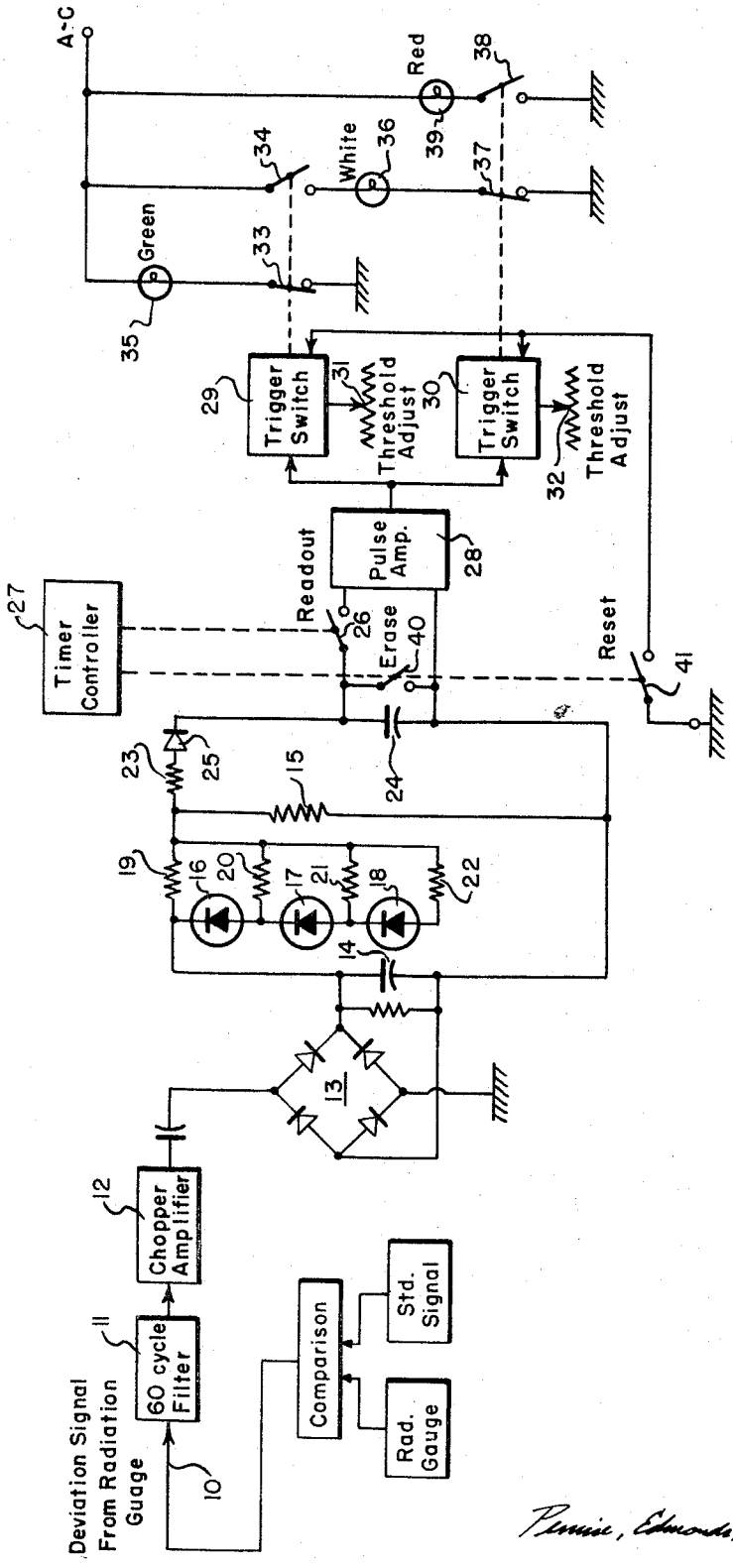
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APPARATUS FOR MEASURING THE QUALITY OF A CIGARETTE MANUFACTURING PROCESS

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APPARATUS FOR MEASURING THE QUALITY OF A CIGARETTE MANUFACTURING PROCESS

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ABSTRACT OF THE DISCLOSURE

The density of a rod of tobacco is measured continuously by a radiation gauge and electronically compared with a standard density signal. The resulting density deviation signal is passed through a non-linear voltage divider and integrated over time to produce an integrand signal varying as a function of the magnitude of the deviation signal raised to a power greater than unity. The integrated signal representative of the quality of the tobacco rod manufacturing process is periodically sampled and presented to indicators and alarm devices.

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 and 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 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 produced by radiation transmitted through a standard rod material. The result of this comparison is a deviation signal **10**, shown in the figure, 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 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 ($\sigma 2$) of the distribution of density of the rod passing the sensing station during a period of time.

The statistical variance ($\sigma 2$) 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

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

where n is the number of samples, dn is the nth 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

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

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 are as follows:

Zener diodes:		
16, 17, 18	volts	4.7
Resistors:		
19	megohms	4.7
20	do	2.4
21	do	2.4
22	ohms	47,000

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 values for the integrating network are as follows:

23	megohms	10
24	mfd	4

At this point the voltage stored on the integrator capacitor **24** may be measured after a suitable integration period by conventional voltmeter means to give a measure of the variance of the process. However, in the preferred embodiment shown in FIG. 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 thyratron 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 does not fire the thyratron into the conducting state. For weight distributions that are greater 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 switch 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 contacts **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 thyratrons are utilized as trigger switches, for example, the switch contacts **41** are advantageously connected to ground the anodes and thereby re-set the thyratrons to a biased "off" condition. On completion of the charge time, the read-out switch contacts **26** are again closed and the signal pulse developed at the output of the amplifier **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 controllers 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 is claimed 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:

(a) 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;

(b) circuit means for operating upon the deviation signal in a non-linear manner to produce an integrand signal varying as a function of the magnitude of the deviation signal raised to a power greater than unity;

(c) means for integrating the integrand signal over a period of time; and

(d) 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:

(a) 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;

(b) 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;

(c) means for integrating the integrand signal over a period of time; and

(d) 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:

(a) radiation gauge means for producing a measured density signal corresponding to the density of the rod at the sensing station;

(b) means for producing a standard density signal corresponding to a standard value of density;

(c) 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;

(d) means for operating upon the deviation signal to produce an integrand signal varying as a function of the magnitude of the deviation signal raised to a power greater than unity;

(e) means for integrating the integrand signal over a period of time; and

(f) 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:

(a) radiation gauge means for producing a measured density signal corresponding to the density of the rod at the sensing station;

(b) means for producing a standard density signal corresponding to a standard value of density;

(c) 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;

(d) 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;

(e) 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;

(f) means for integrating the integrand signal over a period of time; and

(g) 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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