

[54] **METHOD AND APPARATUS FOR SEPARATING POTATOES FROM STONES AND SOIL CLODS**

[72] Inventor: Albert G. Story, Fort Collins, Colo.

[73] Assignee: Colorado State University Research Foundation, Fort Collins, Colo.

[22] Filed: Feb. 3, 1971

[21] Appl. No.: 112,322

[52] U.S. Cl. 209/73, 209/111.5

[51] Int. Cl. B07c

[58] Field of Search 209/111.5, 111.7, 73, 74; 250/83

[56] **References Cited**

UNITED STATES PATENTS

2,984,352	5/1961	Gilman	209/111.5
3,373,869	3/1968	Burson, Jr.	209/111.5
3,435,950	4/1969	Soverkrop	209/111.5 x
3,594,579	7/1971	Garrett	209/111.5

Primary Examiner—Allen N. Knowles

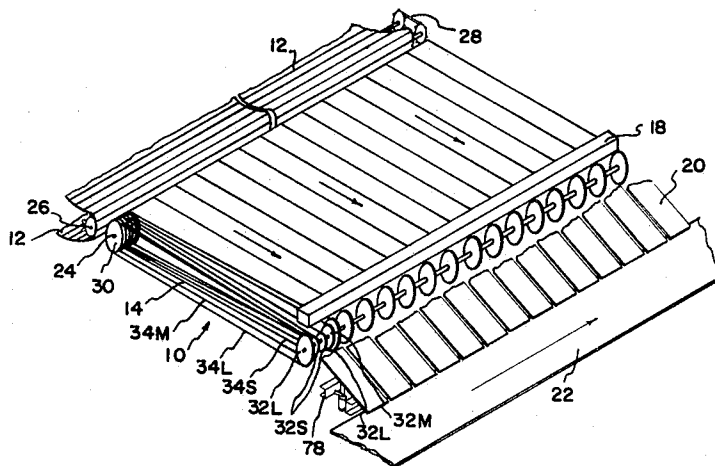
Attorney—Anderson, Spangler & Wymore

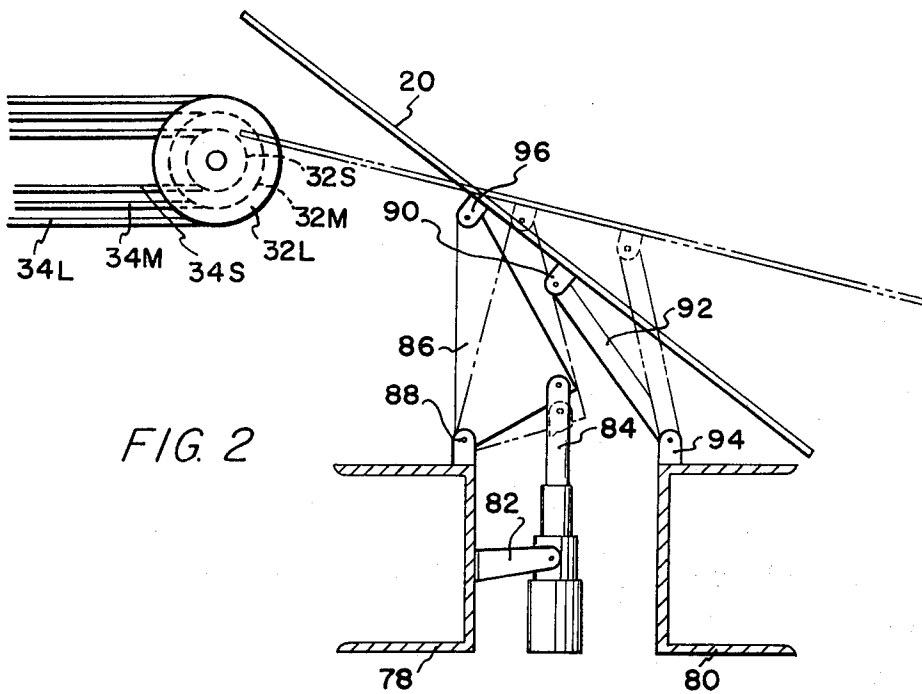
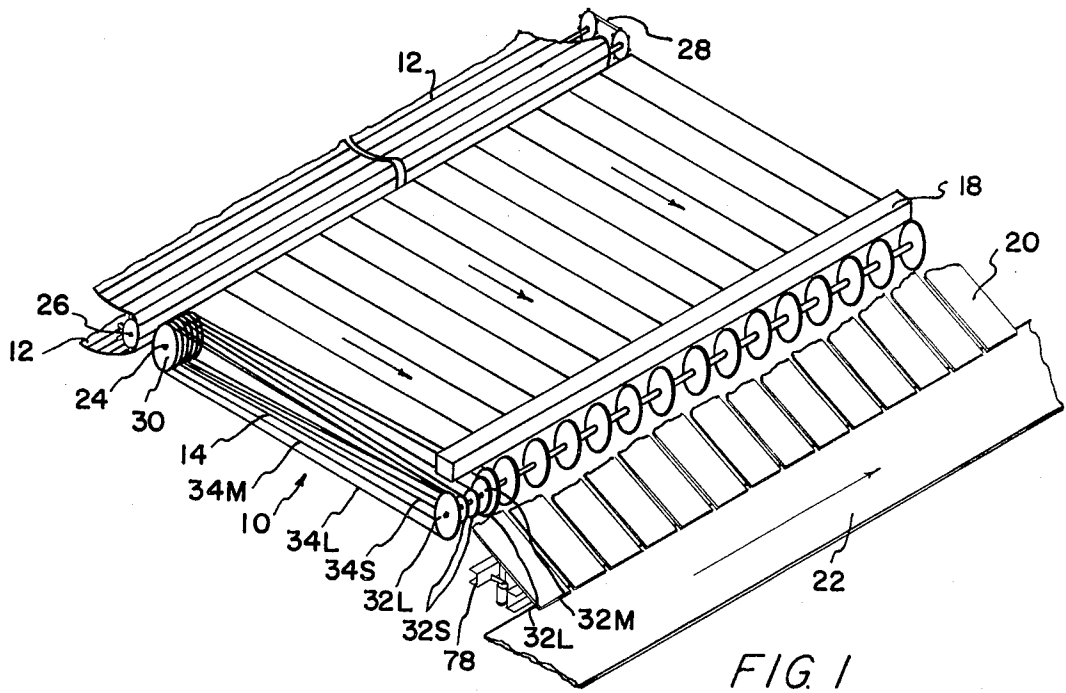
[57]

ABSTRACT

This invention relates to a novel method for separating potatoes from stones and soil clods which comprises channeling a mixture thereof beneath a source of both visible and invisible light as well as infrared radiation covering that portion of the spectrum between approximately 0.2μ and 3.0μ , measuring the reflectance of each element of the mixture within the narrower band of approximately 0.6μ to 1.3μ as well as the band below the latter from about 1.4 to 2.0μ , formulating a ratio based thereon, comparing the ratios thus adduced for each element of the mixture and sorting the elements of the mixture into two groups having similar reflectance ratios. The invention also encompasses the novel apparatus for carrying out the aforesaid separation which comprises a first conveyor locatable at the discharge end of a conventional potato harvester adapted to receive a mixture of potatoes, stones and soil clods therefrom and channel same into a series of side-by-side parallel lines of individual elements; an emitter of both visible light and infrared radiation located above each line of elements in position to shine thereon one-at-a-time; differential detection means responsive to the light reflected from each element adapted to classify the latter into two categories based upon the ratio of their reflectivities within the selected radiant energy bands; and, sorting means connected to the detection means operative to separate each element of the mixture into one of two categories in accordance with the previously determined classification thereof.

