

[54] **AUTOMATIC GRADER**

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[58] Field of Search 209/111.6, 111.7;
356/173, 186

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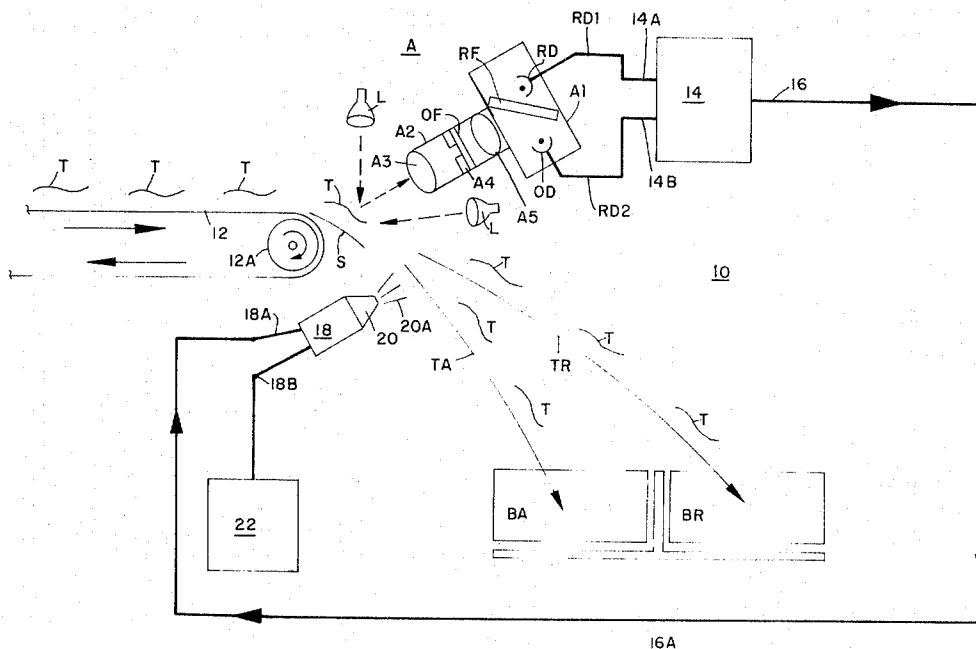
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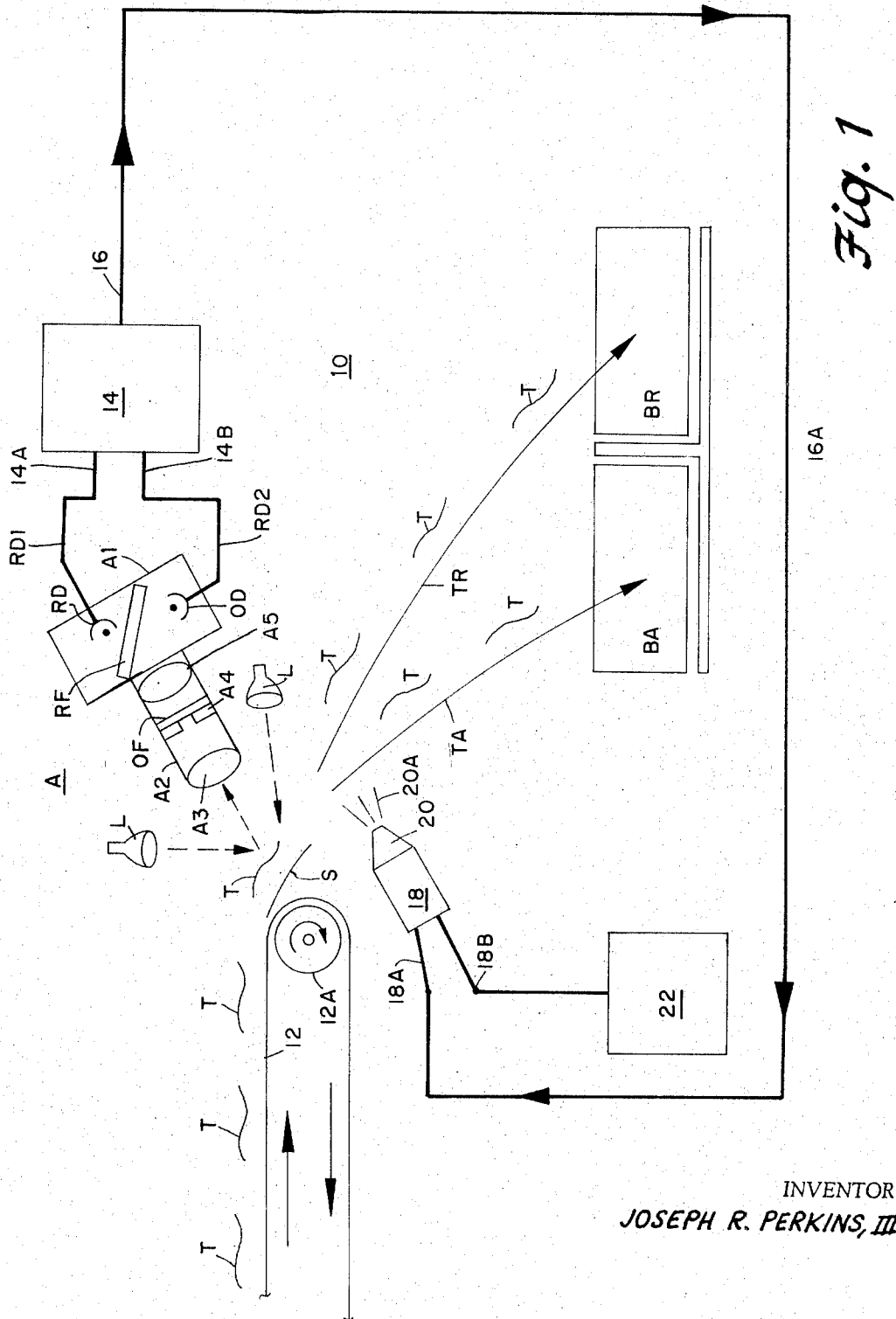
[57] **ABSTRACT**

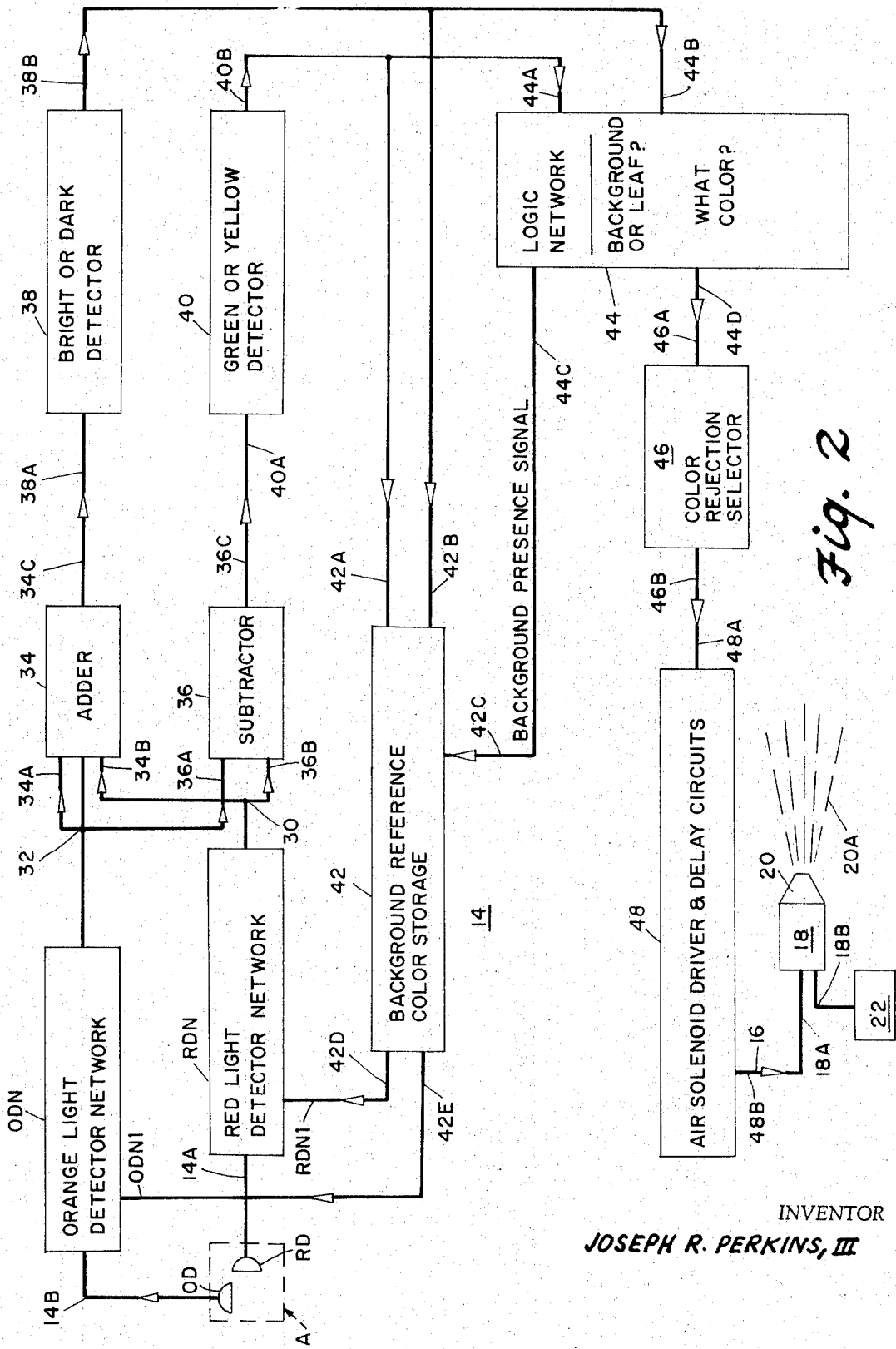
A system and apparatus for grading and sorting tobacco leaves and the like according to color and brightness are provided. The color of each tobacco

leaf is compared photoelectrically with the color of a replaceable background color standard over which each leaf is conveyed. The system can be operated in either a normal mode, i.e., detecting and separating all those leaves darker than the background standard, or a reverse mode, i.e., detecting and separating all those leaves that are lighter than the background standard. A plurality of such systems are set to perform a series of sequential detections and separations, against a selected plurality of background color standards to effect separation of a plurality of tobacco leaves into a preselected number of grades or classifications. The system and apparatus can be embodied in a transducer unit for converting existing tobacco sorting machinery from a manual to an automatic sorting mode of operation. Two color detection of reflected light is used to determine brightness as well as greenness. A separate detector for each color is positioned behind a broad band color filter to sense reflected light from the tobacco leaves and the background standard. Either one or the sum of the resulting signals for each detected color is indicative of the brightness of the leaves while the difference between the signals is indicative of the greenness. A pneumatic reject mechanism is actuated in response to given leaf grade conditions, or a lack thereof, to separate undesired grades of leaves from the plurality of leaves being graded.

