

PATENT SPECIFICATION

DRAWINGS ATTACHED

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COMPLETE SPECIFICATION

Improvements in Continuous Quality Indicator for Cigarette Maker

We, THE AMERICAN TOBACCO COMPANY, a corporation organized and existing under the laws of the State of New Jersey, United States of America, of 150 East 42nd Street, New York, State of New York, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to the manufacture of cigarettes and, more particularly, to apparatus for automatically measuring and indicating the quality of cigarettes manufactured by cigarette making machines.

It is important in the production of cigarettes for the manufacturer to maintain careful quality control checks throughout the various stages of production. One cigarette characteristic which provides a reliable indication of final overall quality is that of the distribution of weight among the cigarettes produced. The final cigarette weight varies as a function of tobacco moisture content, tobacco density, firmness of packing etc. Automatic radiation type gauge systems have been proposed for continuously monitoring the production of cigarette rod material for regulating automatic machinery which controls the amount of tobacco supplied to the rolling apparatus and the like. Although such automatic monitoring and regulating systems are intended to function automatically without human intervention, it has frequently been found that the distribution of cigarette weights does not fall within the narrow tolerances imposed by the high quality standards of commercial production.

It is a primary object of the present invention to provide a highly sensitive automatic alarm system which continuously monitors

the output signal from a radiation type cigarette gauge and automatically actuates an operator's alarm indicator when the distribution of the weight of the cigarette rod material departs from a desired normal weight distribution.

The present invention is therefore an apparatus for measuring the quality of a cigarette manufacturing process wherein a rod of tobacco moves past a sensing station. The apparatus comprises radiation gauge means for producing a deviation signal corresponding to the deviation of the density of the rod at the station from a standard value of density, circuit means for operating upon the deviation signal in a non-linear manner to produce an integrand signal varying as a function of the deviation signal raised to a power greater than unity, means for integrating the integrand signal over a period of time, and means for indicating the result of the integration.

The various operational features and advantages of the present invention will be further appreciated by consideration of the following description taken in connection with the accompanying drawing, in which:

The single figure is a block and schematic diagram illustrating the electrical circuits provided by the present invention.

In accordance with the present invention, a varying D-C measured density signal from a radiation type gauge is utilized as an input monitoring signal to the automatic alarm of the present invention. The D-C measured density signal from the gauge is inversely proportional to the density of the cigarette rod moving past the gauge. It is customary practice to differentially compare the signal voltage produced by radiation particles passing through the moving cigarette rod with a reference standard density signal pro-

duced by radiation transmitted through a standard rod material. The result of this comparison is a deviation signal 10, shown in Figure 1, from the measuring head corresponding to the variation of the density of the cigarette rod at the sensing station from the standard value of cigarette density. The deviation signal 10 is zero for exactly standard weight cigarette rod and increases in a negative or positive direction from the reference zero value for cigarette rod material that is respectively overweight or underweight. The above described varying signal 10 is submitted to a 60 cycle rejection filter 11 and amplified by a chopper-type amplifier 12, and the chopped A-C voltage is rectified by a bridge rectifier 13 to produce across a filter capacitor 14 a magnitude signal which is proportional to the absolute magnitude of the deviation of the cigarette rod density at the sensing station from the standard density. This magnitude signal across capacitor 14 is then applied to a non-linear voltage divider comprising an output shunt arm 15 and a non-linear network series arm including zener diodes 16, 17, 18 and shunt resistance arms 19, 20, 21, and 22 connected in series parallel as shown. The zener diodes 16, 17, 18 are provided to switch in the shunt resistance arms 20, 21, and 22 in parallel with the resistor 19 as the input voltage progressively increases in the positive direction. The resistance value of the series arm of the voltage divider thus varies inversely in a non-linear manner with the applied input voltage from the rectifier 13 so that as the magnitude signal across the filter capacitor 14 increases, the resistance value of the series arm in the divider decreases and a larger proportion of the input voltage is applied across the output arm 15 of the divider to produce an integrand signal which is then transmitted to an integrating circuit 23, 24. The integrand signal presented to the integrator circuit corresponds to the deviation of the cigarette rod density raised to a power greater than unity.