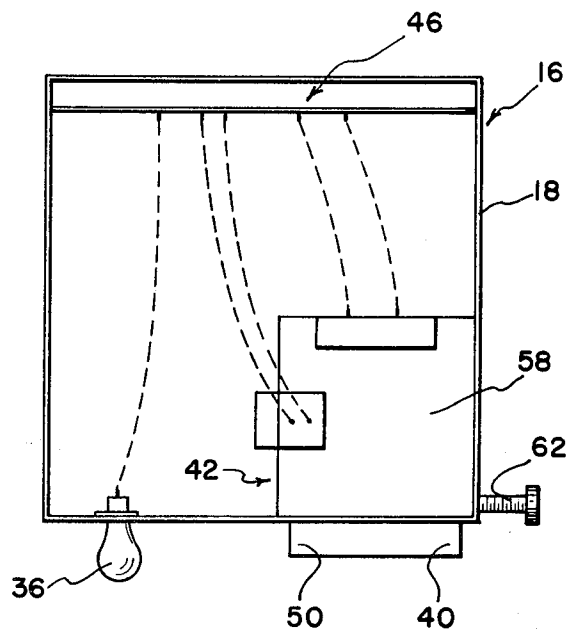
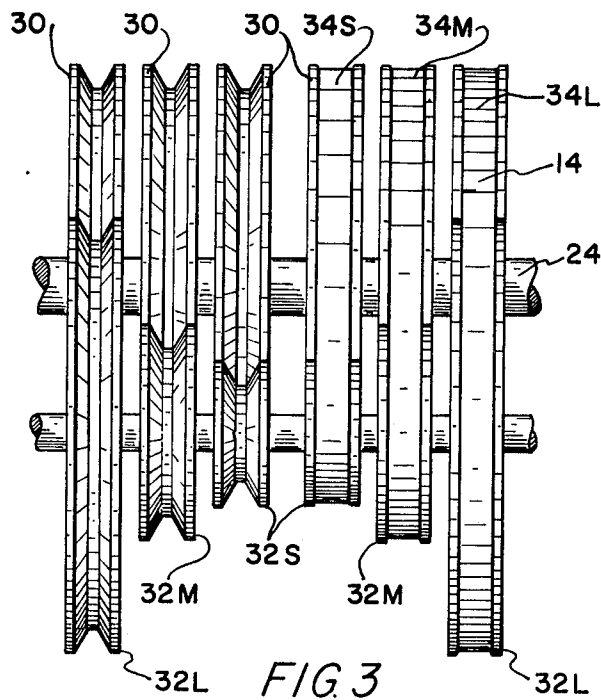
10 Claims, 8 Drawing Figures