38 Claims, 5 Drawing Figures







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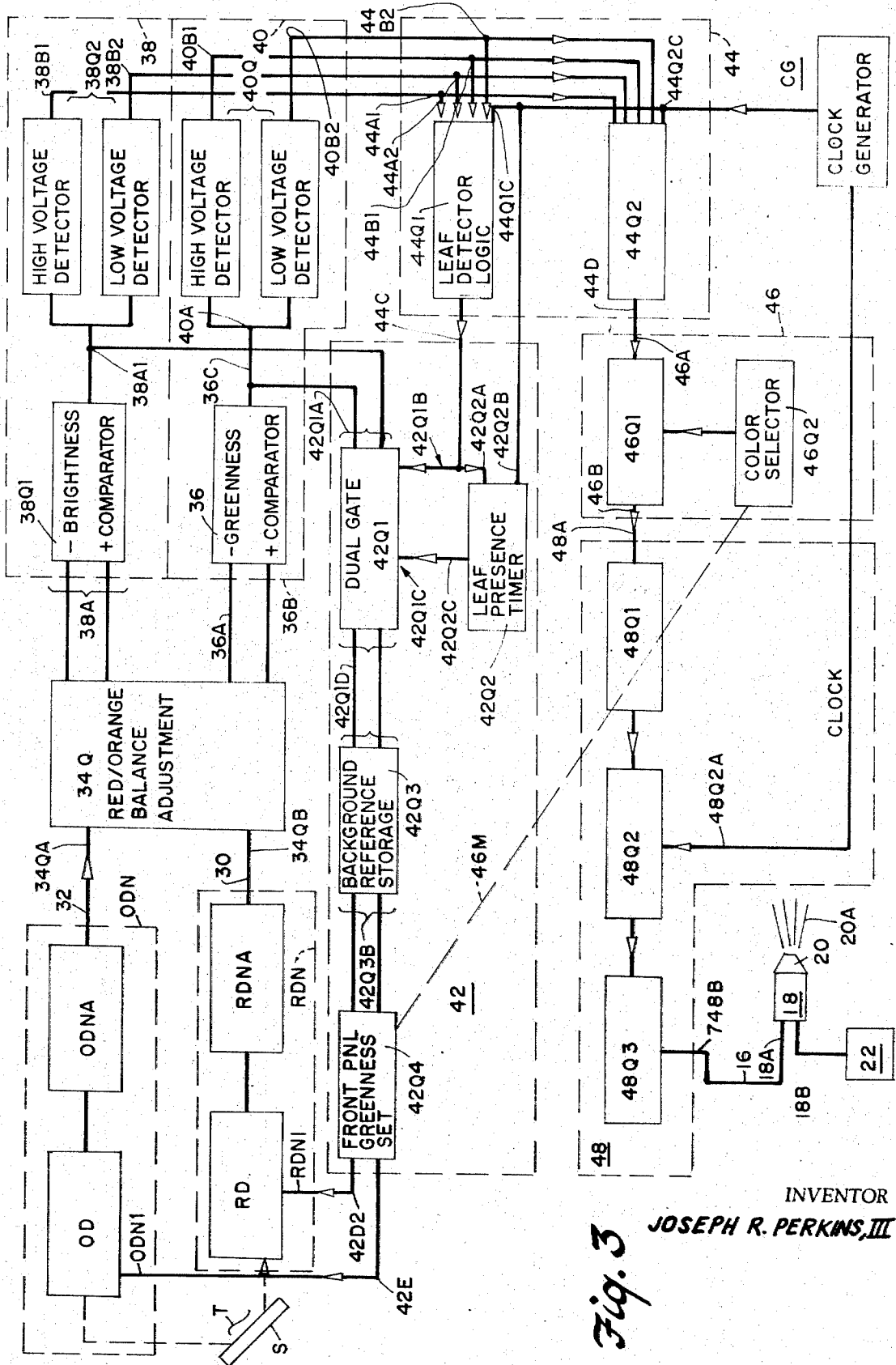


Fig. 3

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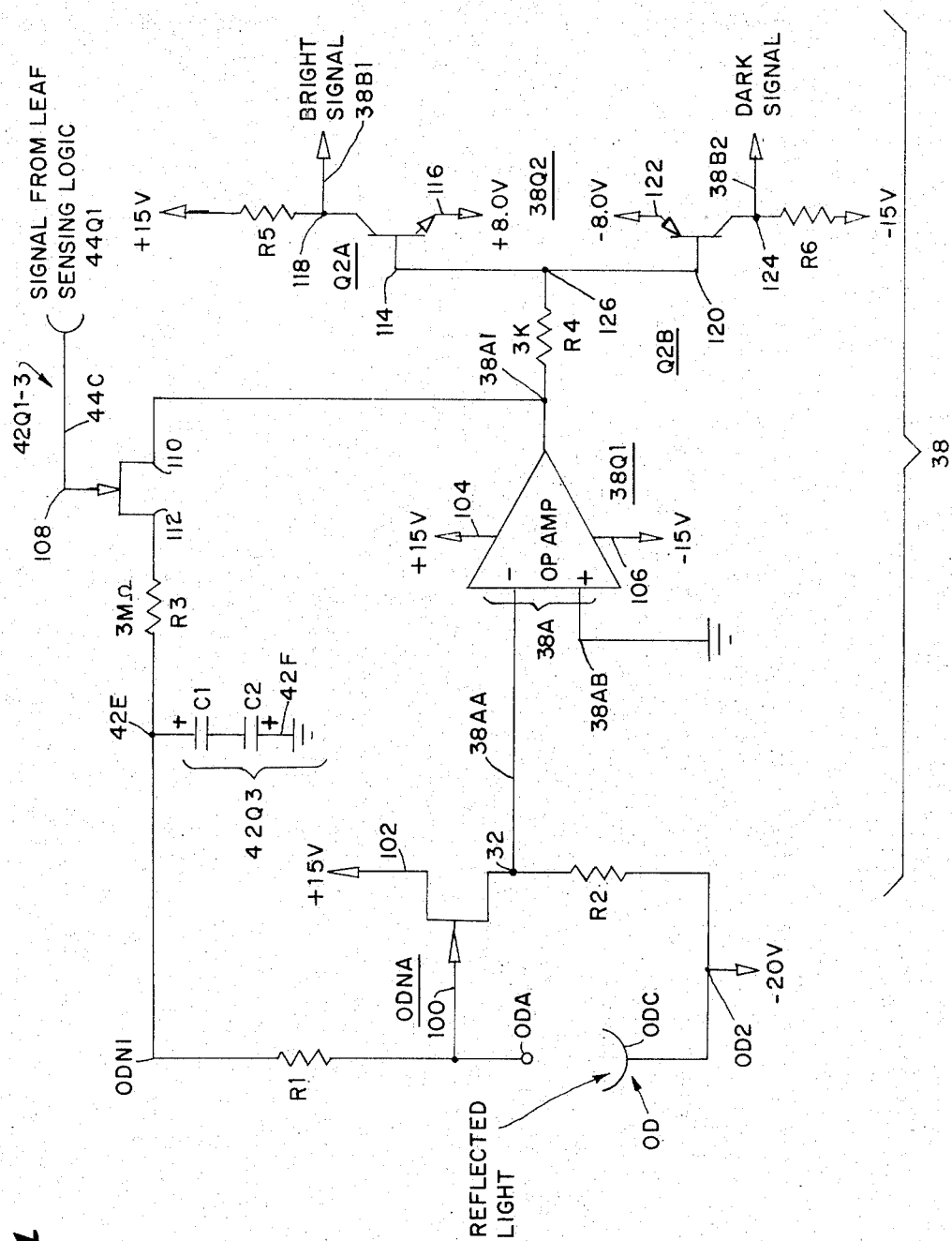
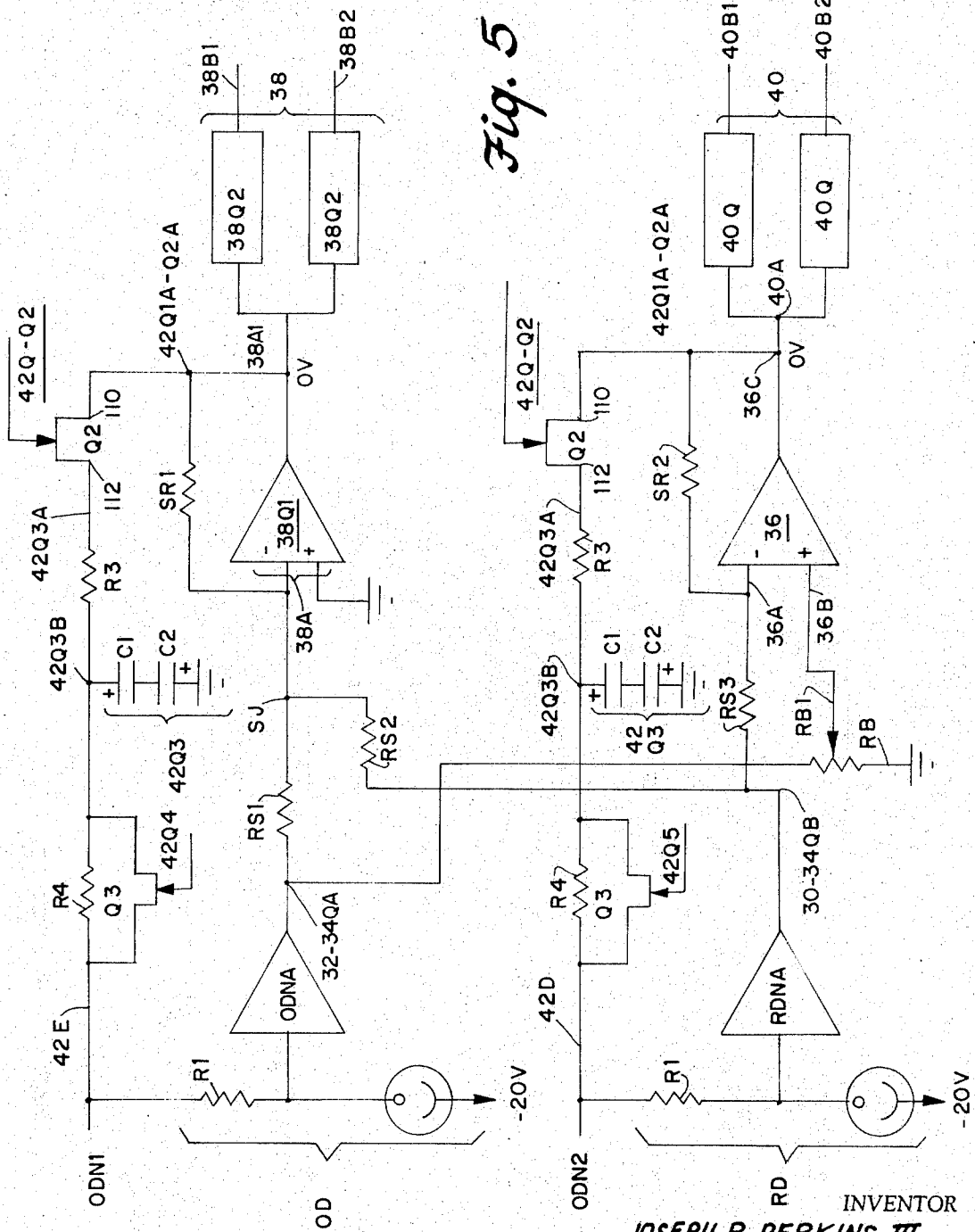


Fig. 4

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AUTOMATIC GRADER

This is a continuation of application Ser. No. 145,444, filed May 20, 1971.

This invention relates to automatic graders and more particularly to systems and apparatus for automatically grading tobacco leaves and the like according to color.

