

- [54] **APPARATUS FOR DETERMINING THE FIRMNESS OF FILLERS IN CIGARETTE RODS OR THE LIKE**
- [75] Inventors: **Joachim von der Lohe; Heinz Gretz,**
both of Hamburg; **Uwe Heitmann,**
Luneburg, all of Germany
- [73] Assignee: **Hauni-Werke Korber & Co. KG,**
Hamburg, Germany
- [22] Filed: **Mar. 5, 1971**
- [21] Appl. No.: **121,404**

Related U.S. Application Data

- [62] Division of Ser. No. 764,482, Oct. 2, 1968, Pat. No. 3,595,067.

Foreign Application Priority Data

Oct. 9, 1967 Germany..... 1632208

- [52] U.S. Cl. 131/21 B; 131/21 D
- [51] Int. Cl.² A24C 5/34
- [58] Field of Search..... 131/21 B, 21 R, 21 D, 21 A

References Cited**UNITED STATES PATENTS**

- | | | | |
|-----------|---------|--------------------|------------|
| 2,660,886 | 12/1953 | Milmore..... | 131/21 R X |
| 2,861,683 | 11/1958 | Gilman..... | 131/21 B X |
| 2,952,262 | 9/1960 | Pocock et al. | 131/21 B |
| 3,031,883 | 5/1962 | Pocock et al. | 131/21 B |
| 3,089,497 | 5/1963 | Molins et al. | 131/21 D |

- | | | | |
|-----------|---------|--------------------|------------|
| 3,288,147 | 11/1966 | Molins et al. | 131/21 D |
| 3,306,304 | 2/1967 | Molins et al. | 131/21 D |
| 3,380,351 | 4/1968 | Cox et al. | 131/21 B X |
| 3,411,513 | 11/1968 | Knobel..... | 131/21 B |
| 3,428,052 | 2/1969 | Patterson..... | 131/21 B X |
| 3,431,914 | 3/1969 | Richter..... | 131/21 A |
| 3,633,590 | 1/1972 | Pocock et al. | 131/21 B |

FOREIGN PATENTS OR APPLICATIONS

- | | | | |
|---------|---------|---------------------|----------|
| 958,207 | 5/1964 | United Kingdom..... | 131/21 B |
| 961,731 | 6/1964 | United Kingdom..... | 131/21 D |
| 242,333 | 12/1962 | Australia..... | 131/21 D |

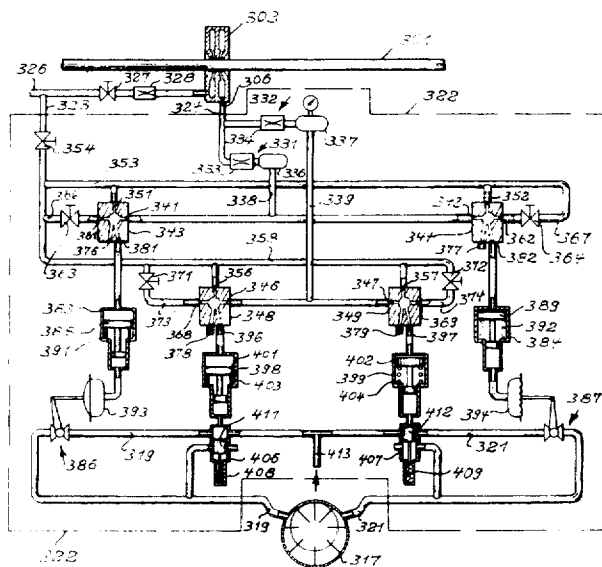
Primary Examiner—Joseph S. Reich

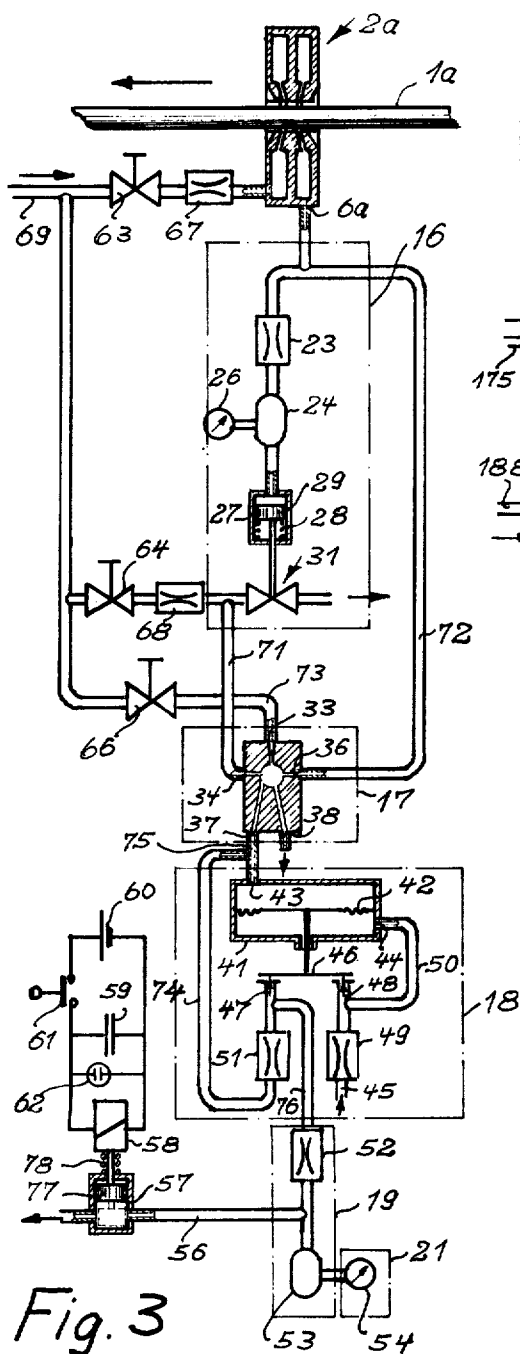
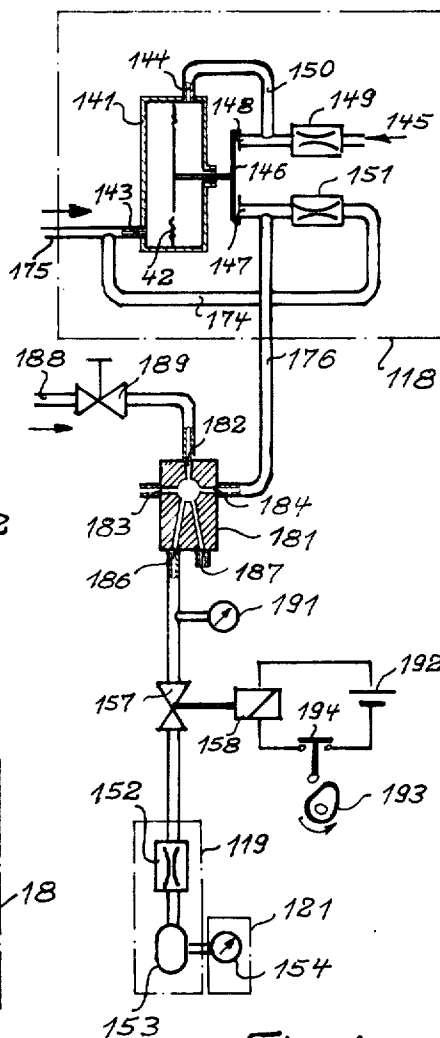
Attorney, Agent, or Firm—Michael S. Striker

[57]**ABSTRACT**

The firmness of rod-like fillers in cigarettes or cigarette rods is determined by directing an air stream against the wrapper of a cigarette or cigarette rod and by measuring the extent of deformation which the filler undergoes in response to deforming pressure of the air stream. The results of measurements can be utilized to furnish visual indications of firmness, to furnish visual indications of differences between a desired firmness and the measured firmness, to furnish visual indications of average firmness of predetermined lengths of the filler, and/or to effect automatic adjustment of the machine which produces the filler.

