

Oct. 20, 1970

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MICROWAVE MOISTURE MEASURING APPARATUS HAVING AUTOMATIC
LEVEL AND FLOW CONTROL MEANS

3,535,629

Filed July 26, 1967

3 Sheets-Sheet 1

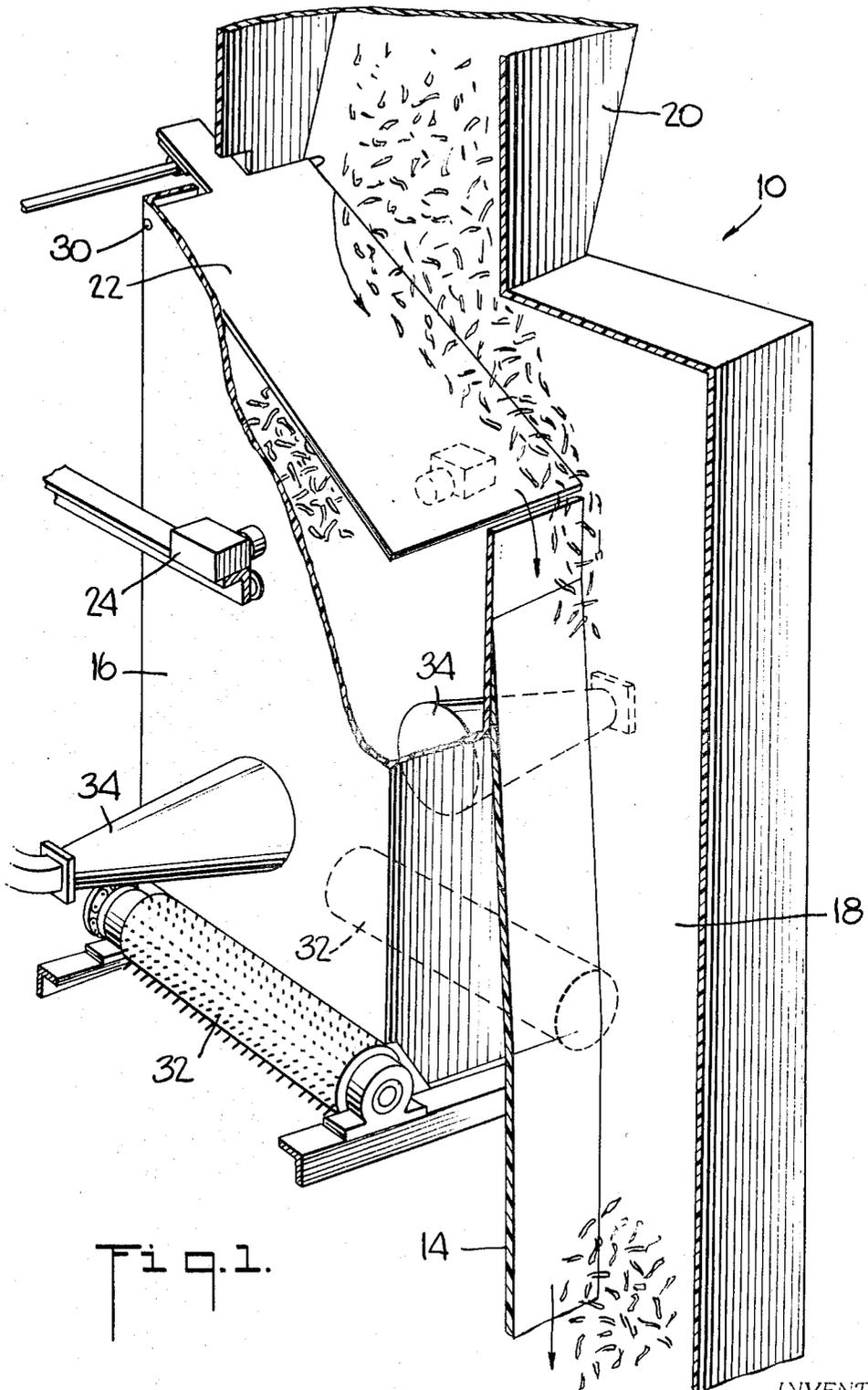


Fig. 1.