In the past and at the present time, it is a normal practice to grade tobacco by manual methods, i.e., by visual inspection of each leaf to determine given grades of tobacco leaves. Furthermore, should a leaf be too green for present processing, such as a green sucker, manual inspection is also presently used to remove these leaves from further processing as undesirable grades.

As a result, arcuate duplication of tobacco grades is very difficult to achieve at the present time. This is due to the difference of opinion which exists among manual sorters who must use their own judgment in determining the grade of a given tobacco leaf. The eye of the observer is the standard rather than an actual grade reference.

It is, therefore, an object of the present invention to provide a new and novel automatic grader which can readily duplicate grades of tobacco leaves and the like through the use of known background color standards for any given grade.

It is another object of the present invention to provide a means of rapidly grading tobacco leaves and the like without the need for manual inspection of each leaf.

It is another object of the present invention to provide a new and novel automatic grading system and apparatus which operates to grade tobacco leaves and the like by comparing the color of a given leaf with a background color standard over which the given leaf must pass during the sorting and grading process to which it is being subjected.

Still another object of the present invention is to provide a new and novel automatic grader utilizing a color comparison system which may be embodied in a transducer arrangement for adapting existing manual sorting equipment to fully automatic sorting and grading equipment.

Still another object of the present invention is to provide a new and novel automatic grader system and apparatus utilizing an unique combination of two color detection and resulting detected color signal strength to provide selective grading of tobacco leaves and the like for both brightness of color and greenness of leaf.

Yet another object of the invention is to provide a new and novel automatic tobacco sorting and grading system and apparatus which may be operated as a series of machines or devices performing a like series of sorting and selecting functions such that all of the leaves in a given batch of tobacco being graded will be separated into desired categories, these categories being determined by various background color standards which are interchangeable in each of the said machines and/or devices.

These and other objects of the present invention will become more fully apparent with reference to the following specification and drawings which relate to a preferred embodiment of the invention.

In the drawings:

FIG. 1 is a general schematic of the present invention including the basic physical details of a preferred optical system for same;

FIG. 2 is a general block diagram of the control circuit of the invention;

FIG. 3 is a more detailed block diagram of the control circuit of the invention;

FIG. 4 is a circuit diagram of a single color detector and brightness comparator circuit of the present invention including normalizing, updating and reset means; and

FIG. 5 is a circuit diagram of a two color detector and brightness and greenness comparator circuits of the present invention including normalizing, updating and reset means.

REFLECTIVITY OF TOBACCO LEAVES AND BACKGROUND STANDARDS

It has been ascertained that for properly cured tobacco leaves, there is a predictable difference between the reflectivity of orange/light and red light, the red reflectivity being on the order of 4 - 8 percent greater than the orange, depending upon the type of tobacco and its curing process.

This predictable difference will be varied by the greenness of the leaf being monitored, thereby providing parameters that are determinative of the acceptability of a tobacco leaf according to its degree of greenness, regardless of its acceptance in a given color grade based on its relative brightness.

Either the red reflectivity or the orange reflectivity of a given leaf can be utilized to effect automatic grading on the basis of relative brightness of the leaf to a background color standard.

By the use of a two color system and utilizing the sum of the signals representing the strength of the red and orange reflected light from the leaf and background standards, improved performance and reliability is effected. Furthermore, the versatility of this system to detect greenness of the leaf from the same two reflected light transducers is made possible.

The optical system A comprises a housing A1 with an elongated telescope tube A2 extending therefrom. An objective lens A3 is mounted in the front of the telescope tube A2 facing the obverse surface of the background reference S and focuses reflected light from the latter through an apertured plate A4, defining the field of view of the optical system A.

THE BASIC SYSTEM AND APPARATUS

With the foregoing consideration of reflectivity established, the basic system and apparatus of the present invention can best be described by reference to FIG. 1, where the grading means 10 of the present invention is schematically illustrated.

Tobacco leaves T are fed sequentially over a background color standard (platen) S by means of an endless belt conveyor 12 driven by a pulley drive 12A (or by other suitable conveyor means).

Mounted above the color standard S is a light source comprising a pair of lamps L, a pair of detector means, namely, a red light detector RD and an orange light detector OD.

Over these detector means RD and OD are positioned suitable optics and filter combinations, namely, a red filter and optics RF and an orange filter and optics OF, respectively.

The optical system A comprises a housing A1 with an elongated telescope tube A2 extending therefrom. An objective lens A3 is mounted in the front of the tele-

scope tube A2 facing the obverse surface of the background reference S and focuses reflected light from the latter through an apertured plate A4, defining the field of view of the optical system A.

The orange filter OF is positioned over the apertured plate A4 such that only the orange and red components of light reflected from the background reference S and/or tobacco leaves T will be passed through the apertured plate A4.

A field lense A5 is positioned in the telescope tube A2, and directs the orange and red light into the housing A1.

Within the housing A1, the red filter RF is placed transversely of the optical axis of the telescope tube A2 at an angle of 45° thereto.

The red detector RD (shown as a phototube) is placed behind the red filter RD to receive only the red component of reflected light through the red filter RF.

The obverse surface of the red filter RF serves as a mirror and reflects the incoming orange light from the orange filter OF at right angles to the optical axis of the telescope tube A2 and the orange detector OD (shown as a phototube) is disposed within the housing A1 to receive the orange light reflected from the obverse surface of the red filter RF.

The detector means RD and OD are connected via signal leads RD1 and OD1, respectively, to signal inputs 14A and 14B of a control circuit 14, the latter generating a control signal at a control output 16 which signal is conveyed through output lead 16A to the control terminal 18A of a pneumatic reject mechanism 18.

The pneumatic reject mechanism 18 includes a solenoid controlled air jet 20 which directs a stream of air 20A against the underside of selected ones of the tobacco leaves T, namely, undersired or rejected ones of the leaves T to constrain upon the latter a trajectory TR which, when leaving the background standard S, is predictably different from the trajectory TA taken by acceptable ones of the leaves T which are of the grade desired.

The trajectories TA and TR carry the leaves T into a pair of receiving bins or conveyor belts BA and BR, respectively, for acceptable and rejected ones of the leaves T.

As further shown in FIG. 1, the pneumatic reject mechanism has a pressure input 18B which is connected to a pneumatic source 22 to provide the pressurized air for the jet 20.

The light source L is positioned to illuminate the background reference S and any leaf T thereon and cause reflection of that light back to the optical system A.

In basic operation, which will be hereinafter more fully described, those leaves T which are within the color limit set by the background reference S, are permitted to fall from the reference S and assume the acceptable trajectory TA into the acceptable grade bin BA.

When a leaf T is of a color external of the limit determined by the background reference S, this difference is detected by the detectors RD and OD and a resulting control signal is generated in the control circuit 14, and thence transmitted through the control output 16, control lead 16A and input terminal 18A to energize the pneumatic reject mechanism 18 before that particular leaf T leaves the platen shaped background reference S.

Accordingly, an upwardly directed stream of air 20A is emitted from the jet 20 and lifts the rejected (undesirable) leaf T to constrain it into the reject trajectory TR and into the reject bin BR, effecting a selective grading of the tobacco leaves T.

As will be hereinafter more fully described, the duration of the airstream 20A is timed such that it will not interfere with the trajectory of the next successive leaf T unless the latter is not within the color limits of the background reference S.

THE FUNCTION OF THE BACKGROUND REFERENCE S AND THE VARIOUS GRADING MODES OF THE INVENTION

The tobacco grading means 10 operates by comparing the color of the tobacco leaves T with a selected replaceable background reference S. The color of the background reference S acts as a divider between the color of the tobacco leaves T that are to be kept and the color of the tobacco leaves T that are to be rejected.

There are two modes of grading which are selectively initiated in the apparatus and means of the present invention.

The first mode is the "normal grading" mode. In the normal grading mode, all leaves that are lighter than the background reference S will be retained in the acceptable bin BA. By the same token, all those leaves which are darker than the background will be constrained into the reject trajectory TR and captured in the reject bin BR by the tobacco grader 10. It should be clearly understood that the color of the background reference S is not the color of the desired grade of tobacco leaf T, but is the color of the darkest leaf T that is to be kept, i.e., the darkest leaf T that is to be captured in the acceptable bin BA. Therefore, the color of the background reference S corresponding to a particular grade of tobacco leaf T will not be the same color as an average leaf T in that grade, but will be somewhat darker than average.

By way of specific example of the normal grading mode, let us first assume that the background reference S is red-orange in color. Consequently, all yellow and orange leaves T will be permitted to follow the acceptable trajectory TA into the acceptable bin BA because they are lighter than the background reference S. Likewise, all red, brown, and black leaves will be rejected because they are darker than the background reference S.

The alternate mode of grading is known as reverse grading and is performed by setting suitable controls on the tobacco grader 10 to cause rejection, via the trajectory TR, of all leaves T that are lighter than the color of the background reference S.

By way of specific example, if the background reference S is colored yellow-orange, the reverse grading mode of operation will cause all yellow leaves to be constrained to the reject trajectory TR and will permit all orange, red, brown and black leaves to follow the acceptable trajectory TA into the acceptable bin BA. Therefore, in the reverse grading mode, the color of the background reference S corresponding to a certain desired grade of tobacco leaf T will be somewhat lighter than the average leaf for that desired grade.

If a plurality of tobacco graders 10 of the present invention are placed in series, a plurality of grades can be

effectively isolated from a given bath of tobacco leaves T.

By way of specific example, if two tobacco graders 10 are put in series and the first of these graders is set for the reverse grading mode with a yellow-orange background and the second of these tobacco graders 10 is set for a reverse grading mode with an orange-red background then all yellow tobacco would be constrained into the reject bin BR of the first grader 10, all orange tobacco would appear in the reject bin BR of the second tobacco grader 10, and the red, brown, and black tobacco leaves T would be passed through the first and second tobacco graders 10 to ultimately end up in an acceptable bin BA at the second grader.

Furthermore, should it be desired to further separate the red leaves from the brown and black leaves, another grader 10 could be set up down stream from the first two in a reverse grading mode wherein the background reference is colored red-brown and thereby, all of the lighter leaves, namely, the red leaves T would be constrained into a reject trajectory TR while the browns and blacks would be passed to acceptance bin BA at the third grader.

A further function of the tobacco grader 10 of the present invention is for the separation of the tobacco leaves which are too green for further processing. This will be hereinafter referred to as the separation of tobacco leaves T according to greenness.

As with the separation on the basis of brightness of the color of the leaves T, the greenness of background reference S determines the division of the accepted and rejected tobacco leaves T. In the normal grading mode, these leaves T that are greener than the background reference S will be rejected and those leaves T that are not as green as the background reference S will be accepted.

By way of specific example, if the background reference S is a greenish-red-orange and all green leaves are being rejected, then a green sucker or a green-yellow leaf would be rejected and all yellow, orange, red, and brown leaves would be accepted by the grader 10.

In the same manner that the background reference S must be darker than the desired grade when operating the tobacco grader 10 the normal grading mode for brightness, the background reference S, in grading for greenness must be somewhat greener than the desired grade. It must not be as green, however, as the leaves T that must be rejected.

Intermingling of the brightness and greenness constraints in the tobacco grader 10 is effective, selectively, to provide various control functions on such tobacco leaves T as greensuckers and sweat greens. These combined functions will be hereinafter more fully described with reference to the more detailed embodiments to follow.