1 Claim, 9 Drawing Figures





Inventor:
JOACHIM VON DER GÖHE
HEINZ GRETZ
UWE HEITHANN
BY *Edw. J. Shaker*
ATTORNEY

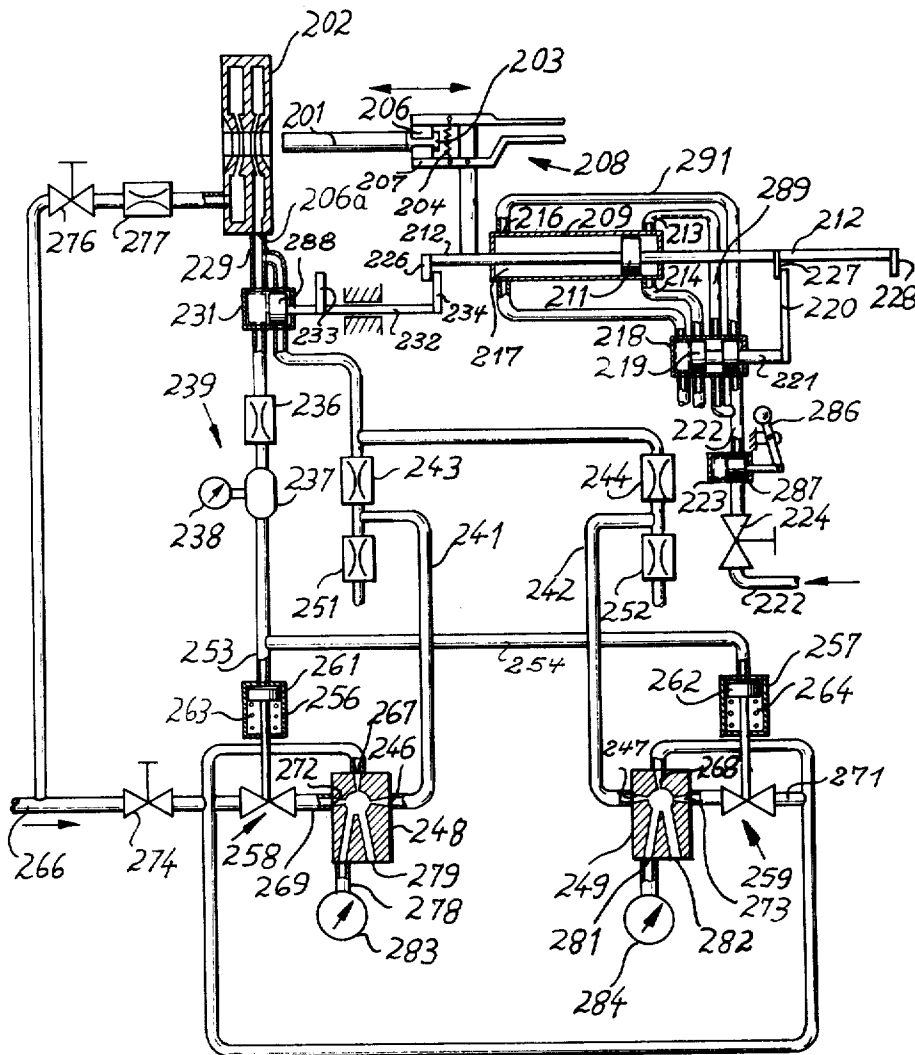
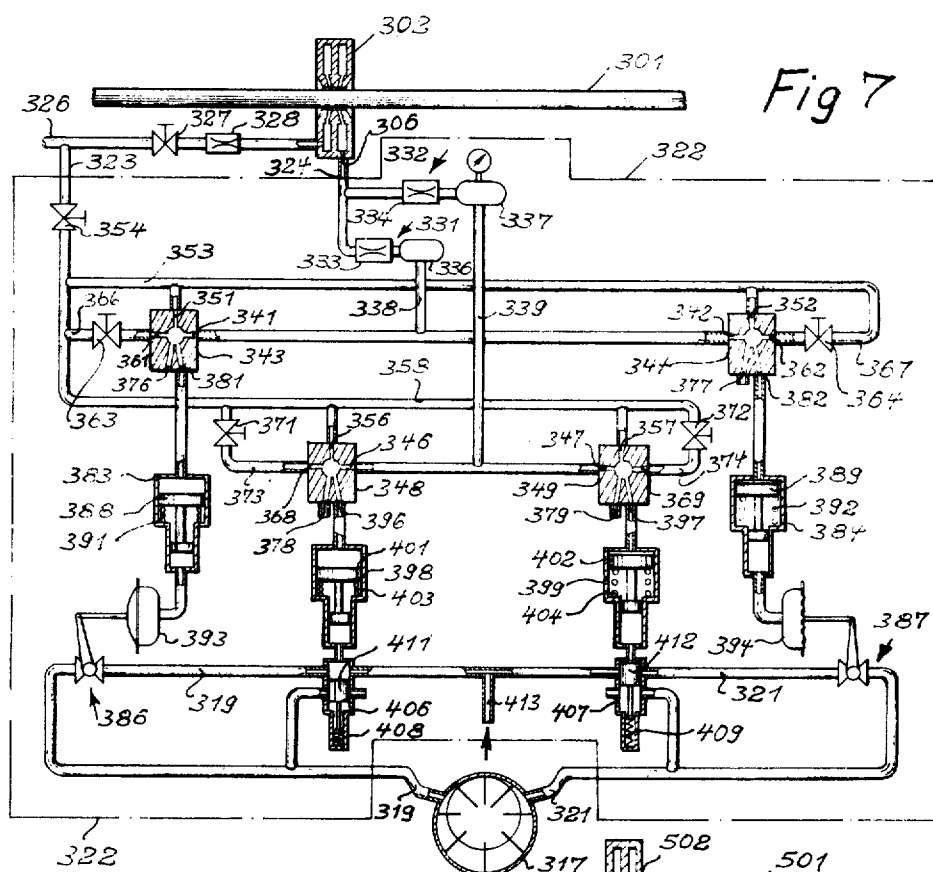
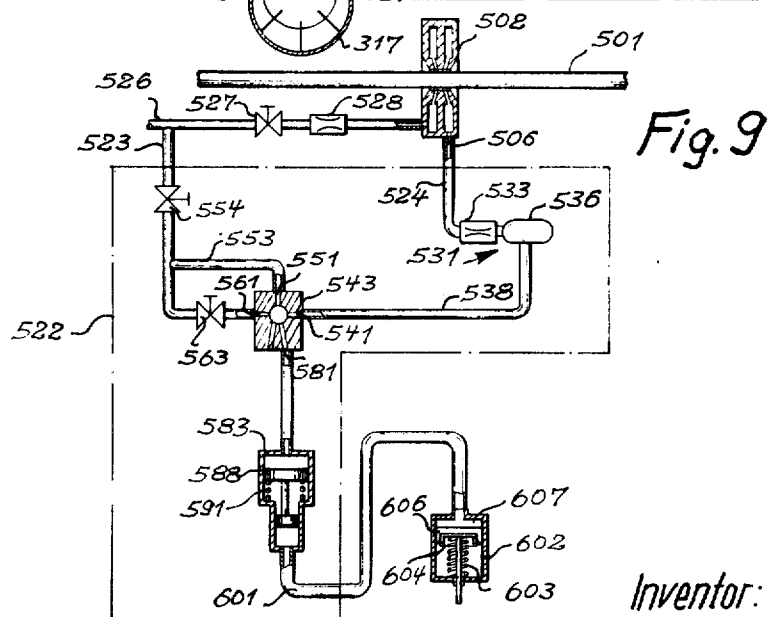


Fig. 5

Inventor:
JESCHKE VON DER LÖHE
HEINZ GRETZ
OLKE HEITMANN
Bismarckstr. 1, 1000 Berlin
ATTORNEY



Inventor:

JOACHIM VON DER LÖHE
HEINZ GRETZ
OLIVIER HEITHANNBILLY L. LEE
ATTORNEY

APPARATUS FOR DETERMINING THE FIRMNESS OF FILLERS IN CIGARETTE RODS OR THE LIKE

CROSS-REFERENCE TO RELATED APPLICATION

This is a division of our copending application Ser. No. 764,482, filed Oct. 2, 1968, now U.S. Pat. No. 3,595,067 granted July 27, 1971.