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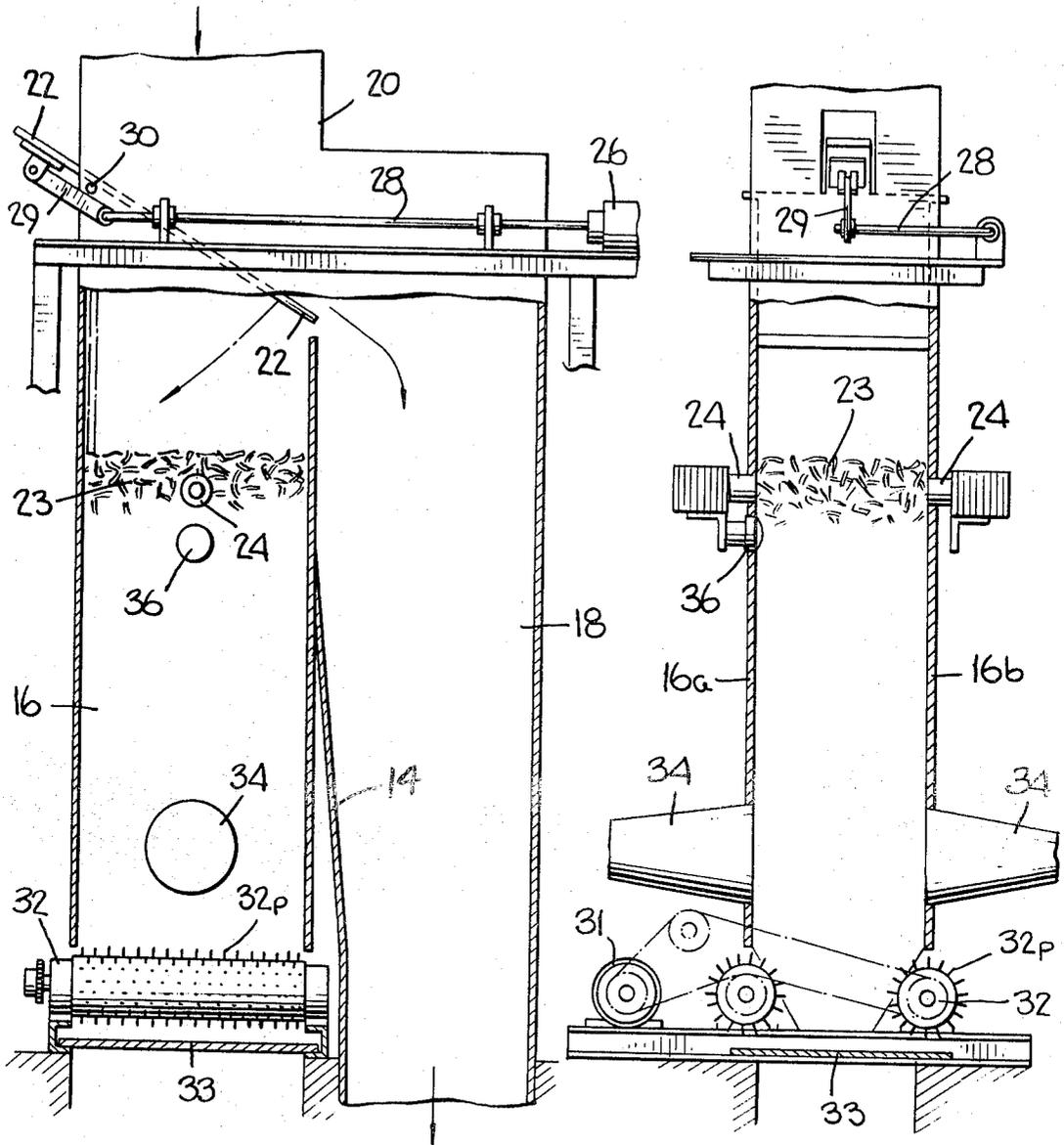


Fig. 2.

Fig. 3.

