interior pressure is outside said range;

(g) means synchronized with said conveyor means for producing a normal output signal except when an article passes a predetermined point in said station, and a contrasting output signal only when an article passes said point; and

(h) third fluid amplifier means responsive only to concurrent contrasting signals from both said signal producing means to switch said first bistable fluid amplifier means to its reject condition.

11. Apparatus as defined in claim 10, including means responsive only to a contrasting signal from said synchronized means concurrently with a normal output signal from said second bistable fluid amplifier means to reset said bistable means to its normal condition.

12. Apparatus for testing cigarettes for leaks, comprising:

(a) conveyor means for moving successive cigarettes in a predetermined spaced relation along a normal path through a testing zone having a length in the direction of movement no greater than one end one-half times the spacing between successive cigarettes;

(b) means for connecting the interior of each cigarette in the testing zone to a source of fluid under a pres-

sure having a predetermined difference from the ambient pressure outside said cigarette;

(c) means for sensing the interior pressure of each cigarette as it moves through the testing zone;

(d) means selectively operable to eject cigarettes from said normal path to a reject path;

(e) actuating means operatively connected to said ejecting means and shiftable between a normal condition in which it does not actuate the ejecting means and a reject condition in which it actuates the ejecting means;

wherein the improvement comprises:

(f) fluid amplifier means in said sensing means including first and second output conduits, a power supply conduit, and a control input conduit communicating with the interior of said cigarette;

(g) means responsive to the pressure in said control input conduit for controlling the division of flow from said power supply conduit between said output conduits;

(h) means responsive to a predetermined flow in one of said actuating means to its reject condition; and

(i) said operating means being located in said testing zone and cooperating with said actuating means to eject a defective cigarette from the normal path before the cigarette leaves the testing zone.

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U.S. Cl. X.R.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,426,582 Dated February 11, 1969

Inventor(s) Colin S. McArthur and Bruce Wall McKnight

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

Col. 4, line 9, "inspecion" should read -- inspection --.

Col. 7, line 56, "values" should read -- valves --.

Col. 9, line 42, "arm 10" should read -- arm 104 --;

Col. 9, line 49, "comprise" should read -- compromise --;

Col. 11, line 71, "imperiousness should read -- imperviousness --.

Col. 13, line 45, at the end of the line, "outside the" should be deleted.

Col. 14, line 24, the word "hollow" is misspelled;

Col. 14, line 71, "end" should read -- and --.

Col. 15, line 22, after "said" insert -- output conduits for operating said --.

SIGNED AND
SEALED
NOV 17 1970

(SEAL)
Attest:

Edward M. Fletcher, Jr.
Attesting Officer

WILLIAM E. SCHUYLER, JR.
Commissioner of Patents

Disclaimer

3,426,582.—*Colin Shaw McArthur* and *Bruce Wall McKnight*, Winston-Salem, N.C. CIGARETTE INSPECTION APPARATUS. Patent dated Feb. 11, 1969. Disclaimer filed July 19, 1972, by the assignee, *R. J. Reynolds Tobacco Company.*

Hereby enters this disclaimer to claims 10 and 11 of said patent.

[*Official Gazette February 19, 1974.*]