The non-linear divider characteristic is adapted to greatly expand the deviation signal as the cigarette rod density departs from the value corresponding to standard weight cigarettes. In this manner small variations from the standard density value will be accorded relatively less weight in the integration process than larger variations from the standard value. This non-linear operation serves to make the apparatus less sensitive to small variations from the standard density which are to be expected in any process and much more sensitive to large variations in density even though these latter variations may be of short duration.

The resistance of the series arm of the divider in a preferred embodiment of the invention varies inversely with the square of

the applied magnitude signal so that the result of the integration over a period of time corresponds to the statistical variance (σ^2) of the distribution of density of the rod passing the sensing station during a period of time.

The statistical variance (σ^2) of the density distribution is a convenient factor to use in the description and evaluation of a cigarette manufacturing process and in the comparison of one cigarette process or machine with another. Variance may be understood as a measure of the "sharpness" of a process distribution curve; thus a process in which the cigarette weights are distributed over a wide range of values will have a larger variance than a process in which the cigarette weights are limited to a narrow range of values around a standard or mean value. In this way it can be seen that variance is a direct measure of the "quality" of a process, i.e., how closely its product adheres to a desired standard value.

With discrete sampling of cigarette density, the equation for variance takes the form

$$\sigma^2 = \sum_{n=1}^n (d_n - d^*)^2$$

where n is the number of samples, d_n is the n th sample of density and d^* is the standard value of density. Where the density d is a continuous variable the variance may be given as

$$\sigma^2 = \int_0^T (d - d^*)^2 dt$$

where T is the period of time over which the integration is made. The preferred embodiment uses this latter process to obtain the variance.

Component types and values for a typical non-linear voltage divider which produces a square law effect on the magnitude signal is as follows:

16	4.7 volt zener diodes	resistors
17		
18		
19	4.7 megohms	
20	2.4 megohms	
21	2.4 megohms	
22	47,000 ohms	

It should be understood, however, that the desired exaggeration of off-standard densities and the correspondingly exaggerated weight such densities are allotted in the integration process can be achieved by having the voltage divider vary in any monotonic non-linear fashion such that the integrand signal presented to the integrator varies as a function of the input voltage raised to a positive power greater than unity.

The output voltage from the non-linear divider developed across resistance 15 is integrated by a resistor 23 and capacitor 24 network. A diode 25 is connected in series

with the network resistor 23 and is poled to conduct and charge the capacitor 24 when a positive voltage is applied to the integrating resistor 23. The diode 25 accordingly prevents discharge of the capacitor 24 through the resistance 23.

The practical value for the integrating network are as follows:

23—10 megohms

23—4 mfd.

At this point the voltage stored on the integrator capacitor 24 may be measured after a suitable integration period of conventional voltmeter means to give a measure of the variance of the process. However, in the preferred embodiment shown in Figure 1, the result of the integration stored in the integrating capacitor 24 is periodically read out by closure of the normally opened contacts 26 of a relay switch located in a timer controller 27, a step voltage from the capacitor 24 being applied across the input terminals of a pulse amplifier 28. The output pulse voltage from the amplifier 28 is applied to separate trigger switches 29 and 30, each of which has an adjustable operating threshold control 31 and 32. The trigger switches 29 and 30 advantageously comprise thyatron controlled relay switches which are normally biased to the "off" condition by the variable threshold controls 31 and 32. In normal operation, the trigger switch 29 is negatively biased so that pulse voltages from the amplifier 28 corresponding to standard values of cigarette weight distribution do not fire the thyatron into the conducting state. For weights that are greater or less than acceptable values, the output pulse from the amplifier 28 exceeds the cut-off bias value provided by the threshold adjust 31 and the trigger switch 29 is fired, opening the normally closed trigger switch contacts 33 associated with trigger switch 29 and simultaneously closing the normally open trigger contacts 34. Accordingly, the green indicator lamp 35 which normally indicates production of normal weight cigarettes is turned off and the white indicator lamp 36, indicating production of slightly off-weight cigarettes, is turned on. In like manner, when the amplitude of the output pulse from the amplifier 28 increases further, indicating the production of objectionably off-weight cigarette rod, the trigger switch 30 is turned on so as to open the normally closed contacts 37 and to close the normally open contacts 38. In the latter operation, the white light 34 is turned off and the red indicator light 39 is turned on, thus warning the operator that the production weight distribution has departed by a significant amount from the normal desired value. Following the read-out of the voltage stored on the integrating capacitor 24, the relay contact 26 are opened by the timer controller 27 and its normally open switch contacts 40 are momentarily

closed. Closure of the contacts 40 completely discharges the capacitor 24, thereby conditioning the capacitor to accept a new signal voltage from resistance 15. Following erasure of the charge on the capacitor 24, the contacts 40 are opened by the timer controller 27 and the capacitor 24 is allowed to charge for a period of time sufficient to assure build-up of the peak voltage appearing across the shunt resistance 15. For the component values given above, a charge time of approximately 55 seconds has been found to be satisfactory.