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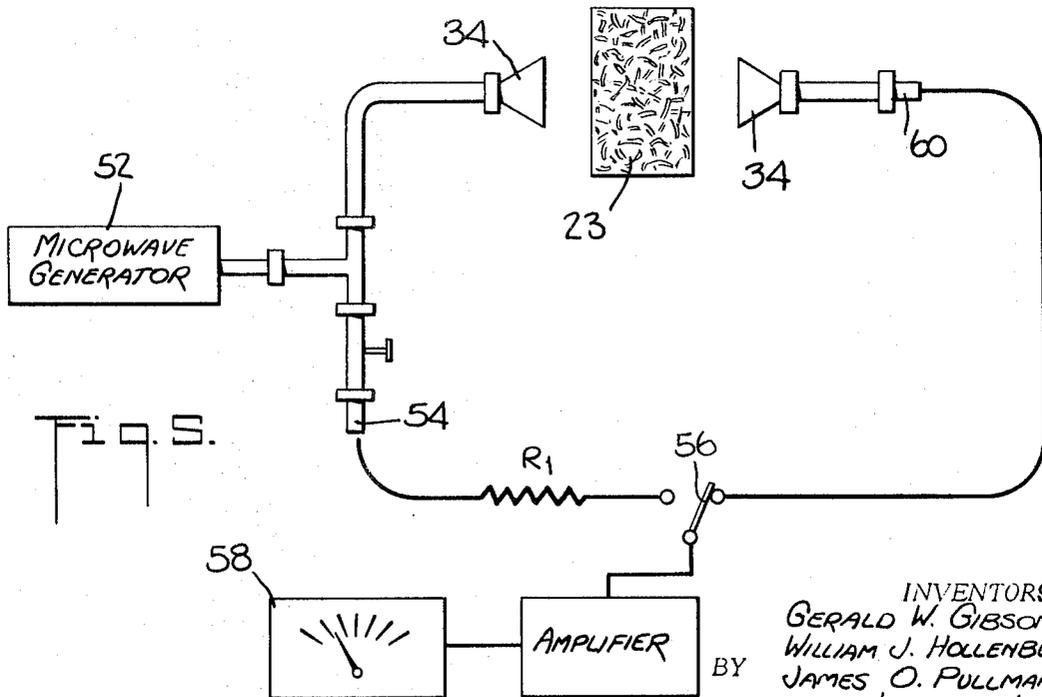
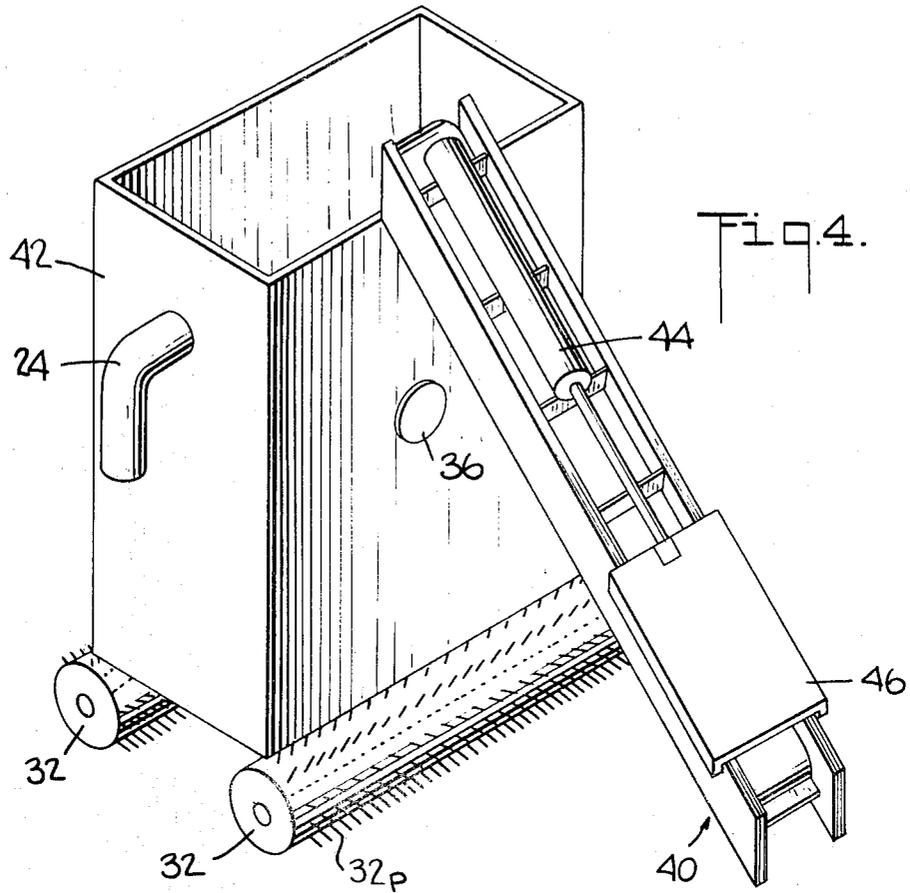
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MICROWAVE MOISTURE MEASURING APPARATUS HAVING AUTOMATIC LEVEL AND FLOW CONTROL MEANS