INVENTOR.
ALBERT G. STORY

BY
Anderson, Spangler & Wymore
ATTORNEYS



INVENTOR
ALBERT G. STORY

BY *Anderson, Pappas & Wynn*
ATTORNEYS

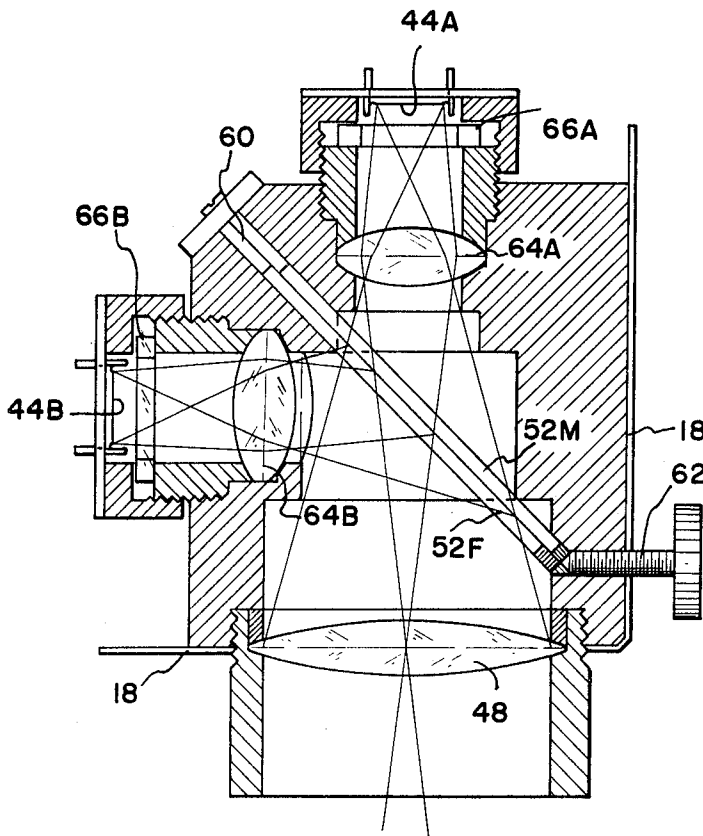


FIG. 5

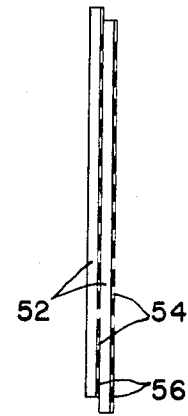


FIG. 7

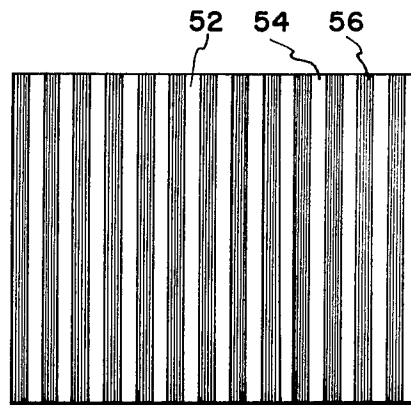


FIG. 6

INVENTOR
ALBERT G. STORY

BY *Conradson, Pomeroy & Montgomery*
ATTORNEYS

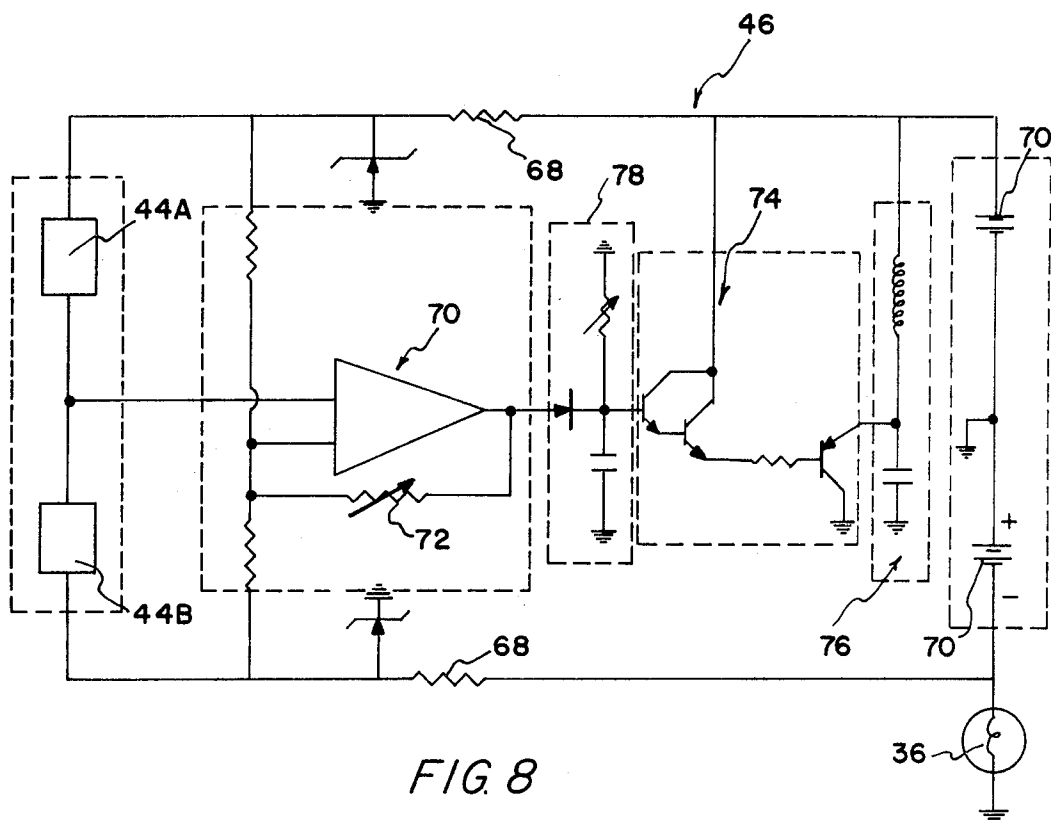


FIG 8

INVENTOR
ALBERT G. STORY
 BY *[Signature]*
 ATTORNEYS

METHOD AND APPARATUS FOR SEPARATING POTATOES FROM STONES AND SOIL CLOUDS

Operation of a conventional potato harvester in stony or cloddy soil results in mixtures containing the latter undesirable elements moving onto the sorting apron along with the potatoes. By far the most widely used method of removing the stones and soil clods from the mixture is by hand and several persons are customarily required to perform this operation. Even so, one pass is seldom sufficient to complete the separation and, therefore, the mixture must be transferred from one conveyor to another two or three times before all the stones and soil clods are removed. This repeated handling and abrasion of the delicate tubers hastens their decay if stored for prolonged periods of time and often brings about a reduction in market grade for a significant proportion of the crop.

In an effort to overcome these problems and also bring about economies in the harvesting operation, many automatic sorting techniques have been attempted. Among these were tilted conveyors, elastic strips, flotation in both solutions and rising air streams, and rotating brushes. For the most part, the prior art mechanical separation techniques resulted in either excessive damage to the potatoes or incomplete sorting or both.

Another sorting technique has been investigated to a limited extent experimentally that showed some promise of providing both complete separation and minimal tuber damage, namely, the relative absorption and reflection of radiant energy between potatoes and foreign objects as a means of differentiating therebetween. Differences in the ability to transmit X-rays proved to be a highly reliable method of differentiating between the potatoes and stones or clods, however, the energy source and detection circuit were both too expensive and too dangerous to be practical.