BACKGROUND OF THE INVENTION

The present invention relates to a method and apparatus for testing of cigarettes or analogous tobacco-containing articles, and more particularly to a method and apparatus for determining the firmness or "feel" of tobacco fillers in cigarettes, cigarette rods or the like. Still more particularly, the invention relates to improvements in a method and apparatus for automatically determining the firmness of fillers in wrapped continuous tobacco-containing rods or in tobacco-containing rods of finite length. The invention also relates to a method and to a machine for automatically regulating the production of fillers for cigarette rods or the like so that the firmness of such fillers remains within a desired optimum range.

Manufacturers of cigarettes, cigarillos or similar wrapped rod-shaped tobacco-containing articles must take particular care to insure that the firmness of the filler is satisfactory to the consumer. In other words, the firmness of the filler must be such that a smoker holding the cigarette between two fingers gains the impression that the wrapper is properly filled and will not yield to a certain finger pressure. Moreover, the manufacturer must insure that the firmness of the filler in each of a batch of smoking articles is the same, i.e., that a pack or another receptacle for cigarettes does not contain cigarettes having fillers of different firmness. The average smoker is not concerned with the weight of a cigarette; all that counts to him is that the touch or feel of the cigarette be satisfactory.

The firmness of the filler depends on the filling force which is a function of the elasticity and mass of tobacco particles in the filler. When a filler contains highly elastic tobacco shreds or strands, its weight per unit length can be reduced considerably without affecting the firmness. The smoker does not detect the reduced weight of the filler because the feel of a cigarette containing a filler which is composed of highly elastic tobacco shreds is the same as that of a much heavier filler which contains less elastic particles of comminuted tobacco.

It is already known to test the firmness of fillers in cigarettes by a device which comprises a row of rams and means for urging the rams against the wrapper of a cigarette with a predetermined force. The extent of displacement of rams in response to the application of such force is indicative of the firmness of the filler. This device is still in experimental stage and exhibits several serious drawbacks, especially high initial cost, complicatedness and the fact that the results are available with a considerable delay following completion of the test so that such results cannot be utilized to bring about immediate remedial action in the production of fillers.

British Pat. No. 985,491 discloses a mechanical device which utilizes a springy feeler serving to detect the dimensions of fillers and to adjust the distributor or the trimming device of a cigarette rod making machine when the dimensions of the filler deviate from a desired value. This device is used exclusively as a means for de-

tecting the mass of unwrapped filler streams, not the firmness, of wrapped cigarette rods.

U.S. Pat. No. 2,952,262 discloses a pneumatic apparatus for detecting variations in the quantity of tobacco contained in a paper tube. This patent relies on a procedure which is known from the art of measuring the diameters of wires and proposes to cause a gas to flow past a length of cigarette rod at a rate determined by the cross-sectional size of the rod. The pressure of gas in such "as to be not greater than the desired minimum pressure of tobacco within the cigarette paper wrapper." Therefore, the method and apparatus of this patent cannot determine the firmness of fillers and much less positive deviations of firmness from a desired optimum range.

SUMMARY OF THE INVENTION

One of several important objects of our invention is to provide a method of rapidly and accurately determining the firmness of masses of comminuted tobacco particles or the like, particularly of determining the firmness of "feel" rod-like fillers in the wrappers of cigarettes, cigarette rods or like rod-shaped articles according to which the firmness of fillers can be measured continuously, with a minimum of delay, and in such a way that the results of measurements indicate variations in firmness of a certain length of a rod-like filler, the average firmness of a certain length of filler, differences between a desired firmness and the measured firmness, the extent to which the measured firmness exceeds or is less than a desired firmness, and/or a combination of the above.

An additional object of the invention is to provide a simple and reliable automatic apparatus for testing the firmness or feel of fillers in cigarette rods or the like and to construct the apparatus in such a way that it can furnish readily detectable readings indicating the firmness, either at regularly recurring intervals or at the will of the person in charge.

A further object of the invention is to provide an apparatus which can be built into or combined with a cigarette rod making machine or another suitable filler-producing machine to monitor the firmness of the filler and to effect appropriate adjustments of the machine when the firmness is unsatisfactory and which can determine the firmness of rod-like fillers in cigarettes or cigarette rods without defacing the wrappers, without unduly deforming or otherwise affecting the appearance and/or quality of tested articles, and with a degree of accuracy which is unmatched by presently known apparatus. The improved testing apparatus both as to its construction and its mode of operation, together with additional features and advantages thereof, will be best understood upon perusal of the following detailed description of certain specific embodiments with reference to the accompanying drawing.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is an axial sectional view of a deforming nozzle forming part of a testing apparatus which embodies the invention;

FIG. 2 is a similar axial sectional view of a second deforming nozzle;

FIG. 3 is a diagrammatic partly sectional view of a testing apparatus which employs the deforming nozzle of FIG. 2 and is utilized to automatically determine differences between measured average firmness of a filler rod and the desired average firmness;

3

FIG. 4 is a similar diagrammatic partly sectional view of a testing apparatus which constitutes a modification of the apparatus shown in FIG. 3;

FIG. 5 is a diagrammatic partly sectional view of a testing apparatus which is utilized to determine the differences between measured firmness and the desired maximum or minimum firmness of a filler rod of finite length;

FIG. 6 is a schematic partly elevational and partly sectional view of a cigarette rod making machine whose operation is regulated by a testing apparatus similar to the one shown in FIG. 5;

FIG. 7 is a schematic view of the testing apparatus for the machine of FIG. 6; FIG. 8 is a diagrammatic and partly sectional view of a portion of a modified cigarette rod making machine; and

FIG. 9 is a view similar to FIG. 7 of a testing apparatus which can be utilized to regulate the operation of the machine shown in FIG. 8.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. 1 illustrates a portion of an apparatus which determines the firmness of a mass of tobacco, namely, the firmness of the rod-like filler in a continuous cigarette rod 101. The rod 101 comprises a filler of shredded tobacco which is enclosed in a tubular wrapper of cigarette paper. The apparatus includes an annular deforming nozzle 102 which admits a stream of gas, preferably air, against the external surface of the wrapper in the cigarette rod 101. The deforming nozzle 102 comprises two inlets 103, 104 for compressed air and an outlet 106 which is connected with a testing or evaluating device serving to determine the characteristics of air in the annular chamber 107 of the nozzle 102. The chamber 107 communicates with the outlet 106 by way of a channel 108. The central portion of the chamber 107 communicates with an annular opening 109 extending into the surface surrounding the central passage or orifice for the cigarette rod 101.