THE REFLECTED COLORS DETECTED AND THEIR CORRELATION WITH BRIGHTNESS AND GREENNESS SIGNALS

The tobacco grader 10 employs two broad band light filters with related optics, namely, the red filter RF, the orange filter and optics A. The red filter is centered at approximately 655 nanometers (nm). The orange is centered at about 600 nm. The respective red and orange light detectors RD and OD provide outputs representative of the strengths of the reflected orange and red light components from the background reference S

and a leaf T on that background and such output signals are either added to obtain a brightness signal or subtracted to obtain a greenness signal.

The brightness signal can be obtained from either one of the red and orange detectors RD and OD. However, by adding the two signals from the said detectors, the signal to noise ratio of the tobacco apparatus 10 is improved. The magnitude of the brightness signal obtained is a measure of the color of the leaves, because red leaves are darker than orange leaves which in turn are darker than yellow leaves. Therefore, the red and yellow light components and the intermix of same are the critical colors of reflected light to determine the brightness of a given tobacco leaf T relative to the background reference S.

The greenness detection function makes use of some of the properties of green light as opposed to red and yellow light. Green light is produced by reflection of white light from a surface if the blue and red ends of the spectrum are absorbed by the surface leaving the green middle portion of the spectrum. Yellow and red light, on the other hand, are typically produced when the blue end of the spectrum is absorbed and the middle portion is partially absorbed leaving the red end of the spectrum. In both cases, the blue end of the spectrum is absorbed. Therefore, to tell green light from red or yellow light, only two light filters and detectors are required, namely, one in the middle of the spectrum (orange, for example) and one in the red end of the spectrum. If the light from the middle of the spectrum is stronger than the light from the red end, then the reflecting surface is green; if the light from the red end is stronger than the light from the middle of the spectrum, the reflecting surface could be yellow, orange, red or brown.

In the case of the preferred embodiment of tobacco grader 10, an orange filter is used rather than one nearer the middle of the spectrum such as a green or yellow filter. This is due to the fact that the orange filter works just as well for the greenness determination and has the advantage of providing a stronger signal since the reflectivity of green tobacco leaves is generally greatest in the orange part of the spectrum.

In the case of tobacco leaves it is rare to find a truly green leaf such as on a living plant. More typically, the leaves are greenish, i.e., greenish yellow, greenish orange, etc. In these cases, the orange signal is not necessarily stronger than the red signal as would be the case for a truly green leaf. The distinctive factor is that the difference between the reflected red and reflected orange signals is not as great for a greenish leaf as it is for a normal acceptable leaf.

For a normal flue-cured tobacco leaf, the difference between its red reflectivity and its orange reflectivity is approximately 8 percent. That is to say, if a yellow flue-cured leaf reflects 50 percent of the orange light (600 nm) it will reflect 58 percent of the red light (670 nm). If a red flue-cured leaf reflects 20 percent of the orange light, it will reflect 28 percent of the red light. On the other hand, a yellow leaf which reflects 50 percent of the orange but reflects only 52 percent of the red light would appear to be greenish. Likewise, a red leaf which reflects 20 percent of the orange light but only 23 percent of the red light will also appear to be green.

Since the determination of greenness and the degree of greenness is relative to the strengths of the red and orange brightness signals, it is best to pick a back-

ground for flue-cured tobacco that is about 4 percent more reflective in the red than in the orange. For other types of tobacco, a different factor may be required although the figure of 4 percent appears to work as well with air cured Burley tobacco as with flue-cured tobacco leaves.

As an additional benefit, white objects which may be intermingled with the tobacco leaves being graded will appear to be green since the white objects will reflect red and orange light in equal strengths. It is theoretically possible, therefore, to pick up a piece of string or other small impurity with the tobacco grader 10 and reject the same if sufficient sensitivity is provided in the control circuit 14.

THE CONTROL CIRCUIT 14

Referring now to FIG. 2, the general details of the control circuit 14, first described with reference to FIG. 1 will be further defined.

The control circuit 14 is shown as including the red and orange light detectors RD and OD respectively, which are connected through the control circuit input terminals 14A and 14B to red light and orange light detector networks RDN and ODN, respectively.

The red and orange light detector networks RDN and ODN have output terminals 30 and 32, respectively, which are mutually connected to the input terminal pairs of an adder circuit 34 and a subtractor circuit 36. The adder circuit has input terminals 34A and 34B connected, respectively, to the orange output 32 and the red output 30 of the said detector networks ODN and RDN. The subtractor circuit 36 has input terminals 36A and 36B connected, respectively, to the orange output 32 and the red output 30 of the said detector networks ODN and RDN.

The adder output terminal 34C is directly connected to the input terminal 38A of a bright or dark detector circuit 38, the latter having an output terminal 38B. The output terminal 36C of the subtractor circuit 36 is directly connected to an input terminal 40A of a green or yellow detector circuit 40, the latter having an output terminal 40B. The outputs 38B and 40B of the bright or dark detector circuit 38 and the green or yellow detector circuit 40, respectively are connected to the input terminals 42A and 42B, respectively, of a background reference color storage circuit 42 and the respective input terminals 44A and 44B of a logic network 44.

The logic network 44 includes first and second output terminals 44C and 44D, respectively, the first output terminal 44C comprising a background presence signal output which is directly connected to a third input terminal 42C of the background reference color storage circuit 42. The background reference color storage circuit 42 further includes first and second output terminals 42D and 42E, respectively, which are directly connected to second input terminals RDN1 and ODN1, respectively, of the red and orange light detector networks RDN and ODN.

The second output terminal 44D which comprises a color output from the logic circuits 44 is directly connected to the input terminal 46A of a color rejection selector circuit 46, the latter having an output terminal 46D directly connected to the input terminal 48A of an air solenoid driver and delay circuit 48. The air solenoid driver and delay circuit 48 has an output terminal 48B which is coincident with the control output termi-

nal 16 of the control circuit 14. Therefore, the output of the air solenoid driver and adjustable delay circuit 48 drives the pneumatic reject mechanism 18 by directing a signal to the input terminal 18A thereof and selectively effecting a blast of air 20A from the nozzle 20.

The various functions of the foregoing circuit means are as follows:

1. The orange light detector network ODN produces a signal representative of the amount of orange light reflected from a tobacco leaf as compared to the particular background upon which the leaf is being examined.

2. The red light detector RDN provides a signal at its output 30 which is representative of the amount of red light reflected from a tobacco leaf, compared to the background color upon which the leaf is being examined.

3. The adder circuit 34 received at its input terminals 34A and 34B the outputs of the red and orange light detector networks RDN and ODN, respectively, and adds these signals to obtain a measure of brightness signal at the output terminal 34C thereof.

4. The subtractor circuit 36 receives at its input terminals 36A and 36B, respectively, the output signals from the output terminals 32 and 30 of the orange and red light detector networks ODN and RDN, and generates a difference signal between the inputs, which difference signal appears at the output terminal 36C of the subtractor 36. Therefore, the signal at the output terminal 36C of the subtractor circuit 36 is a measure of the greenness of a tobacco leaf as compared to the color of the given background. In the particular mode of operation shown, the orange signal is subtracted from the red signal such that when a negative output appears on the output terminal 36C of the subtractor 36, the leaf being examined by the orange and red detectors OD and RD is green. Conversely, when the difference between the orange and red signal is positive, the tobacco leaf is yellow, orange, red or brown.

5. The bright or dark detector circuit 38 is designed to emit at its output terminal 38B digital signals to indicate if the leaf being examined is brighter than the background reference, darker than the background reference or if there is no leaf present upon the background reference.

6. The green or yellow detector circuit 40 is designed to emit at its output terminal 40B digital signals to indicate if the leaf being examined is not greener than the background reference, greener than the background reference, or if no leaf is present upon the background reference.

7. The logic circuit 44 functionally determines whether there is a leaf present upon the background reference or not. The background presence signal appears on the first output terminal 44C of the logic network 44 and is presented as a digital 1 if only the background is in view and as a digital 0 if a leaf is present on the background reference within the field of view of the red and orange detectors RD and OD, respectively. The logic network 44 is also designed to store for one clock cycle the bright/dark and green/not green data from the detectors 38 and 40. Both the leaf presence signal on the first output terminal 44C and the degree of brightness and greenness signal on the second output terminal 44D of the logic network 44 can be ascertained by the relationship between the outputs of the bright or dark detector circuits 38 and the green or yellow

low detector circuits 40 as applied to the inputs 44A and 44B of the logic network 44.

8. The color rejection selector network 46 may be pre-programmed to select any of four combinations of bright and green leaves for rejection. These categories are: (1) dark + green; (2) light + green; (3) dark + not green; and (4) light + not green; relative to the color of the background reference S. This network requires signals from both the greenness and brightness detectors via the signal terminal 44D of the logic network 44 and its own input terminal 46A. The signal on the second output terminal 44D of the logic network 44 as applied to the input terminal 46A of the color rejection selector 46 may comprise logic signals which correspond to one of the four combinations to which the color rejection selector network 46 will respond. Therefore, the color rejection selector network 46 is programmed such that upon coincidence of a logic signal at the input terminal 46A with a preselected color to be rejected, an output control signal will appear on the output terminal 48B of the color rejection selector network 46 which will be transmitted directly to the input terminal 48A of the air solenoid and delay network 48.

9. The air solenoid driver and delay network 48 is programmed consistent with the programming of the color rejection selector network 46 and, therefore, is designed to select any of the four combinations of "bright + green" leaves for rejection. This network includes a delay means with memory (not shown) to compensate for the time delay required for the movement of a leaf across the background reference into the area in which air from the nozzle 20 in the pneumatic reject mechanism 18 can engage the leaf. Upon the receipt of a reject signal at the input terminal 48A of this circuit, a control signal is generated at its output terminal 48B and transmitted through the output terminal 16 of the control circuit 14 to the input terminal 18A of the pneumatic reject mechanism 18, whereby the pneumatic source 22 is connected through the pneumatic terminal 18B to the nozzle 20 and a blast of air 20A is impinged upon the leaf to be rejected to constrain that leaf in the reject trajectory TR. The blast of air is of a duration that corresponds with the size of the leaf T.

10. The background reference color storage network 42 is designed to store the amount of signal provided by the background reference S when no leaf is present. Each time a leaf is absent from the background reference S a reading is taken through the orange and red detector means OD and RD, respectively, and the color signal strength in storage in the network 42 is updated. A timer 42Q2 is also provided in this network to reset the memory therein completely at the time of initial turn-on or any other similar event regarding the control circuits 14. The red signal strength detected from the background reference S stored in the background reference color storage network 42 is transmitted through its first output terminal 42D to the second input terminal RDNI of the red light detector network RDN and thereby subtracted in that network from the signal produced in the red light detector RD. Therefore, when no leaf is present and only the background is in view of the detector RD, a null output is obtained from the red detector network RDN. By transmitting the orange signal strength from the background reference S through the second output terminal 42E of the background reference color storage network 42 to the second input ter-

minimal ODN1 of the orange light detector network ODN and subtracting this signal from the reflected orange signal detected by the orange detector OD, the orange detector network ODN will also exhibit a null output when no leaf is present upon the background reference S. The updating function of the background reference color storage 42 is performed to maintain an accurate and true null signal when no leaves are present upon the background reference S throughout a run of a batch of tobacco leaves through the tobacco grader 10.