Other investigations attempted to differentiate between potatoes and both stones and soil clods based upon the differences in absolute reflectances of an ordinary broad spectrum visible light source, but, they found that a complete separation was virtually unattainable predicated upon this criteria. The main problem came from light-colored rocks and similarly-colored dry clods which exhibited an absolute reflectance nearly the same as that of the potatoes.

By far the most encouraging results appear to be based upon a comparison between the ratios of reflectances within a pair of selected band widths taken from a broad spectrum that initially includes visible light and invisible light in the ultraviolet-near-blue end of the spectrum as well as radiant energy in the infrared end thereof. In other words, rather than trying to predicate a sorting function upon differentiating between the absolute reflectance of potatoes and soil clods or stones over a broad band of radiant energy due to the known higher reflectance of potatoes versus stones and soil clods in the red and infrared ranges thereof, it was found that a far more complete separation could be achieved by comparing the ratios of reflectance within the selected red to infrared-near-red band of approximately 0.6μ to 1.3μ with the band of longer wave length radiant energy immediately adjacent thereto that extends from approximately 1.4μ up to around 3.0μ . Since potatoes exhibit a high degree of reflectance in the red to infrared-near-red range and a strong degree of absorption outside this band on both ends, one ratio can be derived which is readily compared and differentiated from a second ratio based upon the reflectance of stones and clods which exhibit a relatively more uniform spectral distribution of reflectivity over the entire range of radiant energy extending from 0.6μ all the way up to 3.0μ , although the absolute reflectance may be much higher than potatoes at wavelengths greater than about 1.4μ .