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Continuation-in-part of application Ser. No. 559,785, June 23, 1966. This application July 26, 1967, Ser. No. 679,582

Int. Cl. G01r 27/04; G08b 21/00; B67d 5/08
U.S. Cl. 324—58.5 7 Claims

ABSTRACT OF THE DISCLOSURE

The embodiment of the invention described in the following specification involves a chute into which tobacco in either shredded or strip form is fed until the tobacco rises to a predetermined level. At the predetermined level it interrupts a photocell which actuates a paddle which diverts the flow of tobacco into a bypass channel. The chute is open at the bottom and has two picker rolls aligned along the bottom so that the tobacco bridges across the rolls and builds up in the chute to form a column of tobacco. The picker rolls are rotated so that they pull tobacco through the chute at a predetermined rate. When the tobacco drops below the photocell level, the diverted paddle is dropped so that the tobacco flows into the chute again. In this fashion, a continuous flow of tobacco through the chute is obtained while the tobacco height is maintained at a fairly constant level. As a consequence, the density of the tobacco at any one level in the column of tobacco in the chute is fairly constant with time. A sending microwave horn and receiving microwave horn are rigidly mounted facing one another on opposing sides of the chute so that microwave energy may be beamed from the sending horn to the receiving horn. These horns are connected in a known type of circuit so that the amount of microwave attenuation from sending horn to receiving horn may be measured and thus provide an indication of the moisture content of the tobacco in the chute.

This application is a continuation-in-part of application Ser. No. 559,785 filed June 23, 1966, now abandoned, and having the title Continuous Moisture Measurement.

This invention relates in general to an apparatus for the continuous measurement of the moisture of a product. More particularly, this invention is an apparatus for use with a known microwave energy absorption technique for measuring the moisture content of tobacco. The apparatus permits the known techniques to be employed for moisture measurement on a continuous sampling basis.

This invention will be described in connection with a system for measuring the moisture content of tobacco, generally shredded or strip tobacco; which system is broadly similar to the system described in patent applications Ser. No. 320,015 filed Oct. 30, 1963 and Ser. No. 506,955 filed on Nov. 9, 1965, both of which are owned by the assignee of this application. Both of these patent applications describe a technique for measuring the moisture content of tobacco by passing a microwave signal through a standardized sample of tobacco and electronically measuring the attenuation in the signal caused by the tobacco. The amount of attenuation is a partial function of moisture. By employing techniques which normalize the other parameters that affect attenuation, a moisture content measurement is obtainable.

The significant factors, other than moisture, that affect

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the attenuation of the microwave energy beamed through a sample of tobacco are (1) tobacco temperature, (2) variations in tobacco density, and (3) variation in the placement of the tobacco sample with respect to the microwave radiating and pickup sensors.

In patent application Ser. No. 320,015, a batch type moisture measurement technique is described which requires the employment of a family of moisture versus attenuation curves, having temperature as a parameter, so that attenuation readings can be accurately interpreted in terms of moisture content. Patent application Ser. No. 506,955 describes an improvement that automatically compensates for the variation in attenuation due to temperature variations. Thus this latter invention makes it possible to use a single curve instead of a family of curves. However, both of these applications describe a batch type process in which the density and placement factors mentioned above require very careful filling and placement of the container containing the batch of tobacco whose moisture is being measured.