Referring to FIG. 3, a more detailed block diagram of the control circuit 14 will now be described, with like elements to FIG. 2 bearing like numerals.

The red and orange detector networks RDN and ODN are shown as including high impedance followers RDNA and ODNA, respectively. The second input terminals RDNI and ODNI of the red and orange detector networks RDN and ODN, respectively, are shown as directly connected at the red and orange detectors RD and OD, respectively, such that the reflected light from the background reference S can be nullified at the detectors, prior to amplification of the response of the said detectors to the reflected light.

The adder network 34 of FIG. 2 is combined in a signal balancing network 34Q having input terminals 34QA - 34QB connected to the outputs 32 and 30, respectively, of the high impedance followers ODNA and RDNA to combine the outputs of the latter to produce a "red + orange" signal.

The "red + orange" signal is amplified (by a factor of 1000, for example) in a conventional comparator circuit 38Q1, which produces either a high or low level output voltage at an intermediate terminal 38A1 in the bright or dark detector circuit 38, from whence a high and low voltage detector network 38Q2 generates appropriate digital output states on a pair of output terminals 38B1 and 38B2, which, together, are equivalent to the general terminal designation 38B in the embodiment of FIG. 2.

The "orange-red" signal is calculated and amplified (by a factor of 2,000, for example) in a "greenness comparator" circuit 36 (subtractor circuit 36 of FIG. 2) and the amplified difference signal voltage produced at the intermediate output terminal 36C, from whence it is directed into the green and yellow detector network 40, the latter comprising a second high and low voltage detector network 40Q for generating appropriate digital output states on a pair of output terminals 40B1 and 40B2 which, together, are equivalent to the general terminal designation 40B of the embodiment of FIG. 2.

Thus, on the terminals 38B1, 38B2, 40B1 and 40B2 of the "bright" and "green" detector networks 38 and 40 are digital signals representative of the color of tobacco leaves T, relative to the background reference S as well as an indication of the presence or absence of such leaves over the obverse face of the background reference S.

All of these terminals are interconnected with the logic circuit 44 such that all of the comparative information is fed from the terminals 38B1, 38B2, 40B1 and 40B2 to the logic circuit input terminals 44A1, 44A2, 44B1 and 44B2, respectively.

The logic circuit 44 has two logic blocks connected with these logic input terminals, namely, a leaf detection circuit 44Q1 and a color data storage circuit 44Q2.

The intermediate output terminals 38A1 and 36C of the brightness and greenness comparators 38Q1 and 36, respectively, are cross connected to the data input terminal pair 42Q1A of a reference gate 42Q1 in the background reference color storage network 42.

The update reference gate has a third data input terminal 42Q1B which is directly connected to the leaf presence output terminal 44C of the leaf presence logic block 44Q1 of the logic circuit 44.

Also connected to the leaf presence output changed a leaf presence timer input terminal 42Q2A of a leaf presence timer network 42Q2. The timer network 42Q2 has a clock input terminal 42Q2B connected to a common system clock generator CG and an enabling output 42Q2C directly connected to a fourth input terminal 42Q1C of the reset reference gate 42Q2. As will be hereinafter more fully described, the clocked leaf presence timer 42Q2 is responsive for storing the color of the background in the background reference storage 42Q3 when the unit 10 is turned on or the background platen S is changed and insures that this condition endures while leaves T are being graded.

The outputs 42Q1D of the reference gate 42Q1 are connected to respective inputs 42Q3A of a background color reference store 42Q3, the output 42Q3B of the latter being connected through a greenness set module 42Q4 controlled from the color selector means 46. Subject to the imposed color constraint from the color selector means 46, the balance between the response of the red and orange detectors RD and OD is modified over and above the constraints imposed thereon by the information in the background color reference store 42Q3, to thereby superimpose a desired greenness response on the red and orange response characteristics of the said detectors, i.e., a degree of greenness sensitivity adjustment.

The color logic storage block 44Q2 of the logic circuit 44 has its output 44D connected to the input terminal 46A of a color logic decoding circuit 46Q1 of the color selector network 46. The storage provides continuity between the clock pulses that are used to "gate" the system in time with the 120HZ A-C ripple in the light output of the lamps L.

The color logic decoding circuit 46Q1 has a constraining input 46Q1A connected directly to the output 46Q2A of a manual color selector switch board 46Q2, the latter being a preset device for effecting a predetermined output function of the logic decoding circuit 46Q1 in response to the color logic stored in the color logic storage block 44Q2. This output function appears at the output terminal 46B of the color selector network 46, from which it passes through the input terminal 48A into a shift register and gate 48Q1, the latter comprising a delay line in the air solenoid driver and a means of requiring that the reject signal be present for a period of time to effect rejection, hence eliminating response to false and spurious signals.

The output of the shift register and gate 48Q1 is fed to the input of a solenoid pulse generator 48Q2, which is also constrained by a direct connection 48Q2A to the clock generator CG to produce an on-off pulse of the length equal to the length of the leaf T plus enough time to compensate for the delay in the air lines of the reject mechanism 18.

The output of the solenoid pulse generator 48Q2 is connected to energize a solenoid driver circuit 48Q3 which generates the on and off full cycle pulses for the

solenoid valve control terminal 18A in the pneumatic reject mechanism 18, to energize the latter to emit a blast of air 20A from the nozzle 20 thereof over a period of time sufficient to constrain a rejected leaf T in the reject trajectory TR as previously described with reference to FIG. 1.

To complete the synchronization of the control logic 14 with the 120HZ ripple from the lamps L, the logic blocks 44Q1 and 44Q2 of the logic network 44 are both constrained by direct input connections 44Q1C and 44Q2C to the clock generator CG.

The interconnection of the greenness set network 42Q4 with the color selector network 46 is schematically illustrated by the dotted line interconnection 46M extending from the said greenness set network to the said switchboard 46Q2 of the selector network 46. This interconnection may be of the manual type or the electrical type, within the purview of those of ordinary skill in the art, to modify the response characteristic of the red and orange light detectors RD and OD.

INTERACTION OF LIGHT DETECTOR, BACKGROUND REFERENCE STORAGE AND LEAF SENSING LOGIC SIGNAL TO PRODUCE BRIGHT AND/OR DARK OUTPUT SIGNALS

Referring now to FIG. 4, a simplified version of a brightness detector circuit will be described which includes the following equivalent elements from the embodiment of FIG. 3:

1. One of the red and orange light detectors RD and OD;
2. One of the high impedance amplifiers ODNA and RDNA;
3. Brightness comparator circuit 38Q1;
4. High and low voltage detector network 38Q2;
5. Background reference storage and delay circuit 42 exclusive of the front panel greenness selector 42Q4.

These are the essential analog logic elements needed to produce dark and bright digital logic outputs to ultimately control the pneumatic reject mechanism 18 of the previous embodiments. These logic outputs are those that appear on output terminals 38B1 and 38B2 of the embodiment of FIG. 3.

The circuit will now be described with reference to the orange light detector OD and its accompanying circuitry as representative of a more sophisticated circuit in which two light inputs, namely, that of the orange detector OD and that of the red detector RD are utilized.

The orange detector OD is illustrated as comprising a photo-tube having a light receiving cathode ODC and an output anode ODA, the latter being connected through a load resistance R1 to the input terminal ODN1 of the orange detector OD. As previously described with reference to FIG. 2 and 3, the input terminal ODN1 of the orange detector OD is directly connected to the input terminal 42E of the background reference color storage circuit 42Q3.

The background reference storage circuit 42Q3 is shown as comprising first and second oppositely polarized capacitors C1 and C2 of equal value, connected in series from the output terminal 42E to ground. The cathode ODC of the orange detector OD is connected to a negative voltage bias terminal OD2, which for purposes of illustration is indicated as carrying a negative 20 volts.

The anode ODA of the orange detector OD is directly connected to the input gate terminal 100 of the

detector amplifier circuit ODNA which is shown as comprising a field effect transistor connected in voltage follower configuration, one of its load terminals 102 being connected to a positive 15 volt bias and the other of its load terminals comprising the output terminal 32 of the amplifier ODNA and being connected through a resistance R2 to the negative voltage bias terminal OD2.

One alternate form of this circuit is to use a semiconductor diode in place of the photo-tube for light detection. Another alternative is to replace the photo-tube OD and the field effect transistor follower ODNA with a photo-sensitive field effect transistor. In the latter case the logic outputs must be reversed.

The brightness comparator 38Q1 is shown as a differential operational amplifier having a positive bias terminal 104, connected to a 15 volt bias source, and a negative bias terminal 106 connected to a -15 volt bias source. As previously described, the output of the brightness comparator 38Q1 is designated as output terminal 38A1. The input terminals 38A of the operational amplifier 38Q1 comprise a pair of input terminals 38AA and 38AB. The input terminal 38AA is directly connected to the output terminal 32 of the orange detector input amplifier ODNA and the input terminal 38AB is connected to the same ground as the capacitors C1 and C2.

The gating portion of the background reference storage circuit 42, namely, 42Q1-3 is shown as comprising a field effect transistor having a gate terminal 108 connected to the leaf detection logic output 44C and a pair of load terminals 110 and 112, the terminal 110 being directly connected to the output terminal 38A1 of the brightness comparator circuit 38Q1 and the load terminal 112 being connected through a load resistance R3 to the output terminal 42E of the background reference storage 42Q4.

The bright and dark detector circuit 38Q2 is shown as comprising a first transistor Q2A having base emitter and collector terminals 114, 116 and 118, respectively, and a second transistor Q2B, of opposite polarity from the first, having base, emitter and collector terminals 120, 122 and 124, respectively. The base terminals 114 and 120 are commonly connected to an input terminal 126 which in turn is connected through an input resistance R4 to the output terminal 38A1 of the brightness comparator circuit 38Q1. The collector terminal 118 of the first transistor Q2A is connected through a biasing resistance R5 to a positive 15 volt bias source, while the emitter terminal 116 thereof is connected to a positive 8 volt reference source. These voltages are exemplary and are not intended as specific limitations. The collector terminal 124 of the second transistor Q2B is connected through a bias resistance R6 to a negative 15 volt bias source while the emitter terminal 122 is connected to it by negative voltage reference source which is indicated as 8 volts by way of example.

The collector terminal 118 of the first transistor Q2A corresponds to the first output terminal 38B1 (the "bright" terminal) of the bright and dark detector network 38Q2. The collector terminal 124 of the second transistor Q2B corresponds to the second output terminal 38B2 (the "dark" terminal) of the bright and dark detector network 38Q2.

In operation, light reflected from the tobacco leaves T and background reference S (not shown in FIG. 4) strikes the cathode ODC of the orange detector OD

causing electrons to be knocked off the said cathode by the photo-electric effect. The electrons are drawn to the anode ODA by the approximately 20 volt bias across the detector photo-tube OD. The movement of these electrons causes the photo-tube OD to act like a very high impedance current source.

Since the photo-tube OD acts like a current source, the best signal-to-noise ratio is obtained when the load resistor R1 thereof is as high as practical. The high impedance of the load resistor R1 requires the use of a high impedance detector amplifier ODNA, which has already been described as a high impedance junction field effect transistor connected in a voltage follower configuration to drive the input 38AA of the brightness comparator network 38Q1, the latter being shown as a differential operational amplifier.