It has now been found in accordance with the teaching of the instant invention that a reliable sorting method and apparatus for separating potatoes from stones and soil clods becomes practical based upon the aforementioned reflectance ratios. All elements of the mixture undergo mechanical segregation preparatory to being channeled one-at-a-time beneath a source of radiant energy that provides a discreet

look at each element for sorting purposes. The energy source, while emitting light in both the visible and invisible ends of the spectrum that includes the ultraviolet-near-blue also emits considerable heat energy in the infrared range yet remains very inexpensive and completely safe. The reflected energy is collected and split into two separate beams, the relative intensities of which can be varied by an adjustable beam-splitting mechanism. The reflected energy thus collected and divided is then passed to separate yet identical photo cells, however, the character of the light reaching them is of a mutually-exclusive wave length due to selective filtration. The magnitude of the band of filtered energy reaching one photo cell from a particular element is combined with a like measure of a different band of filtered energy reaching the other detector and a ratio thereof is formed which is then used to identify and differentiate between the various elements of the harvested mixture.

The resulting mechanism is fully automatic thus eliminating the need for any hand-sorting in an era where even common labor is both expensive and hard to find. Minimal handling of the potatoes is required thus assuring that the crop will not be downgraded because of abuse during the sorting operation. For the most part, the mechanical elements of the system are simple, cheap and readily available even in farm communities. About the only items that aren't easily repaired in the field are the optical subassembly and the electromechanical subassembly; however, these subassemblies are quite rugged and, therefore, capable of withstanding considerable abuse. The electronic components are both simple and inexpensive. Even the optical components comprise little more than silvered beam-splitting grids, simple double-convex collector lenses and inexpensive filters, none of which need even be of particularly high quality. In fact, both the optical and electronic subassemblies are well-suited to modular treatment whereby an inoperative unit can be replaced with a serviceable one even in the field in a matter of minutes.

It is, therefore, the principal object of the present invention to provide a novel method and apparatus for sorting and separating potatoes from both stones and soil clods.

A second objective is the provision of a method of the type aforementioned in which the sorting function is reliably performed by discriminating between the relative absorptive and reflective characteristics of the elements of the mixture within selected bands of visible light and radiant energy in the infrared end of the spectrum.

Another objective of the invention herein disclosed and claimed is to provide a potato separating apparatus which involves minimal handling and abuse thereof while removing the stones and soil clods therefrom.

Still another objective is to provide a potato sorting and separating device that is readily integrated with existing potato harvesting equipment.

An additional object is to provide a sorting method whereby the elements of the heterogeneous mixture being sorted are segregated and individually examined one-at-a-time in a plurality of parallel lines moving simultaneously past a series of identical optical discriminators.

Further objects of the invention forming the subject matter hereof are to provide a potato separating apparatus that is fast, reliable, rugged, easy to repair and service, relatively inexpensive, compact, and sufficiently versatile to discriminate reliably between potatoes and both stones and soil clods irrespective of the shape, specific gravity, rolling resistance, or other geological characteristics of the latter.

Other objects will be in part apparent and in part pointed out specifically hereinafter in connection with the description of the drawings that follows, and in which:

FIG. 1 is a perspective view looking down and to the left upon the sorting and separating apparatus of the present invention, it having been shown located adjacent the discharge end of the soil-separating rod-link conveyor that forms a part of a conventional potato harvester; however, the apparatus need not be located at that particular point in order to operate;

FIG. 2 is a longitudinal section to an enlarged scale showing one of the solenoid-actuated sorting gates and associated linkage that are used to pass the potatoes on through the system while discharging the stones and soil clods therefrom;

FIG. 3 is a rear fragmentary elevation to an enlarged scale showing one section of the V-belt and pulley system that is used to channel the elements of the mixture into line relation preparatory to their passing beneath the discriminators;

FIG. 4 is an end view to a somewhat enlarged scale showing the relative locations of the energy source, the optical and electromechanical subassemblies of the differential discriminator as they are arranged within the housing therefor;

FIG. 5 is a fragmentary section to a further enlarged scale showing the details of the optical subassembly and photo cell sensing elements of photoelectric detector housed therein;

FIG. 6 is a plan view of one of the silvered beam splitting grids of the optical subassembly; FIG. 7 is an edge view showing a pair of said beam-splitting grids superimposed one atop the other for relative parallel adjustment; and,

FIG. 8 is a schematic view showing the electromechanical circuit used in association with the optical subassembly to trigger the sorting gate.