It is desirable to have a continuous measurement of tobacco moisture so as to obtain a continuous flow of information for control of the manufacturing process. The continuous measurement also provides a more accurate indication of variations within the output product.

Accordingly, it is a major purpose of this invention to provide an accurate continuous moisture measurement of tobacco.

It is a more specific object of this invention to provide a continuous measurement of tobacco moisture which measurement automatically compensates for or eliminates errors due to variations in tobacco temperature, tobacco density and the spatial relation between the tobacco and microwave sensors.

In brief, this invention involves a chute having two sidewalls and microwave horns mounted to have a fixed relationship relative to each other and with respect to the chute's sidewalls. Tobacco is fed to the chute and piles up in a column between the two horns so as to intercept the microwave energy transmitted between horns. Constant tobacco density is achieved by maintaining the tobacco column at a constant height in the chute. Tobacco fed into the top of the chute piles up in the chute until it reaches a predetermined level. A photoelectric device is installed at the predetermined level and when the tobacco piles up so as to break the light beam, a diverter paddle is operated to cause the tobacco stream to bypass this measuring chute. Tobacco is fed through the chute at a constant rate of approximately five inches per minute, which rate is controlled by the use of two picker rolls located at the bottom of the open ended chute. The picker rolls cause the tobacco in the chute to be discharged out the bottom and thus cause the tobacco to periodically fall below the level of the photocells. When the tobacco falls below the photocell level, the diverter paddle is switched back into position to feed the tobacco to the measuring chute.

A temperature compensating sensor, normally a thermistor, is installed in the device of this invention in a convex disc of brass which is mounted on the interior surface of the chute. Thus as the tobacco column flows over the sensor, the temperature level of the incoming tobacco is detected. The thermistor resistance is thus affected. The thermistor is incorporated in an unbalanced bridge portion of the measurement system in a fashion indicated in patent application Ser. No. 506,955 to provide an automatic compensation for temperature variations.

As has been mentioned above, in order to have an accurate measure of moisture by means of a system employing the measurement of microwave attenuation through the tobacco, it is necessary that the tobacco mass being measured always have a constant relationship to the

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microwave horns and that the tobacco mass being measured always have a constant density. The accurate positioning of the tobacco mass being measured is achieved by the use of a chute which restrains a tobacco column to constant dimensions in the area of the microwave horns and that is affixed with respect to these horns so that the chute itself is stationary with respect to the microwave horns. Constant density is achieved by maintaining the tobacco column at a constant height within the chute by means of the photoelectric cells.

The device of this invention has been successfully tested for use with either shredded or strip tobacco. Shredded tobacco is a common industry term for tobacco after it has been cut into the size and shape particles which are rolled into a cigarette. Strip tobacco is a common industry term for those portions of the tobacco leaf that remain after the stem and the veins have been removed. Strip tobacco is of varying lengths but individual strips may be as long as several inches. Accordingly, it should be understood that this invention may be employed with tobacco that is in small bits and pieces or particulate form in general.

Other objects and purposes of this invention will become apparent from a consideration of the following detailed description and drawings in which:

FIG. 1 is a partially cut away perspective view of one embodiment of this invention;

FIG. 2 is a front view and FIG. 3 is a side view, both in partial cross-section, of the FIG. 1 embodiment;

FIG. 4 is a perspective view of a second embodiment of this invention; and

FIG. 5 is a schematic of a circuit employed to insure against electronic drift.

As may be seen from FIGS. 1, 2 and 3, the device of this invention 10 is a chamber having a divider 14 which divides the lower portion of the chamber into two chutes 16 and 18. Tobacco is continuously fed into the chamber through the inlet hopper 20 and is then channeled either into the measuring chute 16 or the flow through chute 18 depending upon the position of the diverter paddle 22.