The operation:

The inlets 103, 104 are connected with a source of compressed air so that a stream of air flows into the chamber 107 and against the peripheral surface of that circumferentially complete portion of the wrapper which is surrounded by the opening 109. Depending on the firmness of the filler in the cigarette rod 101, air which impinges against the wrapper in the region of the opening 109 effects a greater or lesser elastic deformation of the filler in the cigarette rod so that the wrapper is formed with an annular constriction or neck which causes the cigarette rod to develop two annular beads flanking the constriction and to produce a more or less pronounced sealing action between the wrapper and the annular surfaces flanking the opening 9. Thus, when the filler is relatively soft (readily deformable), the wrapper of the cigarette rod 101 produces a stronger sealing action so that the pressure of air which flows into the channel 108 rises because compressed air admitted at 103, 104 cannot escape by way of the opening 109. When the tobacco filler is firm, the sealing action of the wrapper in the region of the opening 109 is less pronounced and the pressure of air in the channel 108 decreases. A very firm tobacco filler can withstand the pressure of air in the chamber 107 and does not permit any appreciable deformation of the wrapper. The air stream is then free to flow around the wrapper and to escape from the opening 109 with a minimum of ob-

4

struction so that the pressure in the channel 108 does not increase at all. Thus, the chamber 107 and the channel 108 constitute that portion of the nozzle 102 which can measure elastic deformation and hence the firmness of the filler in the cigarette rod 101. The firmness is inversely proportional to the extent of deformation of the filler. The outlet 106 discharges a series of pneumatic signals which form an air stream and whose magnitude (pressure) is indicative of the firmness of corresponding increments of the filler in the rod 101. The pressure of testing air is preferably less than required to effect a permanent deformation of the filler.

FIG. 2 illustrates a modified annular deforming nozzle 2 which surrounds a travelling cigarette rod 1. The nozzle 2 comprises inlets 3, 4, an annular chamber 7, a central opening 9 surrounding the rod 1, and an annular inlet 11 which is machined into one of the surfaces flanking the opening 9 and communicates with a second annular chamber 12. The latter communicates with an outlet 6 which is connected with a testing or evaluating device. A channel 8 connects the chamber 12 with the inlet 11.

The operation of this deforming nozzle is similar to that of the nozzle 102. Compressed air which issues from the opening 9 causes deformation of the filler and wrapper in the cigarette rod 1 whereby the extent of such deformation depends on the firmness or lack of firmness of the filler. Tobacco shreds which are displaced in response to a constriction of the wrapper in the area surrounded by the opening 9 cause the wrapper to bulge radially outwardly at both sides of the constriction and to thus furnish a more pronounced sealing action against the escape of air by way of the opening 9. If the sealing action of the wrapper is pronounced, the inlet 11 receives a greater amount of air and the pressure of air in the second chamber 12 increases. Such pressure is detected by the evaluating or testing device which is connected to the outlet 6.

Since the rod 1 is transported lengthwise, the pressure in the outlet 6 is indicative of the firmness of successive increments of the filler in the rod 1. The outlet 6 can be said to produce a series of pneumatic signals whose magnitude reflects the extent of deformation and hence the firmness of those increments of the filler which advance through the area surrounded by the opening 9. The aforementioned evaluating or testing device determines the changes of that characteristic (pressure) of air issuing from the outlet 6 which is variable as a function of the resistance offered by corresponding increments of the filler to deformation by the air stream entering the opening 9 of the deforming nozzle 2. In this embodiment of our testing apparatus, the opening 9 admits a stream of air radially inwardly against the wrapper of the cigarette rod 1, and the thus admitted stream is deflected in the opposite direction (i.e., substantially radially outwardly) to enter the channel 8 and the second chamber 12.

FIG. 3 illustrates a testing apparatus including an annular deforming nozzle 2a which surrounds a travelling cigarette rod 1a and cooperates with a pneumatic testing or evaluating device serving to determine deviations of the firmness of successive increments of the rod-like filler from an optimum standard value. The testing device includes a pneumatic testing unit 16 which receives from the outlet 6a of the nozzle 2a signals indicating the firmness of successive increments of the filler and comprises an averaging unit which produces and stores signals indicating the average firmness

of several increments of the travelling filler. The testing unit 16 is connected with an integrator unit 17 and the latter is connected with a signal amplifier unit 18. The testing apparatus further comprises a second pneumatic averaging unit 19 and a reducing or indicating unit 21.

The averaging unit of the testing unit 16 comprises a so-called laminar resistor 23 in series with an air tank 24 provided with a pressure gauge 26. The tank 24 is in series with an adjusting cylinder 27 which accommodates a piston 29 biased by a helical spring 28. The piston 29 can actuate an adjustable setting or regulating valve 31 which is adjusted in dependency on the average firmness of the filler in the rod 1a to thereby regulate an air stream whose rate of flow is proportional to the firmness of the filler. The construction of the laminar resistor 23 is such that its resistance does not change in response to changes in air pressure or in response to changes in quantity of the air flowing there-through.

The integrator unit 17 comprises an inlet 33 for compressed air, two inlets 34, 36 for reference air streams and two outlets 37, 38 the latter of which is in communication with the atmosphere. Integrator units which can be utilized in the apparatus of FIG. 3 normally operate on the principle known as Coanda effect. Such units are known as fluidic summing junctions and are manufactured by Corning Glass Works of Corning, N.Y. (see item No. 19071 in Catalogue of January, 1967).

The amplifier unit 18 comprises a housing 41 with an amplifier diaphragm 42 and two openings 43, 44 for air. The diaphragm 42 is coupled with a flap 46 which is mounted externally of the housing 41 and controls two nozzles 47, 48. The nozzle 48 is connected to the opening 44 by a pipe 50 and with a laminar resistor 49. The latter is connected to the atmosphere by way of a pipe 45. The other nozzle 47 is connected with the opening 43 of the housing 41 by way of a further laminar resistor 51. The intensity of the signal furnished by the nozzle 47 is the square of the intensity of the signal at the opening 43. The pipe 45 admits to the laminar resistor 49 air for admission into the nozzle 48. The pipe 50 admits air to the diaphragm 42 in the housing 41. A similar amplifier unit is shown, for example, in FIG. 27 on page 151 of the publication entitled "Regelungstechnik", Volume 4, published in 1967.

The second averaging unit 19 comprises a laminar resistor 52 and an air tank 53. The reducing unit 21 comprises an appropriately calibrated pressure gauge 54. The pipe connecting the laminar resistor 52 with the tank 53 communicates with a pipe 56 which contains a valve 57 operated by a solenoid 58 and having a valve member 77 which moves to the broken-line position when the solenoid 58 is energized. A return spring 78 urges the valve member 77 to the solid-line position of FIG. 3. The circuit of the solenoid 58 includes a time-lag device here shown as a capacitor 59 which is charged by an energy source 60 in response to closing of a master switch 61 to maintain the solenoid 58 in energized condition for a predetermined interval of time. The exact moment when the capacitor 59 is fully charged following closing of the master switch 61 is indicated by a lamp 62.

The testing or evaluating device of FIG. 3 further comprises adjustable valves 63, 64, 66 and laminar resistors 67, 68. A supply conduit 69 furnishes compressed air from a compressor, pump or blower. The

pressure of air entering the inlet 33 of the integrator unit 17 is indicative of the desired optimum firmness of the filler in the rod 1a. The pressure of air at the inlet 34 is indicative of measured average firmness, and the pressure of air at the inlet 36 varies as a function of the firmness of successive increments of the filler in the rod 1a.