Increased light striking the cathode ODC causes current to flow into the photo-tube OD through the load resistor R1 from the background reference storage capacitors C1, C2 via the terminals 42E and ODN1. Therefore, the voltage appearing via the output terminals 32 of the amplifier ODNA and at the first input terminal 38AA (negative input) of the brightness comparator network 38Q1 will be the same as the voltage across the background reference storage capacitors C1, C2 less than the voltage drop in the load resistor R1 caused by the photo-current and the small bias required for the gate terminal 100 of the field effect transistor in the detector amplifier ODNA. The differential action of the brightness detection network 38Q1 amplifies the difference between the light input signal detected by the orange detector OD and the ground reference applied to the positive input terminal 38AB. A very high gain on the order of about 2,000 is employed by way of example.

With the exemplary bias and reference voltages as shown, for example, a positive swing of 8.5 volts at the output 38A1 of the brightness comparator 38Q1 will indicate that increased light is hitting the cathode ODC of the orange detector OD and will cause the first transistor Q2A in the bright and dark detector network 38Q2 to turn on. This will cause a commensurate voltage change at the collector 118 and output terminal 38B1, thus producing a "bright" output signal on the output terminal 38B1. On the other hand, a negative swing at the output 38A1 of the brightness comparator network 38Q1 on the order of 8.5 volts, will indicate that less light is being reflected onto the cathode ODC of the orange detector OD and will cause the second transistor Q2B in the bright and dark detector 38Q2 to turn on, thereby generating a "dark" signal via the collector 124 on the second output terminal 38B2 of the bright and dark detector 38Q2.

For purposes of grading tobacco leaves, it is desirable to have the output 38A1 of the brightness comparator 38Q1 stationary at a near ground potential when the background reference S is being viewed so that neither a "bright" nor a "dark" signal is produced in the bright and dark detector circuit 38Q2. This is accomplished by use of a conventional negative feedback loop via the feedback resistance R3 and the load terminals 110 and 112 of the field effect transistor comprising the gating circuits 42Q1-3 of the background reference storage circuitry 42. The gate 42Q1-3 will be turned off by the signal from the leaf sensing logic output 44C when a leaf is being viewed.

During this viewing of the leaf, the appearance of the background reference S is effectively stored in the storage capacitors C1, C2 (background reference storage 42Q3) since the effect of the negative feedback through the gates 42Q1-3 is such as to place a voltage on the capacitor C1, C2, sufficient to counter-balance the voltage drop in the load resistor R1 of the orange detector OD which is produced by orange light reflected from the background S striking the cathode ODC.

The feedback resistor R3 prevents the voltage on the storage capacitor C1, C2 from changing too rapidly, and the input resistance R4 between the output terminal 38A1 and the common input terminal 126 of the bright and dark detector 38Q2 prevents the first and second transistors Q2A and Q2B of the latter from shorting out the output signal of the brightness comparator amplifier 38Q1. As previously described, the background reference storage circuit 42Q3 is made in a non-polarized configuration by placing two polarized capacitors C1 and C2 back-to-back.

The feedback gating transistor 42Q1-3 performs two functions. The first function, already described, is to turn off the negative feedback loop when a leaf is being viewed so that false data is not stored in the background reference storage circuits 42Q3, thereby precluding overshooting. The second function is to gate the negative feedback loop so that alternating current can be used on the light sources that illuminate the viewing area of the background reference S. Since the light output of lamps used on alternating current is about one-eighth of the alternating current frequency in nature, considerable alternating current will occur in the output of the differential brightness comparator amplifier output 38Q1. By gating the negative feedback in time with the alternating current from the supply mains, essentially the same results as using direct current in the light sources is obtained.

The logic circuits which follow the AC and DC amplifier must be similarly gated, of course, and this is accomplished by conventional methods.

THE TWO-COLOR CIRCUIT

Referring to FIG. 5, wherein like numerals to FIGS. 1-4 denote like elements, there is shown a more specific representation of the details and interconnections of the detector network DN, balance adjustment network 34Q, brightness detector 38, greenness detector 40, update-reset gates 42Q1-Q2, background reference store 42Q4 and greenness set 42Q5.

The red and orange balance adjustment network 34Q is shown as including a summing junction SJ at the negative input terminal 38A of the brightness comparator 38Q1, the said summing junction SJ being connected through a first summing resistance RS1 to the output terminal 32 (designated as 32-34aA in common with the balance input 34QA) of the orange detector amplifier ODNA and through a second summing resistance RS2 to the output terminal 30 (designated as 30-34QB in common with the balance input 34QB) the red detector amplifier RDNA.

The balance network 34Q is completed by connecting the output 32-34QA of the orange detector amplifier ODNA to ground through a balance resistance RB having a variable tap RB1 thereon connected with the positive input terminal 36B of the greenness comparator 36; and by connecting the output 30-34QB of the

red detector amplifier RDNA through an input resistance RS3 to the negative input terminal 36A of the greenness comparator 36.

The feedback loop of the brightness comparator 38Q1 includes a first stabilizing resistance RS1 connected from the output 38A1 thereof to its negative input 38A; while the feedback loop of the greenness comparator includes a second stabilizing resistance SR2 connected from the output 36C thereof to its negative input 36A.

The greenness set 42Q4 is shown as including auxiliary load resistance R4 in series between the output terminals 42Q3B of the background reference store 42Q4 (in the configuration described in reference to FIG. 4) and the load resistance R1 of the orange and red detectors OD and RD, respectively.

Each such auxiliary load resistance R4 is shunted by a field effect transistor Q3 which is selectively gated to shunt its associated auxiliary load resistance R4 out of the circuit to vary the sensitivity of response of the red and/or orange detectors RD and OD to the light reflected from the background reference S and/or tobacco leaves T. This has been generally described in reference to FIG. 3.

The speed of establishing the proper reference voltage in the background reference store 42Q3 (capacitors C1 and C2) for each of the red and orange detectors RD and OD, can be varied by controlling the duration of the enabling signal placed upon the gate terminal of the transistors Q3 in the reference gates 42Q4.

The duration of the enabling signal is controlled by the leaf presence timer 42Q2 (FIG. 3), which causes a rapid reset of the reference store 42Q3 in the event of an abnormally long duration (6 seconds, for example) between the successive sightings of the background reference S by the detectors RD and OD.

This condition denotes such occurrences as a memory loss, a leaf T stuck on the obverse surface of the reference S or a change from one reference to another, and suitable alarms and/or surface clearing devices are contemplated and can be provided to indicate correct those conditions which are adverse to the proper operation of the tobacco grader 10.

As indicated in FIG. 5, by way of example, the output voltages of the brightness and greenness comparators can be normalized to zero when the detectors OD and RD are viewing the background reference S in the absence of leaves T thereon.

When the output voltages swing plus or minus 8 volts or greater the signals represent the intermediate output parameters which define the logical states "LIGHT⁽⁺⁸⁾ + NOT GREEN⁽⁺⁸⁾", "LIGHT⁽⁺⁸⁾ + GREEN⁽⁻⁸⁾", "DARK⁽⁻⁸⁾ + NOT GREEN⁽⁺⁸⁾", "DARK⁽⁻⁸⁾ + GREEN⁽⁻⁸⁾".

Thus, intermediate positive output voltages of 8 volts or more will change the digital state on the output terminal 38B1 and 40B1 of the brightness and greenness networks 38 and 40 and an intermediate negative output voltages of 8 volts or more will change the digital state on the output terminals 38B2 and 40B2 of said networks.

Therefore, if the quiescent (normalized state of each of the terminals 38B1, 38B2, 40B1, 40B2 is a digital "zero", the logic would appear as follows in response to the various combinations of relative brightness and greenness:

Digital State of Terminals

Condition	38B1	38B2	40B1	40B2
1. BRIGHT+NOT GREEN	1	0	1	0
2. BRIGHT+GREEN	1	0	0	1
3. DARK+NOT GREEN	0	1	1	0
4. DARK+GREEN	0	1	0	1
5. BACKGROUND ONLY	0	0	0	0

Other combinations are forbidden by the high gain of the comparators 38Q1 and 36.

Condition 5 is used when "updating" the storage capacitors (42Q3), since no leaf T is then present over the background S.

OPERATION

Referring jointly to FIGS. 1 and 3, the operation of the tobacco grader 10 of the present invention will now be described. In considering the following description of operation, it should be realized that the specific internal operations of the color sensing detectors OD and RD, the detector amplifiers ODNA and RDNA, the bright or dark detector network 38, the green or yellow detector network 40 and the background reference storage network 42 (including its components) have all been previously defined with reference to FIGS. 1-4, such that persons of ordinary skill in the art can practice the invention with regard to the two-color embodiment of FIGS. 1-3.

Assuming first that no tobacco leaf T is present over the obverse face of the background reference S, the response of the red and orange light detectors RD and OD is to the reflection of light from the desired color standard of the said reference S and can be balanced and attenuated by known passive means in the balance network 34Q such that the output of the brightness comparator network 38Q1 is maintained at the same level as the input reference voltage thereto, thereby precluding the appearance of "bright" or "dark" signals on the output terminals 38B1, 38B2 of the bright and dark detector network 38.

The greenness set 42Q4 is utilized to vary the bias on the red and green detectors RD and OD by imposing additional constraints upon the said detectors to vary the relative sensitivities thereof to their respective reflected light colors, whereby the difference between the two responses can be augmented to effectuate the desired response of the greenness comparator network 36, the latter comprising a differential operational amplifier for determining an orange-red difference signal. Consider, for example, that a field effect transistor could be placed in shunt with a portion of the phototube load resistance R1 of FIG. 4, whereby the effect of the photo-electric current through that resistance in effecting a voltage variation at the anode ODA would clearly vary the proportionate response of the phototube OD to its selected portion of the spectrum, without varying the effect of the background reference storage bias thereon. Furthermore, if the red and orange signals are balanced and added in an interface, such as a conventional passive input network, at the output 32 of the voltage following detector amplifier ODNA, both of these initial conditions will be compatibly imposed on the circuit.

That is, the added signal (red + orange) will indicate relative brightness of leaf T to background reference S (normalized to a fixed reference voltage) and the subtracted signal (orange - red) will indicate relative greenness of leaf T to background reference S (normalized to a fixed reference voltage).

Upon discharge of a leaf T from the conveyor 12, the leaf T floats across the obverse surface of the background reference S and if a different color from the reference S, causes a change of potential on one of the outputs 38B1, 38B2 of the bright and dark detector network 38, commanding the control circuit 14 to either accept or reject the leaf T on the basis of relative brightness.

Concurrently, if the difference signal (orange-red) is of sufficient magnitude, the logic of the output terminals 40B1, 40B2 of the green or yellow detector network 40 will change, commanding the control circuit 14 to either accept or reject the leaf T on the basis of relative greenness.

Therefore, these logic signals enter the logic blocks 44Q1 and 44Q2 which are synchronized by the clock generator CG and change the state of the following:

1. Initiate operation of the leaf presence timer 42Q2;
2. Disable the update reference gate 42Q1 and thereby maintain the reference voltages in the background reference store 42Q4 at the proper levels; and
3. Enter the dark-bright and green-not green data in the leaf color logic block 44Q2 of the logic network 44.

Subsequently, but substantially instantaneously, the brightness and greenness data is screened by the color logic decoder 46Q1, preset for response by the color selector panel 46Q2, and the decoded logic is entered into the shift register 48Q1.