The diverter paddle 22 has two positions in normal operation. The position of the paddle 22 shown in the figures is the one which would divert incoming tobacco to the flow through chute 18 and is the position of the paddle that is brought about when the tobacco 23 in the measuring chute 16 is above the level of the photocell 24. The photocell 24 is incorporated into a standard control circuit for controlling the energization of an actuator 26, the state energization of the actuator 26 determining which of the two positions the paddle 22 will have. In one embodiment, the actuator 26 is a pneumatic cylinder that is actuated by an electrically operated valve that in turn is controlled by the photocell 24.

As may be seen from FIGS. 2 and 3, the actuator 26 is linked to the paddle 22 by means of links 28 and 29 which are pivotally connected to each other and in turn pivotally connected to the paddle 22. In FIG. 2, when the actuator 26 changes state (which will occur when the level of tobacco 23 in the measuring chute 16 drops below the photocell 24) and link 28 moves to the left causing the link 29 to rotate relative to the paddle 22 in a clockwise direction thereby pushing the left end of the paddle 22 up to cause the paddle 22 to rotate clockwise about fixed axis 30.

The bottom of the measuring chute 16 is open except for two picker rolls 32 that are driven at a constant rate by motor 31 and that thereby control the rate at which tobacco 23 passes through the measuring chute 16. Shredded and strip tobacco has the property that it will bridge openings and support a considerable weight of tobacco from falling through an opening. This property is taken advantage of in the device of this invention in that the picker rolls 32 are spaced apart so that the tobacco will bridge the spacing. When the rolls are rotated, one roll clockwise and the other counter-clockwise, the pins

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32p on the rolls 32 pull the tobacco 23 that is being measured through the opening so that there is a constant flow of tobacco through the measuring chute 16.

A removable floor board 33 is provided at the base of the measuring chute 16. When this apparatus 10 is first being employed on a run of tobacco, the floor board 33 is put into position so that the tobacco 23 fed into the measuring chute 16 has a chance to pile up in the chute 16. Once the tobacco 23 has attained any appreciable height beyond the picker rolls 32, the floor board 33 is removed and the ability of shredded tobacco to bridge the distance between the picker rolls 32 without falling through is sufficient to maintain the column of tobacco 23 in the chute 16 without having it fall through. When the motor 31 is turned on and the picker rolls 32 are caused to rotate, then the pins 32p on the rolls 32 cause the tobacco 23 to be pulled down past the rolls 32 and discharged from the chute 16.

Two microwave horns 34 are affixed opposite one another at opposing walls 16a, 16b of the measuring chute 16 so that microwave energy may be beamed from one horn 34 to the other. The tobacco 23 between these horns will intercept a portion of the microwave energy. The proportion intercepted will be a function, among other things, of the moisture in the tobacco. By incorporating the microwave horns 34 in a measuring system such as those described in the two applications referenced above, the percentage or amount of moisture in the tobacco 23 can be measured.

The temperature compensating circuit sensor 36 for this instrument is a thermistor mounted in a convex brass disc affixed to the inside of the wall 16a of the measuring chute 16. This thermistor 36 is mounted sufficiently below the level of the photocells 24 so that the tobacco 23 in the measuring chute 16 never falls below the thermistor 36. In this fashion, the thermistor 36 is always exposed to a temperature determined by the temperature of the tobacco column in the measuring chute 16. The thermistor 36 is associated with a circuit such as the unbalanced bridge described in application Ser. No. 509,955.

In one particular embodiment, the dimensions for the measuring chute 16 are approximately eight inches by thirteen inches in cross-section and the height of tobacco to the photocell 24 is approximately twenty-three inches. The spacing between the outer tips of the pins 32p of the two picker rolls 32 is five inches. In that embodiment, the picker rolls 32 are wooden rollers two and one-half inches in diameter with one-quarter inch long metal pins 32p (approximately one-sixteenth of an inch in diameter) protruding at right angles all around the wooden surface. These picker rolls 32 are driven by a one-half r.p.m. geared motor and cause the tobacco to be fed through the measuring chute at approximately five inches per minute. In that particular embodiment, the amount of tobacco passing through the measuring portion of the chute came to approximately 176 pounds per hour while the quantity of tobacco diverted by the paddle 22 into the flow through chute averaged 261 pounds per hour so that the total quantity of tobacco being fed into the hopper 20 was 437 pounds per hour. These figures are simply details of a particular embodiment. However, it should be noted that the quantity of tobacco fed into the hopper 20 must be substantially greater than the amount of tobacco that the measuring chute 16 is set to pass.