The operation is as follows:

The cigarette rod 1a is moved lengthwise through the area surrounded by the central opening of the nozzle 2a, and the outlet 6a of the nozzle discharges a series of pneumatic signals which form an air stream and whose pressure is indicative of the firmness of the corresponding increments of the filler in the cigarette rod 1a. A portion of the thus discharged air stream enters the tank 24 by way of the laminar resistor 23. The tank 24 serves as an averaging element, i.e., as a means for damping the signals, in that it eliminates short-lasting fluctuations in the pressure of incoming air stream. This is due to inertia of the series-connected parts 23, 24. Pressure in the tank 24 changes in response to longer-lasting deviations of firmness from a standard value so that readings furnished by the gauge 26 represent an average value of the pressure which depends on the firmness of the filler in the cigarette rod 1a. The pressure of air in the tank 24 causes the piston 29 in the cylinder 27 to assume a position which is a function of the firmness of the filler, and the piston 29 adjusts the setting valve 31 to regulate the air stream which flows through this valve. It can be said that this air stream constitutes a pneumatic output signal whose characteristics vary as a function of changes in average firmness of the filler in the rod 1a. A pipe 71 is connected with the supply conduit 69 upstream of the valve 31 and serves to deliver a stream of compressed air to the inlet 34 of the integrator unit 17. As stated before, the pressure of such air stream is proportional to the pressure of air in the tank 24. The other inlet 36 of the integrator unit 17 is connected with a pipe 72 which receives air from the outlet 6a so that the pressure of air in the inlet 36 fluctuates in the same way as the firmness of successive increments of the filler in the rod 1a. The inlet 33 admits to the integrator unit 17 compressed air from the conduit 69 by way of a pipe 73 which contains the valve 66. The valve 66 is adjusted in such a way that the pressure of air at the inlet 33 corresponds to or reflects the desired optimum firmness of the filler. The air stream which enters via inlet 33 is deflected to the right or to the left, as viewed in FIG. 3, depending on the pressure of air which is admitted by way of the inlets 34, 36. The pressure at the outlet 37 is indicative of the difference between the pressures in the inlets 34, 36. Air issuing at 37 flows through a pipe 75 which is connected to the opening 43 so that such air exerts pressure against the upper side of the diaphragm 42 in the housing 41. A pipe 74 which branches from the pipe 75 upstream of the opening 43 is connected with the laminar resistor 51 in the amplifier unit 18 to admit air into the nozzle 47. The stream of air issuing from the orifice of the nozzle 47 impinges against the flap 46. A pipe 76 which is connected with the pipe 74 in the region between the laminar resistor 51 and nozzle 47 transmits signals whose intensity is the square of the intensity of pneumatic signals emitted by the outlet 37 of the integrator unit 17. The air tank 53 of the averaging unit 19 has a large time constant and the pressure therein is indicative of the average value of amplified pneumatic signals furnished by the pipe 76. The gauge 54 of the reducing unit 21 indicates the pres-

sure of air in the tank 53.

The operation of the testing device is started in response to closing of the master switch 61. The switch 61 is held in closed position until the signal lamp 62 lights up to indicate that the capacitor 59 is charged. The solenoid 58 is energized and moves the valve member 77 to the broken-line position to seal the pipe 56 and to thereby seal the outlet of the tank 53. Thus, the pressure of air in the tank 53 begins to rise above atmospheric pressure. After the elapse of a predetermined interval of time, for example, after one minute, the charge of the capacitor 59 drops sufficiently to permit the spring 78 to return the valve member 77 in the valve 57 to the solid-line position. The pointer of the gauge 54 remains in the position of maximum deflection from zero position and thus indicates the average deviation of firmness of the filler in the cigarette rod 1a from a desired standard firmness.

A fresh testing operation can begin as soon as the pressure in the tank 53 decreases to atmospheric pressure and in response to renewal closing of the master switch 61. Thus, the apparatus of FIG. 3 is always ready to furnish information as to the standard deviation of firmness from desired firmness and the gauge 54 furnished readings in response to closing of the master switch 61.

An important advantage of the just described apparatus is that it furnishes information which is indicative of average deviations of firmness of the filler from a desired standard firmness. Thus, it is not necessary to carry out a series of short-lasting measurements and to thereby calculate the average deviation on the basis of a series of short-lasting tests. The measurements carried out by the apparatus of FIG. 3 are detected with a certain delay because the pointer of the gauge 54 indicates the average deviation of firmness from standard firmness in that portion of the filler in the rod 1a which has already advanced beyond the opening of the nozzle 2a. However, this is of no consequence because the firmness of a filler changes rather gradually.

In the apparatus of FIG. 3, the nozzle 2a causes deformation of successive increments of the filler, the outlet 6a of the nozzle furnishes pneumatic signals which indicate the firmness of successive increments of the filler, the averaging unit 23, 24 of the testing unit 16 produces a signal which indicates the average firmness of several successive increments of the filler, the valve 31 serves to produce an output signal which is indicative of the average firmness of several successive increments (such signal, i.e., the air stream flowing through the valve 31, can be utilized to adjust the machine which produces the filler for the rod 1a), the integrator unit 17 furnishes at 37 a series of signals which indicate deviations of the firmness of successive increments of the filler from a desired standard firmness, the amplifier unit 18 amplifies such signals, and the averaging unit 19 furnishes a signal (at 54) which is indicative of average deviation of firmness from the desired firmness. The parts 56-62 constitute a means for initiating and terminating the operation of the averaging unit 19 for desired periods of time.

The testing or evaluating apparatus of FIG. 4 is similar to the just described apparatus and many of its parts are denoted by similar numerals plus 100. The purpose of this apparatus is to process pneumatic signals which are admitted by way of a pipe 175 and represent the average value of differences between measurements carried out at a remote point and indicating, for example,

the firmness of successive increments of a cigarette rod. Signals transmitted by the pipe 175 need not necessarily be obtained by pneumatic means in a manner as shown in FIG. 3. Thus, it is also possible to produce pneumatic signals in response to measurements which are carried out by mechanical means and which can represent the firmness or another characteristic of the filler in a cigarette or cigarette rod. Thus, signals admitted by way of the pipe 175 can represent deviations of the weight of successive increments of a travelling cigarette rod from a standard value.

The parts in the amplifier unit 118 of the apparatus shown in FIG. 4 are identical to the corresponding parts of the amplifier unit 18 in FIG. 3. The amplifier unit 118 is connected with a pneumatic integrator or summing junction 181 by way of a pipe 176. The integrator 181 has an inlet 182 connected with a pipe 188 corresponding to the pipe 73 of FIG. 3 and containing a regulating valve 189. The integrator 181 further comprises inlets 183, 184 and outlets 186, 187 which respectively correspond to the inlets 34, 36 and to the outlets 37, 38 of the integrator unit 17 in FIG. 3. A similar integrator, called proportioning device, is described by Corning Glass Works as item No. 190040 in the Catalog dated May 1966.

The outlet 186 of the integrator 181 is connected with a pressure gauge 191 and with a valve 157 which can be opened by a solenoid 158. The valve 157 is installed in a pipe which further contains a laminar resistor 152 and discharges into the air tank 153 of the averaging unit 119. The circuit of the solenoid 158 includes an energy source 192 and a master switch 194 which is periodically opened by a rotary cam 193.

Signals furnished by the pipe 175 are amplified in the unit 118 and are transmitted to the integrator 181 prior to being transmitted to the second integrator unit 119. When the cam 193 allows the master switch 194 to close, the solenoid 158 is energized and opens the valve 157 for a predetermined interval of time so that the latter transmits pneumatic signals to the averaging unit 119. The intensity of such signals is a function of signals which are transmitted by way of the pipe 175.

In the manufacture of cigarettes, it is often desirable to determine deviations of firmness of fillers in cigarettes from an arithmetic average value, especially to determine whether or not the average firmness of the filler in a cigarette exceeds or is below a certain desirable maximum or minimum value. An apparatus which can furnish information whether or not the average firmness of discrete cigarettes 201 exceeds a permissible maximum value or is below a permissible minimum value is shown in FIG. 5. This apparatus comprises a deforming nozzle 202 which corresponds to the nozzle 2 of FIG. 2; however, it is equally possible to employ the deforming nozzle 101 of FIG. 1. The cigarette 201 is a filter cigarette and its filter tip 203 is held by two jaws 206, 207 which are biased thereagainst by a spring 204. The jaws 206, 207 form part of a gripper or holder 208 which is reciprocable by a drive including a fluid-operated cylinder 209 and serves as a means for effecting relative movement between the deforming nozzle 202 and the filler in the cigarette 201. The cylinder 209 accommodates a piston 211 having a piston rod 212 which supports the gripper 208. The cylinder 209 is connected with a first pair of conduits 213, 214 which admit fluid serving to move the piston 209 in a direction to the left, as viewed in FIG. 5, and with a second pair of conduits 216, 217 which admit fluid to move the

piston 209 in a direction to the right. The means for regulating the flow of fluid by way of the conduits 213, 214, 216, 217 comprises a valve 218 having a reciprocable valve member 219 which is provided with a stem 221 connected with a follower 220. A supply conduit 222 for compressed air accommodates a manually operated control valve 223 and an adjustable throttle valve 224. The right-hand portion of the piston rod 212 of the piston 211 in the cylinder 209 has two axially spaced abutments 227, 228 for the follower 220. The control valve 223 has a plunger 287 which is reciprocable by a lever 286.