The data is shifted through register 48Q1 at a rate determined by the clock generator CG such that the path of travel of the leaf T, over and off of the background reference S, will be sufficient to permit the leaf T to be positioned with respect to the nozzle 20 of the pneumatic reject mechanism 18, such that the air blast 20A, if initiated, will properly impinge upon the leaf T to constrain it in the reject trajectory TR and such that the reject pulse is required to be present for a fixed amount of time to effect a rejection.

The shift register 48Q3 transmits the decoded data into the pneumatic solenoid pulse generator 48Q2, thereby activating the solenoid driver 48Q3 and energizing the pneumatic reject mechanism 18 for a duration of time corresponding to the size of the leaf T.

Thus, if a leaf T is rejected based on its comparison with the background reference S, the air blast 20A is emitted from the nozzle 20 at the proper time and for a sufficient duration to constrain the rejected leaf T in the reject trajectory TR.

Therefore, in the normal grading mode, those leaves T which are darker and/or greener than the background reference S will be constrained in the reject trajectory TR; and in the reverse grading mode, those leaves T which are lighter and/or less green than the background reference S will be constrained in the reject trajectory TR.

By way of specific example of the grading functions of the grader 10, assuming the normal grading mode, a background reference S colored greenish-red-brown, and a requirement to reject only green suckers, which are both darker and greener than the background reference S, the color selector panel 46Q2 would be set such that the color logic decoder 46Q1 would produce an output only in response to a "DARK and GREEN" logic signal from the color logic storage 44Q2. As a result, no response of the logic decoder 46Q1 would occur for the conditions "DARK and NOT GREEN," "BRIGHT and GREEN" or "BRIGHT and NOT

GREEN". Accordingly, all leaves except green suckers would be permitted to enter the accept trajectory TA and be collected in the acceptable bin BA.

Should it be desired to remove brown and black leaves T as well as green suckers, the color selector 46Q2 would be set to constrain the color logic decoder 46Q1 to additionally respond to the logic condition "DARK and NOT GREEN" in the color logic storage block 44Q2, thereby constraining all black and brown leaves T in the reject trajectory TR along with the green suckers for collection in the reject bin BR.

In the foregoing example, an additional reject requirement for greenish yellow, greenish red and greenish orange leaves T might be desired.

Accordingly, since these are lighter than the background reference S, the color logic decoder 46Q1 would be set via the color selector 46Q2 to respond to "LIGHT and GREEN" logical state in the color storage block 44Q2. Then, only "LIGHT and NOT GREEN" leaves T will be accepted by the grader 10.

If the degree of greenness rejection is too great or relatively non-responsive for the light leaves when normally grading, the greenness set 42Q4 can be adjusted via the control link 46M from the color selector 46Q2, to vary the response differential between the red and orange detectors Rd and OD to either reduce or increase the sensitivity of the grader 10 to the greenness parameter of the lighter leaves T.

What is claimed:

1. Grading and sorting means for comparing objects with a background color reference having an obverse surface over which said objects are transported, comprising:

a background color reference;

source means impinging polychromatic light on the obverse surface of said background reference;

conveyor means directing objects to be graded over said obverse surface;

first and second light detector means positioned over said obverse surface to receive light reflected therefrom and constrained to respond to first and second respectively distinct portions of the spectrum and providing first and second output parameters representative of the respective intensity of the reflected light in said portions of the spectrum;

reference means establishing a reference parameter representative of said color of said background reference and normalizing said detector means thereto;

first computer means responsive to at least one of said first and second output parameters, comparing same with a representation of said reference parameter and generating a first intermediate output and a first logic signal representative of the relative brightness of each object traversing said obverse surface to the brightness of said surface;

second computer means deriving a difference between said first and second output parameters and generating a second intermediate output and a second logic signal representative of the relative color tone of each said object traversing said obverse surface to a preselected color tone of said surface;

means selectively sorting objects of like grade into common paths of travel; and

logic means, responsive to said first and second logic signals and programmed to respond to selected ones of said logic signals representing a given grade

of each of said objects relative to said background reference, generating an actuating signal for said sorting means upon the occurrence of a said selected one of said logic signals.

2. The invention defined in claim 1, wherein said reference means comprises data storage means, connected in a negative feedback configuration with said detector means and constrained by said first and second intermediate outputs in the absence of an object over said obverse surface, to effectuate and store said reference parameter and apply same as a normalizing bias to said detector means.

3. The invention defined in claim 1, where said reference means comprises data storage means, connected in a negative feedback configuration with said detector means, constrained by said first and second intermediate outputs, in the absence of an object over said obverse surface, to effectuate and store said reference parameter and apply same as a normalizing bias to said detector means, and gate means selectively directing said intermediate outputs into said data storage means, wherein said logic means further provides, in response to said first and second logic signals, an object presence signal; and

wherein said gate means is interconnected with said logic means to receive said object presence signal, the latter disabling said gate means to preclude the imposition of a constraint on said data storage means by said first and second intermediate outputs during the presence of an object over said obverse surface.

4. The invention defined in claim 1, wherein said objects comprise tobacco leaves; said first and second portions of the spectrum comprise the orange and red bands thereof; and said preselected color tone of said obverse surface is a green color tone.

5. The invention defined in claim 1, wherein said objects traverse said obverse surface and fall therefrom in a normal trajectory unless otherwise constrained; and wherein said sorting means comprise a pneumatic jet, selectively actuate by said logic means to emit and impinge a jet of air upon those said objects of undesirable brightness and color tone relative to said standard color.

6. The grading and sorting means defined in claim 1, wherein said reference means comprises data storage means, connected in a negative feedback configuration with said detector means and constrained by said first and second intermediate outputs in the absence of an object over said obverse surface, to effectuate and store said reference parameter and apply same as a normalizing bias to said detector means, and color tone selection means superimposing, on said first and second detector means, first and second sensitivity constraints, respectively, to selectively vary the individual response of said detectors to said respective portions of the spectrum and thereby adjust the sensitivity of said grading and sorting means to the color tone of said objects relative to said standard color.

7. The invention defined in claim 1, wherein said detector means each comprises a photoelectric cell having an anode, a cathode and a load resistance in series with said anode and said cathode, and voltage follower amplifier means having an input connected with said anode and an output carrying a respective one of said output parameters;

wherein said reference means comprises gate means and timing resistance means in series with each said load resistance, a source of reference voltage, and storage capacitance means connected from the common connection between said load resistance means and said timing resistance means to said source of reference voltage;

wherein said first computer means comprises a differential operational amplifier having a first input connected to receive at least one of said output parameters from said voltage follower amplifier means, a second input terminal receiving said reference voltage and having an operational output at which is generated a voltage comprising said first intermediate output; and

wherein said second computing means comprises a second differential operational amplifier having inputs respectively receiving said output parameters from said voltage follower amplifier means and having an operational output at which is generated a voltage comprising said second intermediate output;

said first and second intermediate outputs being fed back through said gate means, in the absence of an object over said obverse surface, through said timing resistances.

8. The invention defined in claim 7, wherein said grading and sorting means further includes color tone selection means superimposing, on said first and second detector means, first and second sensitivity constraints, respectively, to selectively vary the individual response of said detectors to said respective portions of the spectrum and thereby adjust the sensitivity of said grading and sorting means to the color tone of said objects relative to said standard color;

said color tone selection means including selectively variable resistance means in series with said load resistance and said timing resistance of each said detector means, into said storage capacitance means to thereby charge said capacitance means to a voltage representative of said standard color of said background reference and place a normalizing voltage constraint on the said anode of each of said detector means;

each said gate means having a control terminal connected with said logic means to receive said object presence signal whereby said gate is disabled precluding a voltage change in said storage capacitance means during the presence of an object over said obverse surface.

9. The invention defined in claim 1, wherein said sorting means further includes delay means precluding actuation of said reject means by said logic means for a selected time subsequent to the advent of traverse of one of said objects over said obverse surface.

10. The invention defined in claim 1, wherein said reference means comprises data storage means, connected in a negative feedback configuration with said detector means and constrained by said first and second intermediate outputs in the absence of an object over said obverse surface, to effectuate and store said reference parameter and apply same as a normalizing bias to said detector means, and color tone selection means superimposing, on said first and second detector means, first and second sensitivity constraints, respectively, to selectively vary the individual response to said detectors to said respective portions of the spectrum

and thereby adjust the sensitivity of said grading and sorting means to variations in the relative color tone of said objects;

wherein said logic means further provides, in response to said first and second logic signals, an object presence signal; and

wherein said gate means is interconnected with said logic means to receive said object presence signal, the latter disabling said gate means to preclude the imposition of a constraint on said data storage means by said first and second intermediate outputs during the presence of an object over said obverse surface.

11. The invention defined in claim 1, wherein said reference means comprises data storage means, connected in a negative feedback configuration with said detector means and constrained by said first and second intermediate outputs in the absence of an object over said obverse surface, to effectuate and store said reference parameter and apply same as a normalizing bias to said detector means;

wherein said objects traverse said obverse surface and fall therefrom in a normal trajectory unless otherwise constrained;

wherein said sorting means comprises a pneumatic jet, selectively actuated by said logic means to emit and impinge a jet of air upon those said objects of undesirable brightness and color tone relative to said standard color.

12. The invention defined in claim 1, wherein said reference means comprises data storage means, connected in a negative feedback configuration with said detector means, constrained by said first and second intermediate outputs, in the absence of an object over said obverse surface, to effectuate and store said detector means, and gate means selectively directing said intermediate outputs into said data storage means;

wherein said logic means further provides, in response to said first and second logic signals, an object presence signal;

wherein said gate means is interconnected with said logic means to receive said object presence signal, the latter disabling said gate means to preclude the imposition of a constraint on said data storage means by said first and second intermediate outputs during the presence of an object over said obverse surface;

wherein said objects traverse said obverse surface and fall therefrom in a normal trajectory unless otherwise constrained; and

wherein said sorting means comprises a pneumatic jet, selectively actuated by said logic means to emit and impinge a jet of air upon those said objects of undesirable brightness and color tone relative to said standard color and constrain another trajectory thereon.

13. The invention defined in claim 1, wherein said reference means comprises data storage means, connected in a negative feedback configuration with said detector means and constrained by said first and second intermediate outputs in the absence of an object over said obverse surface, to effectuate and store said reference parameter and apply same as a normalizing bias to said detector means, and color tone selection means superimposing, on said first and second detector means, first and second sensitivity constraints, respectively, to selectively vary the individual response to said

detectors to said respective portions of the spectrum and thereby adjust the sensitivity of said grading and sorting means to variations in the relative color tone of said objects;

wherein said objects traverse said obverse surface and fall therefrom in a normal trajectory unless otherwise constrained; and

wherein said sorting means comprises a pneumatic jet, selectively actuated by said logic means to emit and impinge a jet of air upon those said objects of undesirable brightness and color tone relative to said standard color to constrain another trajectory thereon.

14. The invention defined in claim 1, wherein said objects traverse said obverse surface and fall therefrom in a normal trajectory unless otherwise constrained;

wherein said sorting means comprise a pneumatic jet, selectively actuated by said logic means to emit and impinge a jet of air upon those said objects of undesirable brightness and color tone relative to said standard color to constrain another trajectory thereon; and

wherein said sorting means further includes delay means precluding actuation of said sorting means by said logic means for a selected time subsequent to the advent of traverse of one of said objects over said obverse surface.