CALIBRATION PROCEDURE

The calibration curve for the system employing the device 10 of this invention may be obtained as follows. During a calibration run, the moisture of the tobacco going through the device 10 is varied over the anticipated range, which in one application was between 9 percent and 14 percent by weight. The amount of moisture may be readily varied by changing the steam pressure in the drier coils and/or the amount of exhaust air drawn from the cooler. Such procedures are well known in this art.

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Prior to the calibration run, the time required for a particular mass of tobacco to traverse the distance between the center of the microwave horns 34 and the exit of the chute 16 was found to be one minute and forty five seconds. Consequently, all calibration data are obtained by first recording the microwave moisture meter reading and then taking a tobacco sample at the chute exit exactly one minute and forty-five seconds later. Each sample is enclosed in a glass jar with an air tight lid and allowed to come to a homogenous moisture content for a period of three days. After this time, by standard techniques known in this art, moisture analysis of these samples are obtained by the use of a hot air oven process. The results of this moisture analysis are then plotted against the microwave output reading in decibels to obtain the desired calibration curve. There is nothing unique concerning this calibration process except to recognize that the moisture sample selected has to be synchronized to the one minute and forty five second delay in passing through the chute 16.

This invention has been described in detail in connection with one particular embodiment. However, it should be recognized that various modifications could be made by one skilled in this art without deviating from the inventive concept.

For example, FIG. 4 illustrates a second embodiment of the invention in perspective view. This second embodiment differs from the first embodiment primarily in the means for feeding the tobacco to the chute 42. The basic principles described in connection with the embodiment of FIGS. 1-3 applies to the FIG. 4 embodiment. The FIG. 4 embodiment does not employ a paddle and bypass chute but rather employs a small conveyor 40 that samples from a large stream of tobacco and fills the measurement chute 42 until the tobacco column comes up to the height of the photocell 24 arrangement. The photocell 24 operates a pneumatic cylinder 44 that in turn actuates a sliding cover 46. The cover 46 when in the position shown prevents tobacco from a major stream of tobacco from falling into the conveyor 40 and thus shuts off the tobacco supply to the conveyor 40 and to the chute 42. When the tobacco level in the chute 42 falls below the photocell 24, then the pneumatic cylinder 44 pulls the sliding cover 46 back so that tobacco from a large stream of tobacco falls on the conveyor 40 and is thus carried up to the top of the chute 42 to fill the chute 42 to the level of the photocell 24.

FIG. 5 illustrates a technique employed in connection with the device of this invention to monitor electronic drift. A part of the output of the microwave generator 52 is fed to the horns 34 and another part is fed to the circuit which is constituted by the reference detector 54 and the resistor R1. The microwave energy put out by the microwave generator 52 is modulated by a one KC signal so that the output from the detector is a one KC audio frequency signal. The resistor R1 is a load simulator which attenuates this one KC audio signal by a specified amount. As long as the energy transmitted through the resistor R1 remains constant, then the operator knows that there has been no shift in the level of the microwave energy put out by the generator 52. The amount of energy transmitted through the resistor R1 can be checked periodically to determine whether or not there has been any shift in the magnitude of the microwave energy output. The switch 56 makes this periodic check possible. In practice, the one KC reference signal through the resistor R1 is checked every few minutes. This monitoring can, of course, be accomplished automatically by using a motor driven switch and can be performed while the chute 16 is full of tobacco. The meter 58 can conveniently be set to a "red line" deference level. Any shift from that reference level whenever the reference signal is being checked will indicate a shift in the microwave energy provided by the generator 52. In lieu of the meter 58 (or responsive to the meter 58)

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circuits can be provided to signal an alarm or to provide automatic correction whenever variation greater than a predetermined magnitude exists.