The outlet 206a of the nozzle 202 serves to transmit pneumatic signals which indicate the firmness of successive increments of the filler in the cigarette 201. This outlet 206a is connected with a pipe 229 which accommodates a valve 231 having a piston 288 provided with a piston rod 232 having two axially spaced followers 233, 234. The left-hand portion of the piston rod 212 carries a further abutment 226. In one position of the piston 288, pneumatic signals transmitted by the outlet 206a can be admitted into an averaging unit 239 including a laminar resistor 236 and an air tank 237 provided with a pressure gauge 238. The averaging unit 239 serves as a storing means for signals indicating the arithmetic average value of firmness of the filler in the cigarette 201. In the other position of the piston 288 in the valve 231, the pipe 229 connects the outlet 206a of the nozzle 202 with pipes 241, 242 which respectively contain laminar resistors 243, 244 and are connected with integrators in the form of Schmitt triggers 248, 249. These integrators operate on the principle known as Coanda effect and are manufactured by Corning Glass Works (see the item No. 190462 in Catalogue of May 1966).

The numerals 251, 252 denote two additional laminar resistors. The aforementioned air tank 237 is connected with pipes 253, 254 which are respectively connected with adjusting cylinders 256, 257 for two regulating valves 258, 259. The cylinder 256 accommodates a piston 261 which is biased by a spring 263 and is connected with the valve 258. The valve 259 is connected with a piston 262 installed in the cylinder 257 and biased by a helical spring 264. The valves 258, 259 are installed in pipes 269, 271 branching from a supply conduit 266 for compressed air which is also connected with an inlet of the nozzle 202 by way of a throttle valve 276 and laminar resistor 277. The valves 258, 259 respectively admit air to the inlets 272, 273 of the Schmitt triggers 248, 249. The supply conduit 266 contains an adjustable throttle valve 274. This valve insures that the pressure of air at the inlets 267, 268 of Schmitt triggers 248, 249 represents the desired standard firmness of the filler in the cigarette 201. The Schmitt triggers 248, 249 further comprise outlets 278, 279 and 281, 282. The outlets 278, 281 are respectively connected with gauges 283, 284.

The operation:

In order to test the firmness of the filler in the cigarette 201, the latter's filter tip 203 is inserted between the jaws 206, 207 of the gripper 208 in that the jaws are moved apart against the opposition of the spring 204. The spring 204 thereupon contracts and biases the jaws against the filter tip so that the cigarette 201 is held in the position shown in FIG. 5. In the next step, the plunger 287 of the control valve 223 is moved by the lever 286 to assume its phantom-line position so that compressed air can flow through the supply conduit

222, throttle valve 224, control valve 223 and a pipe 289 to the conduit 213 and into the right-hand chamber of the cylinder 209. The piston 211 causes the piston rod 212 to move in a direction to the left and to move the gripper 208 and the cigarette 201 in the same direction. The wrapper of the cigarette 201 passes through the central opening of the nozzle 202 and the outlet 206a transmits pneumatic signals which indicate the firmness of successive increments of the filler. Such signals are transmitted to the averaging unit 239. When the entire filler of the cigarette 201 advances through the central opening of the nozzle 202, the abutment 226 of the piston rod 212 engages the follower 233 on the rod 232 of the piston 288 and moves the latter to the phantom-line position in which the outlet 206a is connected with the pipes 241, 242. The averaging unit 239 is then sealed from the nozzle 202. The pressure in the tank 237 of the averaging unit 239 is indicative of the arithmetic average value of the firmness of all increments of the filler in the cigarette 201, and such pressure causes the adjusting cylinder 256 to change the setting of regulating valves 258, 259 in the pipes 269, 271 which admit air to the inlets 272, 273 of the Schmitt triggers 248, 249.

When the abutment 226 of the piston rod 212 engages the follower 233 on the piston rod 232, the abutment 228 of the piston rod 212 engages the follower 220 and moves the valve member 219 to the broken-line position of FIG. 5. Compressed air flowing through the conduit 222 is then admitted to a pipe 291 which communicates with the conduit 216, i.e., the piston 211 moves back toward the position shown in FIG. 5. During such rightward movement of the piston rod 212, the piston 288 dwells in its phantom-line position and connects the outlet 206a with the pipes 241, 242 which transmit pneumatic signals to the inlets 246, 247 of the Schmitt triggers 248, 249. When the deviations of average firmness (determined by the averaging unit 239 and stored in the tank 237) exceed a predetermined maximum or minimum value, the outlets 278, 281 of the Schmitt triggers 248, 249 produce signals which are indicated by the gauges 283, 284.

When the abutment 226 of the piston rod 212 reaches the follower 234, the piston 288 in the valve 231 returns to the solid-line position of FIG. 5. At the same time, the abutment 227 of the piston rod 212 engages the follower 220 and returns the valve member 219 to the illustrated solid-line position. This completes the testing operation.

The apparatus of FIG. 5 furnishes information regarding deviation of firmness of the cigarette filler above a permissible maximum firmness or below a permissible minimum firmness. However, this apparatus can be readily converted to furnish information regarding deviations of average firmness of cigarettes 201 from a desired standard average firmness. To this end, one of the Schmitt triggers 248, 249 (for example, the trigger 249) can be omitted, together with the corresponding regulating valve (259) and the other Schmitt trigger (248) is replaced by an integrator unit corresponding to the unit 17 of FIG. 3. The thus modified apparatus then further comprises an amplifier unit (18), a second averaging unit (19) and a reducing unit (21).

In the apparatus of FIG. 5, the filler of the cigarette 201 is tested twice, namely, for the first time during leftward movement of the holder 208 (for the purpose of enabling the averaging unit 239 to determine the av-

erage firmness of the filler), and for the second time during return movement of the holder 208 (for the purpose of supplying to the inlets 246, 247 of Schmitt trigger 248, 249 signals which indicate the firmness of successive increments of the filler) in the cigarette rod 201. The Schmitt triggers 248, 249 respectively respond (i.e., the gauges 283, 284 furnish readings) when the firmness of the filler is respectively above or below a predetermined optimum range.

FIG. 6 illustrates certain details of a cigarette rod making machine wherein the trimming or equalizing device 311 is adjusted in accordance with signals furnished by a testing or evaluating device 322 forming part of an apparatus for determining the firmness of successive increments of the cigarette rod 301. The apparatus further comprises an annular deforming nozzle 302 which is similar to or identical with the nozzle 2 or 102 and is installed in the cigarette rod making machine upstream of the customary cutoff (not shown) which serves to subdivide the cigarette rod 301 into cigarette rod sections of unit length or multiple unit length.