The trigger switches 29 and 30 are re-set to an "off" condition just prior to the completion of the charge period by the closure of the switch contacts 41 by the timer controller 27. Where thyatrons are utilized as trigger switches, for example, the switch contacts 41 are advantageously connected to ground the anodes and thereby re-set the thy-trigger switches, for example, the switch completion of the charge time, the read-out switch contacts 26 are again closed and the signal pulse developed at the output of the amplifiers 28 is again evaluated by the trigger switches 29 and 30.

While the invention has been particularly shown and described with reference to a preferred embodiment thereof, it will be understood by those skilled in the art that various changes in form and details may be made therein without departing from the spirit and scope of the invention. For example, a number of well-known controller circuits can be utilized to perform the time sequence control of the read-out switch 26, the discharge switch contacts 40 and the re-set switch contacts 41. The controller 27 can, for example, comprise a motor driven time-sequence control switch.

WHAT WE CLAIM IS:—

1. Apparatus for measuring the quality of a cigarette manufacturing process wherein a rod of tobacco moves past a sensing station, the apparatus comprising radiation gauge means for producing a deviation signal proportional to the deviation of the density of the rod at the sensing station from a standard value of density, circuit means for operating upon the deviation signal in a non-linear manner to produce an integrand signal varying as a function of the deviation signal raised to a power greater than unity, means for integrating the integrand signal over a period of time, and means for indicating the result of the integration.
2. Apparatus according to claim 1 having means for comparing the result of the integration with a threshold value and actuating an alarm when the result exceeds the threshold value.
3. Apparatus for measuring the quality of a cigarette manufacturing process wherein a rod of tobacco moves past a sensing station,



with the network resistor 23 and is poled to conduct and charge the capacitor 24 when a positive voltage is applied to the integrating resistor 23. The diode 25 accordingly prevents discharge of the capacitor 24 through the resistance 23.

The practical value for the integrating network are as follows:

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At this point the voltage stored on the integrator capacitor 24 may be measured after a suitable integration period of conventional voltmeter means to give a measure of the variance of the process. However, in the preferred embodiment shown in Figure 1, the result of the integration stored in the integrating capacitor 24 is periodically read out by closure of the normally opened contacts 26 of a relay switch located in a timer controller 27, a step voltage from the capacitor 24 being applied across the input terminals of a pulse amplifier 28. The output pulse voltage from the amplifier 28 is applied to separate trigger switches 29 and 30, each of which has an adjustable operating threshold control 31 and 32. The trigger switches 29 and 30 advantageously comprise thyatron controlled relay switches which are normally biased to the "off" condition by the variable threshold controls 31 and 32. In normal operation, the trigger switch 29 is negatively biased so that pulse voltages from the amplifier 28 corresponding to standard values of cigarette weight distribution do not fire the thyatron into the conducting state. For weights that are greater or less than acceptable values, the output pulse from the amplifier 28 exceeds the cut-off bias value provided by the threshold adjust 31 and the trigger switch 29 is fired, opening the normally closed trigger switch contacts 33 associated with trigger switch 29 and simultaneously closing the normally open trigger contacts 34. Accordingly, the green indicator lamp 35 which normally indicates production of normal weight cigarettes is turned off and the white indicator lamp 36, indicating production of slightly off-weight cigarettes, is turned on. In like manner, when the amplitude of the output pulse from the amplifier 28 increases further, indicating the production of objectionably off-weight cigarette rod, the trigger switch 30 is turned on so as to open the normally closed contacts 37 and to close the normally open contacts 38. In the latter operation, the white light 34 is turned off and the red indicator light 39 is turned on, thus warning the operator that the production weight distribution has departed by a significant amount from the normal desired value. Following the read-out of the voltage stored on the integrating capacitor 24, the relay contact 26 are opened by the timer controller 27 and its normally open switch contacts 40 are momentarily