15. The invention defined in claim 1, wherein said reference means comprises data storage means, connected in a negative feedback configuration with said detector means and constrained by said first and second intermediate outputs in the absence of an object over said obverse surface, to effectuate and store said reference parameter and apply same as a normalizing bias to said detector means, and color tone selection means superimposing, on said first and second detector means, first and second sensitivity constraints, respectively, to selectively vary the individual response to said detectors to said respective portions of the spectrum and thereby adjust the sensitivity of said grading and sorting means to variations in the relative color tone of said objects;

wherein said logic means further provides, in response to said first and second logic signals, an object presence signal; and wherein said gate means is interconnected with said logic means to receive said object presence signal, the latter disabling said gate means to preclude the imposition of a constraint on said data storage means by said first and second intermediate outputs during the presence of an object over said obverse surface;

wherein said objects traverse said obverse surface and fall therefrom in a normal trajectory unless otherwise constrained; and

wherein said sorting means comprise a pneumatic jet, selectively actuated by said logic means to emit and impinge a jet of air upon those said objects of undesirable brightness and color tone relative to said standard color to constrain another trajectory thereon.

16. Transducer means determining the relative brightness and greenness of tobacco leaves and the like to a known color standard comprising:

a reference surface having a standard color;

source means impinging polychromatic light on the obverse surface of said reference standard to reflect light therefrom;

first and second detector means receiving reflected light from said obverse surface in the red and orange bands of the spectrum, respectively, and producing first and second output parameters representative of the respective intensities of said red and orange reflected light, said parameters being modified in response to the color of a leaf present over said obverse surface;

feedback means including gated data storage means responsive to said output parameters normalizing the respective output parameters of said detector means to said standard color;

logic means precluding further response of said storage means to said output parameters in response to the presence of a leaf over said obverse surface; and

computer means, responsive to said modified output parameters of said first and second detector means, responding to at least one of said modified parameters to derive a first signal representing the relative brightness of said leaf to said standard color, and subtracting said modified parameters to derive a second signal representing the relative greenness of said leaf to said standard color.

17. The invention defined in claim 16, wherein said transducer means further includes control means selectively programmed to respond to said first and second signals from said computer means to impose a physical constraint on each leaf of preselected brightness and greenness relative to said standard color.

18. The invention defined in claim 17, wherein said control means includes pneumatic jet means selectively directing a jet of air against and effecting a predetermined displacement of each said leaf of preselected brightness and greenness relative to said standard color.

19. The invention defined in claim 16, wherein said red and orange bands of the spectrum are defined by broad band red and orange optical filters centered at 655 nm and 600 nm, respectively, said red filter being so disposed as to view said obverse surface through said orange filter.

20. The invention defined in claim 16, wherein said red and orange bands of the spectrum are defined by broad band red and orange optical filters centered at 655 nm and 600 nm, respectively, said red filter being so disposed as to view said obverse surface through said orange filter;

said red filter being disposed at an angle to said obverse surface to reflect said orange band from the front surface thereof;

said first detector means disposed including first photoelectric means to receive light through said red filter; and

said second detector means including second photoelectric means disposed to receive light reflected from the front surface of said red filter.

21. Circuit means detecting and providing an output signal representative of the relative brightness of an object with reference to the color of the obverse surface of a background reference over which said object is passed, comprising, photoelectric means responsive to light reflected from said surface in a selected band of the spectrum to produce a color output signal representative of the intensity of reflected light in said band; differential operational amplifier means including first and second inputs, an output and a source of

reference potential connected with one of said inputs, the other of said inputs being connected to receive said output signal;

said amplifier means producing an operational signal, at said output, representative of the change in said output signal from a given normalized level; and
feedback means from said output to said other of said inputs holding said operational output signal at said reference voltage and normalizing said color output signal to said reference voltage in the absence of a said object over said surface;

said feedback means comprising gate means and voltage storage means selectively connected between said output and said photoelectric means by said gate means; and

control means disabling said gate means in response to the presence of a said object over said surface.

22. The invention defined in claim 21, wherein said voltage storage means comprises timing resistance means and a non-polarized capacitance means connected from said source of reference voltage to said gate means through said timing resistance means.

23. The invention defined in claim 21, wherein said voltage storage means comprises timing resistance means and a non-polarized capacitance means connected from said source of reference voltage to said gate means through said timing resistance means; and wherein said control means includes pulse generating means applying variable duration control pulses to said gate means to selectively vary the rate of information to said voltage storage means as a function of the apparent duration of the presence of a said object over the said surface of said background reference.

24. The invention defined in claim 21, wherein said photoelectric means includes a phototube and a load resistance in series therewith, both connected in series with said gate means; and

wherein said voltage storage means comprises timing resistance means and a non-polarized capacitance means connected from said source of reference voltage to said gate means through said timing resistance means;

said timing resistance being in series with said load resistance and phototube and said capacitance means being in parallel therewith.

25. The invention defined in claim 21, wherein said photoelectric means includes a phototube and a load resistance in series therewith, both connected in series with said gate means, and

wherein said voltage storage means comprises timing resistance means and a non-polarized capacitance means connected from said source of reference voltage to said gate means through said timing resistance means;

said timing resistance being in series with said load resistance and phototube and said capacitance means being in parallel therewith; and

wherein said control means includes pulse generating means applying variable duration control pulses to said gate means to selectively vary the rate of input of information to said voltage storage means.

26. Transducer means determining the relative brightness and color tone of tobacco leaves and the like to a known color standard comprising:

a reference surface having a standard color;

source means impinging polychromatic light on the obverse surface of said reference standard to reflect light therefrom;

first and second detector means receiving reflected light from said obverse surface in first and second and of the spectrum, respectively, and producing first and second output parameters representative of the respective intensities of reflected light in said respective bands said parameters being modified in response to the color of a leaf present over said obverse surface;

feedback means including gated data storage means responsive to said output parameters normalizing the respective output parameters of said detector means to said standard color;

logic means precluding further response of said storage means to said output parameters in response to the presence of a leaf over said obverse surface; and

computer means, responsive to said modified output parameters of said first and second detector means, responding to at least one of said modified parameters to derive a first signal representing the relative brightness of said leaf to said standard color, and subtracting said modified parameters to derive a second signal representing the relative color tone of said leaf to said standard color.

27. The invention defined in claim 26, wherein said transducer means further includes control means selectively programmed to respond to said first and second signals from said computer means to impose a physical constraint on each leaf of preselected brightness and color tone relative to said standard color.

28. The invention defined in claim 26, wherein said control means includes pneumatic jet means selectively directing a jet of air against and effecting a predetermined displacement of each said leaf of preselected brightness and color tone relative to said standard color.

29. Grading and sorting means for comparing objects with a background color reference having an obverse surface over which said objects are transported, comprising:

a background color reference;

source means impinging polychromatic light on the obverse surface of said background reference;

conveyor means directing objects to be graded over said obverse surface;

first and second light detector means positioned over said obverse surface to receive light reflected therefrom and constrained to respond to first and second respectively distinct portions of the spectrum and providing first and second output parameters representative of the respective intensity of the reflected light in said portions of the spectrum; reference means establishing a reference parameter representative of said color of said background reference and normalizing said detector means thereto;

first computer means responsive to at least one of said first and second output parameters, comparing same with a representation of said reference parameter and generating a first logic signal representative of the relative brightness of each object traversing said obverse surface to the brightness of said surface;

second computer means deriving a difference between said first and second output parameters and generating a second logic signal representative of the relative color tone of each said object traversing said obverse surface to a preselected color tone of said surface; 5

means selectively sorting objects of like grade into common paths of travel; and

logic means, responsive to said first and second logic signals and programmed to respond to selected ones of said logic signals representing a given grade of each of said objects relative to said background reference, generating an actuating signal for said sorting means upon the occurrence of a said selected one of said logic signals. 10 15

30. The invention defined in claim 29, wherein said objects comprise tobacco leaves;

said first and second portions of the spectrum comprise the orange and red bands thereof; and

said preselected color tone of said obverse surface is a green color tone. 20

31. The invention defined in claim 29, wherein said objects traverse said obverse surface and fall therefrom in a normal trajectory unless otherwise constrained; and 25

wherein said sorting means comprise a pneumatic jet, selectively actuate by said logic means to emit and impinge a jet of air upon those said objects of undesirable brightness and color tone relative to said standard color.

32. The invention defined in claim 29, wherein said sorting means further includes delay means precluding actuation of said reject means by said logic means for a selected time subsequent to the advent of traverse of one of said objects over said obverse surface.

33. The invention defined in claim 29, wherein said objects traverse said obverse surface and fall therefrom in a normal trajectory unless otherwise constrained; 30

wherein said sorting means comprise a pneumatic jet, selectively actuated by said logic means to emit and impinge a jet of air upon those said objects of undesirable brightness and color tone relative to said standard color to constrain another trajectory thereon; and 40

wherein said sorting means further includes delay means precluding actuation of said sorting means by said logic means for a selected time subsequent to the advent of traverse of one of said objects over said obverse surface. 45

34. Grading and sorting means for comparing objects with a background color reference having an obverse surface over which said objects are transported, comprising: 50

a background color reference;

source means impinging polychromatic light on the obverse surface of said background reference; 55

conveyor means directing objects to be graded over said obverse surface;

first and second light detector means positioned over said obverse surface to receive light reflected therefrom and constrained to respond to first and second respectively distinct portions of the spectrum and providing first and second output param- 60

eters representative of the respective intensity of the reflected light in said portions of the spectrum; reference means establishing a reference parameter representative of said color of said background reference and normalizing said detector means thereto;

computer means responsive to at least one of said first and second output parameters, comparing same with a representation of said reference parameter and generating a first logic signal representative of the relative brightness of each object traversing said obverse surface to the brightness of said surface and deriving a difference between said first and second output parameters and generating a second logic signal representative of the relative color tone of each said object traversing said obverse surface to a preselected color tone of said surface;

means selectively sorting objects of like grade into common paths of travel; and

logic means, responsive to said first and second logic signals and programmed to respond to selected ones of said logic signals representing a given grade of each of said objects relative to said background reference, generating an actuating signal for said sorting means upon the occurrence of a said selected one of said logic signals.

35. The invention defined in claim 34, wherein said objects comprise tobacco leaves;

said first and second portions of the spectrum comprise the orange and red bands thereof; and said preselected color tone of said obverse surface is a green color tone. 35

36. The invention defined in claim 34, wherein said objects traverse said obverse surface and fall therefrom in a normal trajectory unless otherwise constrained; and 40

wherein said sorting means comprise a pneumatic jet, selectively actuate by said logic means to emit and impinge a jet of air upon those said objects of undesirable brightness and color tone relative to said standard color.

37. The invention defined in claim 34, wherein said sorting means further includes delay means precluding actuation of said reject means by said logic means for a selected time subsequent to the advent of traverse of one of said objects over said obverse surface. 45

38. The invention defined in claim 34, wherein said objects traverse said obverse surface and fall therefrom in a normal trajectory unless otherwise constrained;

wherein said sorting means comprise a pneumatic jet, selectively actuated by said logic means to emit and impinge a jet of air upon those said objects of undesirable brightness and color tone relative to said standard color to constrain another trajectory thereon; and

wherein said sorting means further includes delay means precluding actuation of said sorting means by said logic means for a selected time subsequent to the advent of traverse of one of said objects over said obverse surface.

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