The cigarette rod making machine of FIG. 6 further comprises an adjustable distributor 303 which is driven by an adjustable prime mover here shown as an electric motor 305 and showers shredded tobacco particles 304 onto the upper stretch of an endless belt 307. The latter converts showered tobacco particles into a stream which is fed into the circumferential groove 309 of a conveyor here shown as a suction wheel 308. This wheel holds the tobacco stream in the groove 309 by suction and advances it past the trimming device 311 which removes excess tobacco to convert the stream into a filler rod 301a. The filler rod 301a is then fed into a wrapping mechanism 312 wherein it is provided with a tubular wrapper consisting of cigarette paper tape 313 to be thus converted into the cigarette rod 301. The mechanism 312 comprises an endless belt 310 which constitutes a means for effecting relative movement between the deforming nozzle 302 and cigarette rod 301. The means for applying adhesive to overlapping edges of the wrapper and the means for heating the resulting seam are of conventional design and are not shown in FIG. 6.

The trimming device 311 comprises a rotary cutter 316 which is driven by an electric motor 314 and is adjustable with the motor radially of the suction wheel 308 (arrow 318) by an adjusting device including a pneumatic servomotor 317. The thus removed surplus of shredded tobacco is picked up by a collecting conduit 320. The servomotor 317 is connected with the testing device 322 by two conduits 319, 321. The testing device 322 receives compressed air by way of a pipe 323 which is connected with a main supply conduit 326. A further pipe 324 connects the testing device 322 with the outlet 306 of the nozzle 302. The inlet or inlets of the nozzle 302 are connected to the aforementioned main supply conduit 326 by way of a throttle valve 327 and a laminar resistor 328.

The details of the testing or evaluating device 322 are illustrated in FIG. 7. The aforementioned pipe 324 transmits pneumatic signals from the outlet 306 of the deforming nozzle 302 to two pneumatic averaging units 331, 332 each of which comprises a laminar resistor 333, 334 in series with an air tank 336, 337. The outlet of the averaging unit 331 is connected with a pipe 338 and by way of such pipe with the first inlets 341, 342 of two integrator units 343, 344. The output of the aver-

aging unit 332 is connected to the first inlets 346, 347 of two Schmitt triggers 348, 349 by way of a pipe 339. The integrator units 343, 344 further comprise second inlets 351, 352 which are connected to a pipe 353 receiving compressed air from the main supply conduit 326 by way of a throttle valve 354. The Schmitt triggers 348, 349 have additional inlets 356, 357 which receive compressed air from the main supply conduit 326 by way of the throttle valve 354 and a pipe 358. The integrator units 343, 344 further comprise third inlets 361, 362 which receive air by way of adjustable throttle valves 363, 364 installed in pipes 366, 367 respectively branching from the pipes 358, 353. The Schmitt triggers 348, 349 also comprise third inlets 368, 369 receiving air from pipes 373, 374 containing adjustable throttle valves 371, 372. The integrator units 343, 344 respectively comprise first outlets 376, 377 which communicate with the atmosphere and second outlets 381, 382 which are respectively connected with cylinders 383, 384. The Schmitt triggers 348, 349 have first outlets 378, 379 which are connected with the atmosphere and second outlets 396, 397 which are connected with cylinders 398, 399. The cylinders 383, 384, 398, 399 respectively accommodate reciprocable pistons 388, 389, 401, 402 which are respectively biased by helical springs 391, 392, 403, 404. The pistons 388, 389 can adjust regulating valves 386, 387 by way of flexible diaphragms accommodated in housings 393, 394. The cylinders 398, 399 are amplifier cylinders and their pistons 401, 402 can adjust the position of pistons 411, 412 in control valves 406, 407. These pistons are respectively biased by springs 408, 409. The control valves 406, 407 respectively regulate the flow of air in the conduits 319, 321 which furnish pneumatic signals to the servomotor 317. A common supply conduit 413 furnishes compressed air to the conduits 319, 321 upstream of the valves 406, 407.

The elements 343, 344, 348, 349 are identical with or analogous to the integrator unit 17 of FIG. 3 or to the unit 248 of FIG. 5.

The operation of the cigarette rod making machine of FIG. 6 and of the testing apparatus shown in FIG. 7 is as follows:

The motor 305 drives the distributor 303 so that the belt 307 forms a continuous tobacco stream and feeds it into the groove 309 of the suction wheel 308. The stream is advanced past the cutter 316 of the trimming device 311 which removes the surplus and converts the stream into the filler rod 301a which is thereupon wrapped on the belt 310 of the mechanism 312 to be converted into the cigarette rod 301. The tape 313 is drawn upwardly onto the belt 310 and is converted into a tubular wrapper which is coated with adhesive and heated to form a strong seam between the overlapping edge portions. The belt 310 advances the rod 301 through the orifice of the deforming nozzle 302.

The nozzle 302 supplies air which deforms successive increments of the filler 301a in the cigarette rod 301 and its outlet 306 furnishes pneumatic signals which indicate the firmness of such increments. These signals are transmitted, by way of laminar resistors 333, 334, to the air tanks 336, 337 of the averaging units 331, 332. The purpose of these averaging units is to eliminate high-frequency fluctuations of the pneumatic signals. The thus modified signals indicate the average value of firmness of the filler 301a and are transmitted by way of pipes 338, 339 to the inlets 341, 342 of the integrator units 343, 344 as well as to the inlets 346,

347 of Schmitt triggers 348, 349. The corresponding desired values of firmness of the filler rod 301a are furnished in the form of pneumatic signals by way of inlets 361, 362 and 368, 369, i.e., by way of valves 363, 364 and 371, 372. These valves are properly adjusted so that the pressure of air flowing into the inlets 361, 362, 368, 369 is indicative of desired average firmness of the filler rod 301a.

Pressures developing at the outlets 381, 382 of the integrator units 343, 344 are indicative of differences between measured and desired values of firmness of the filler rod 301a. The pressure at the outlet 381 is indicative of positive differences and the pressure at the outlet 382 is indicative of negative differences between the measured and desired values of firmness. Such pressures cause appropriate adjustment of pistons 388, 389 in the cylinders 383, 384 and hence a corresponding adjustment of regulating valves 386, 387.

The pressures at the outlets 396, 397 of Schmitt triggers 348, 349 develop when the intensity of signals indicating the measured firmness is different from the intensity of signals indicating the desired standard firmness. In such an instance, the pistons 401, 402 in the cylinders 398, 399 adjust the pistons 411, 412 of control valves 406, 407 against the opposition of springs 408, 409 so that the conduits 319, 321 receive compressed air from the supply conduit 413.

If the deviation of firmness is positive, i.e., if a particular section of the cigarette rod 301 contains a filler whose firmness exceeds the desired firmness (as indicated by the Schmitt triggers 348), the position of the piston 411 in the control valve 406 is changed so that the conduit 319 admits compressed air to the servomotor 317 which adjusts the trimming device 311 in such a way that the latter removes a greater quantity of tobacco from the stream in the groove 309 of the suction wheel 308. The amount of air which is admitted to the servomotor 317 by way of the conduit 319 depends on the setting of the regulating valve 386 which is installed in the conduit 319 downstream of the control valve 406 and is adjusted in accordance with the signal produced by the integrator unit 343. The signal for adjustment of the regulating valve 386 is transmitted by way of the piston 388 in the cylinder 383 and by way of the diaphragm in the housing 393. The adjustment of the regulating valve 386 is proportional to the extent of deviation of the measured firmness from the desired firmness, i.e., to the extent to which the measured firmness exceeds the desired firmness.

If the difference between the measured firmness and the desired firmness is negative, i.e., if the measured firmness is less than the desired firmness, the conduit 319 is sealed in response to closing of the valve control 406 and the control valve 407 connects the conduit 321 with the supply conduit 413 so that the latter can admit to the servomotor 317 air in the amounts determined by setting of the regulating valve 387 which is mounted in the conduit 321 downstream of the control valve 407. It will be noted that the control valves 406, 407 are shutoff valves. The servomotor 317 then adjusts the trimming device 311 in such a way that the cutter 316 removes a lesser amount of shredded tobacco so that the firmness of the filler 301a in the cigarette rod 301 increases.