As is also shown in FIG. 5, a measuring detector 60 is employed at the output of the receiving microwave horn 34 so as to provide a one KC electrical signal for the purpose of providing an indication of the extent of microwave attenuation in the tobacco 23.

What is claimed is:

1. In the system for measuring the moisture content of tobacco by determining the attenuation of microwave energy passed through a sample of the tobacco, the improvement comprising an apparatus for the continuous measurement of moisture content in a production flow of tobacco including:

a substantially vertical chute having opposite substantially vertical parallel sidewalls,

a pair of microwave horns spaced from and directly facing one another for transmitting microwave energy therebetween, one of said microwave horns fixed relative to one of said vertical parallel sidewalls with the other of said microwave horns fixed relative to the other of said vertical parallel sidewalls to establish a fixed spatial relationship between said horns, feeding means for feeding tobacco into the top of said chute at a rate greater than a predetermined rate,

means for retaining tobacco in said chute whereby tobacco fed to said chute will stack up past said horns,

means responsive to the attainment of a predetermined level of tobacco in said chute, said level being above the position of said horns, to divert tobacco from said chute when tobacco has stacked past said predetermined level, and

means for removing tobacco from the bottom of said chute at said predetermined rate.

2. The apparatus of claim 1 wherein said means responsive to the attainment of a predetermined level of tobacco in said chute includes:

a photoelectric cell circuit mounted across said opposed sidewalls at said predetermined level to provide a signal when said tobacco falls below said predetermined level, and

a pivotally mounted diverter paddle at the top of said chute, said diverter paddle having a first position wherein all of the tobacco being fed to said chute is diverted by said paddle away from said chute and a second position wherein all of the tobacco being fed to said chute is permitted to pass into said chute, said diverter paddle being responsive to said signal provided by said photoelectric cell circuit to pivot into said second position in response to said signal.

3. The apparatus of claim 1 wherein said means for retaining tobacco in said chute includes: a pair of picker rolls rotatably mounted at the bottom of said chute, and a removable baseboard disposable under said picker rolls to cause said tobacco in said chute to build up within said chute when said apparatus is first being employed for a particular run of tobacco.

4. The measuring apparatus of claim 1 wherein said means for removing tobacco from the bottom of said chute includes: a pair of picker rolls spaced from one another at the bottom of said chute, and motor means for driving said picker rolls, one clockwise and one counterclockwise, to discharge tobacco from said chute.

5. In a system for measuring the moisture content of tobacco by determining the attenuation of microwave energy passed through a sample of tobacco, the improvement comprising an apparatus for the continuous measurement of moisture content in a production flow of tobacco including:

a substantially vertical chute having opposite substantially vertical parallel sidewalls, a pair of microwave horns spaced from and facing one another

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for transmitting microwave energy therebetween, each of said microwave horns faced relative to a different vertical parallel sidewall to establish a fixed spatial relationship between said horns determined by the fixed distance between said sidewalls,

a photo responsive circuit mounted at a predetermined level, above the level of said horns, on said sidewalls whereby the level of tobacco in said chute, above or below said predetermined level, will affect the state of said photoelectric circuit,

feeding means responsive to the state of said photoelectric circuit for feeding tobacco into the top of said chute at a rate greater than a predetermined rate when the level of tobacco in said chute is below said predetermined level and to divert tobacco from said chute when the level of tobacco in said chute is above said predetermined level, and

withdrawal means for withdrawing tobacco from the bottom of said chute at said predetermined rate.

6. The measuring apparatus of claim 5 wherein said feeding means includes: a pivotally mounted diverter paddle at the top of said chute, said diverter paddle having a first position that intercepts whatever tobacco is fed

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toward said chute and diverts the tobacco away from said chute and a second position that permits the tobacco being fed toward said chute to pass into said chute, said positions of said diverter paddle being determined by said state of said photoelectric circuit.

7. The measuring apparatus of claim 5 wherein said withdrawal means includes: a pair of picker rolls spaced from one another at the bottom of said chute, and motor means for driving said picker rolls.

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U.S. Cl. X.R.

222—64; 340—246