closed. Closure of the contacts 40 completely discharges the capacitor 24, thereby conditioning the capacitor to accept a new signal voltage from resistance 15. Following erasure of the charge on the capacitor 24, the contacts 40 are opened by the timer controller 27 and the capacitor 24 is allowed to charge for a period of time sufficient to assure build-up of the peak voltage appearing across the shunt resistance 15. For the component values given above, a charge time of approximately 55 seconds has been found to be satisfactory.

The trigger switches 29 and 30 are re-set to an "off" condition just prior to the completion of the charge period by the closure of the switch contacts 41 by the timer controller 27. Where thyatrons are utilized as trigger switches, for example, the switch contacts 41 are advantageously connected to ground the anodes and thereby re-set the thy-trigger switches, for example, the switch completion of the charge time, the read-out switch contacts 26 are again closed and the signal pulse developed at the output of the amplifiers 28 is again evaluated by the trigger switches 29 and 30.

While the invention has been particularly shown and described with reference to a preferred embodiment thereof, it will be understood by those skilled in the art that various changes in form and details may be made therein without departing from the spirit and scope of the invention. For example, a number of well-known controller circuits can be utilized to perform the time sequence control of the read-out switch 26, the discharge switch contacts 40 and the re-set switch contacts 41. The controller 27 can, for example, comprise a motor driven time-sequence control switch.

WHAT WE CLAIM IS:—

1. Apparatus for measuring the quality of a cigarette manufacturing process wherein a rod of tobacco moves past a sensing station, the apparatus comprising radiation gauge means for producing a deviation signal proportional to the deviation of the density of the rod at the sensing station from a standard value of density, circuit means for operating upon the deviation signal in a non-linear manner to produce an integrand signal varying as a function of the deviation signal raised to a power greater than unity, means for integrating the integrand signal over a period of time, and means for indicating the result of the integration.

2. Apparatus according to claim 1 having means for comparing the result of the integration with a threshold value and actuating an alarm when the result exceeds the threshold value.

3. Apparatus for measuring the quality of a cigarette manufacturing process wherein a rod of tobacco moves past a sensing station,

the apparatus comprising radiation gauge means for producing a magnitude signal proportional to the absolute magnitude of the deviation of the density of the rod at the sensing station from a standard value of density, circuit means for operating upon the magnitude signal in a non-linear manner to produce an integrand signal varying as a function of the magnitude signal raised to a power greater than unity, means for integrating the integrand signal over a period of time, and means for indicating the result of the integration.

4. Apparatus for measuring the quality of a cigarette manufacturing process wherein a rod of tobacco moves past a sensing station, the apparatus comprising radiation gauge means for producing a measured density signal corresponding to the density of the rod at the sensing station, means for producing a standard density signal corresponding to a standard value of density, means for comparing the measured density signal with the standard density signal to produce a deviation signal proportional to the deviation of the density of the rod at the sensing station from the standard value of density, means for operating upon the deviation signal to produce an integrand signal varying as a function of the magnitude signal raised to a power greater than unity, means for integrating the integrand signal over a period of time, and means for indicating the result of the integration.

5. The apparatus of claim 4 having means for comparing the result of the integration

with a threshold value and actuating an alarm when the result exceeds the threshold value.

6. Apparatus for measuring the quality of a cigarette manufacturing process wherein a rod of tobacco moves past a sensing station, the apparatus comprising radiation gauge means for producing a measured density signal corresponding to the density of the rod at the sensing station, means for producing a standard density signal corresponding to a standard value of density means for comparing the measured density signal with the standard density signal to produce a deviation signal proportional to the deviation of the density of the rod at the sensing station from the standard value of density, means for operating upon the deviation signal to produce a magnitude signal proportional to the absolute magnitude of the deviation of the density of the rod at the sensing station from the standard value of density, means for operating upon the magnitude signal to produce an integrand signal varying as a function of the magnitude signal raised to a power greater than unity, means for integrating the integrand signal over a period of time, and means for comparing the result of the integration with a threshold value and actuating an alarm when the result exceeds the threshold value.

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