FIGS. 8 and 9 illustrates a modified apparatus which can adjust the trimming or equalizing device 511 (FIG. 8) in a simpler way. Certain parts of this modified apparatus and of the cigarette rod making machine which is

adjusted by such apparatus are denoted by reference numerals similar to those employed in FIGS. 6-7 plus 200.

The testing or evaluating device 522 of FIG. 9 comprises a single pneumatic averaging unit 531, a single integrator unit 543 and a single cylinder 583. The cylinder 583 is connected with the cylinder 602 of a pneumatic servo unit by way of a pipe 601. The cylinder 602 accommodates a piston 604 which is connected thereto by a diaphragm 606. The latter seals a plenum chamber 607 in the cylinder 602. This cylinder is mounted on a supporting rail 609 (FIG. 8) which guides an electric motor 514 serving to rotate the cutter 516 of the trimming device 511. The motor 514 and the cutter 516 are reciprocable (arrow 418) as a unit by the piston rod (output member) 608 of the piston 604.

The operation is as follows:

The outlet 506 of the nozzle 502 (FIG. 9) sends pneumatic signals which are indicative of firmness of the filler 501a in the cigarette rod 501. The latter is moved axially through the central passage of the nozzle 502. The signals are transmitted to the averaging unit 531 which smoothes out high-frequency fluctuations of the continuously transmitting signals and transmits a signal which is indicative of average measured firmness of the filler 501a in the rod 501. Such signal is transmitted to the inlet 541 of the integrator unit 543. The inlet 561 of this integrator unit is connected with a pipe 523 which transmits pneumatic signals indicating desired firmness of the filler 501a. Such signal can be adjusted by the valves 554, 563. The outlet 581 of the integrator 543 transmits a pneumatic signal to the cylinder 583 which latter serves as an amplifier and transmits amplified signals (indicating the difference between the measured firmness and desired firmness) by way of the pipe 601 and on to the plenum chamber 607 of the cylinder 602 of the servo unit for the trimming device 511. The output member 608 of the piston 604 adjusts the motor 514 and the cutter 516 in accordance with the intensity of signals which are amplified by the cylinder 583.

If the difference between the measured and desired signals is positive, the pressure in the chamber 607 of the cylinder 602 rises and the output member 608 moves the motor 514 downwardly, as viewed in FIG. 8, so that the cutter 516 removes more tobacco and reduces the firmness of the filler 501a. If the difference between the measured and desired values of firmness of the filler 501a is negative, i.e., if the desired firmness exceeds the measured firmness, the piston 588 moves upwardly, as viewed in FIG. 9, and the pressure in the chamber 607 of the cylinder 602 decreases so that the spring 603 expands and the piston rod 608 moves the motor 514 and the cutter 516 upwardly to reduce the amount of tobacco which is removed from the stream in the groove 509 of the suction wheel 508.

It is clear that the firmness of the filler rod can be regulated in a number of different ways without departing from the spirit of the present invention. For example, signals produced by the testing apparatus can be employed to adjust the distributor 303 of FIG. 6 so that the latter changes the rate of discharge of tobacco shreds 304 as a function of difference between the measured firmness and desired firmness of the filler rod. An apparatus which can adjust the distributor is disclosed, for example, in British Pat. No. 933,691. The device which adjusts the distributor in the cigarette rod making machine of this British patent can be readily designed to effect adjustments of the distributor in de-

15

pendency on the magnitude and direction (positive or negative) of signals which are furnished by a pneumatic testing apparatus of the type shown in FIG. 7 or 9.

The just described modification is illustrated schematically in FIG. 6 wherein the variable-speed d-c motor 305 of the distributor 303 is controlled by a servo unit 701 which is connected with the nozzle 302 by a pipe 702. The servo unit 701 comprises a suitable transducer which converts pneumatic signals furnished by the pipe 702 and indicating the measured firmness of the filler 301a into d-c voltage signals which are used to regulate the speed of the motor 305. When the firmness determined by the nozzle 302 is less than the desired firmness, the servo unit 701 adjusts the speed of the motor 305 in a sense to reduce the output of the distributor 305 and to furnish less tobacco into the groove 309 of the suction wheel 308. Inversely, and when the firmness of the filler 301a is less than the desired optimum firmness, the servo unit 701 adjusts the motor 305 in a sense to increase the output of the distributor 303 and to insure that the firmness of the rod 301a increases. Transducers which can convert pneumatic signals into electric signals are well known in the art; therefore, the details of the servo unit 701 are not shown in FIG. 6. In addition to the transducer, the servo unit 701 may comprise a circuit which can compare signals furnished by the transducer with signals which indicate the desired firmness of the filler rod 301a and which produces signals to adjust the speed of the motor 305 when the signals furnished by the transducer are stronger or weaker than the signals indicating the desired firmness.

The improved testing apparatus exhibits a number of important advantages. Thus, the apparatus can be used for determining the firmness of fillers in discrete rod-shaped articles (such as plain or filter cigarettes, cigars, cigarillos or the like) as well as for testing the firmness of the filler in a continuous cigarette rod or other wrapped tobacco rod or filter rod. In other words, the apparatus can test the firmness of the filler upstream or downstream of the customary cutoff in a cigarette rod making machine, depending upon whether the apparatus should determine the firmness of a continuous filler or the firmness of sections of a subdivided filler. The measurements carried out by our testing apparatus do not affect the quality, appearance and/or other characteristics of tested goods, and the signals furnished by the testing apparatus are produced with no appreciable delay so that, when necessary, the firmness of a filler can be adjusted immediately upon detection of excessive or insufficient firmness. Depending on the nature of remedial action (adjustment of the trimming device and/or adjustment of the distributor), the testing apparatus can furnish signals which indicate measured firmness which exceeds or is less than the desired maximum or minimum firmness or an average firmness which either exceeds or is less than the desired average firm-

16

ness. As explained in connection with FIG. 7, pneumatic signals can be amplified and otherwise treated to bring about appropriate adjustment of the producing machine without necessitating conversion of such signals into electrical, mechanical or other types of signals.

A further important advantage of the improved testing apparatus is that it can be combined with and can regulate a continuous cigarette rod making machine or a like machine which forms and/or wraps a filler rod. The testing apparatus can adjust the machine in a fully automatic way, with a minimum of delay and with a high degree of accuracy so that the machine can furnish a cigarette rod wherein the firmness of the filler is within desired limits and that the "feel" of cigarettes or other smoker's articles obtained in response to subdivision of the wrapped tobacco rod is always satisfactory to the smokers. As stated before, signals produced by our testing apparatus can be used to adjust a producing machine without necessitating conversion into electrical or other types of signals even though such conversion might be desirable in certain instances, for example, when the distributor is driven by an electric motor.

What is claimed as new and desired to be protected by Letters Patent is set forth in the appended claims:

1. In a machine for the production of articles containing comminuted tobacco, a combination comprising converting means for converting a stream of comminuted tobacco particles into a rod-like filler, including an equalizing device having removing means for removing tobacco particles from the stream; deforming means for directing a gas against successive increments of and for thereby subjecting the filler to deformation whose extent is inversely proportional to the firmness of the filler; measuring means for determining the extent of deformation of the filler and for producing signals indicating such deformation; and regulating means for regulating the quantity of comminuted tobacco in the filler as a function of said signals, said regulating means being arranged to change the position of said removing means with reference to the stream and including a rotary pneumatic motor and a pair of conduit means for supplying compressed gas to said motor whereby the motor causes said removing means to remove less tobacco in response to admission of gas by way of one of said conduit means and to remove more tobacco in response to admission of gas by way of the other conduit means, said measuring means comprising means for producing signals indicating positive and negative deviations from an optimum firmness of the filler, first control means provided in one of said conduit means to admit gas to said motor in response to signals indicating said positive deviations and second control means provided in the other conduit means for admitting to said motor gas in response to signals indicating said negative deviations.

* * * * *