Referring next to the drawings for a detailed description of the present invention and, initially, to FIG. 1 for this purpose, reference numeral 10 has been chosen to broadly designate the sorting and separating apparatus in its entirety while numeral 12 denotes the discharge end of the rod-link conveyor apron that carries the mixture of potatoes, stones and soil clods dug up by a conventional potato harvester of which said apron forms an integral part. What will be denominated here as a segregating conveyor 14, for lack of a more definitive term, forms a continuation of the harvester apron 12 and, as will be seen presently, functions to channel the individual elements of the harvested mixture into a plurality of transversely spaced parallel lines moving, as before, in the direction of the arrows. Just before the elements of the mixture leave the discharge end of the segregating conveyor, they pass one-at-a-time beneath a bank of differential discriminators 16 (FIG. 4) located within housing 18, the details of which will appear shortly. For the present it will suffice to point out that each of the several discriminators is operative to differentiate between potatoes and stones or soil clods passing therebeneath and to generate a triggering pulse whenever a potato is detected.

As the aligned elements of the harvested mixture leave the discharge end of the segregating conveyor, they pass onto a similar bank of individually operated sorting gates 20 that bridge the gap between the latter conveyor and another conveyor 22, which may be an integral part of a conventional potato harvester and which runs laterally in a direction normal to the previous flow. The sorting gates operate independently of one another whenever a potato has been detected to rock forwardly to catch the potato and roll same down onto the lateral conveyor 22. The stones and soil clods, on the other hand, merely drop through the gap between the segregating conveyor 14 and the sorting gates in their unactuated position where they are redirected down onto the ground under the machine.

Next, with reference to FIGS. 1 and 3, it will be seen that the segregating conveyor 14 includes a horizontally disposed transversely extending drive shaft 24 located at the intake end thereof which may either be independently powered by a suitable prime mover (not shown) or, preferably, connected in synchronous driven relation to the adjacent shaft 26 (FIG. 1) of the harvester by an appropriate power transfer mechanism such as the sprocket chain drive designated broadly by numeral 28 in FIG. 1.

Shaft 24 mounts a series of V-belt pulleys 30 in side-by-side relation that are all of the same diameter. Driven shaft 32 at the discharge end of the segregating conveyor, on the other hand, mounts three different sizes of V-belt pulleys, 32L, 32M and 32S. A set of six such pulleys arranged with a pair of the largest diameter pulleys 32L on the outside, a pair of the smallest ones 32S adjacent one another on the inside, and one of the medium sized pulleys 32M positioned between each large

and small one as shown in FIG. 3, cooperate with one another and with the V-belts 34L, 34M and 34S connecting the latter to the pulleys 30 longitudinally aligned therewith at the intake end of the segregating conveyor to define a trough that becomes progressively deeper toward the discharge end. Thus, as the mixture of potatoes, stones and soil clods that leaves the rod-link conveyor apron 12 of the harvester enters the intake end of the segregating conveyor, it immediately becomes subject to the channeling action of the troughs so that by the time such mixture passes beneath the discriminators 16, the three basically different types of harvested elements found therein will have been rearranged into single file lines capable of being individually examined. By having several of such lines in parallel side-by-side relation to one another, the entire output of the harvester can be accommodated with a plurality of segregating, detecting, sorting and separating functions going on simultaneously.

Referring next to FIG. 4 briefly, the differential discriminator 16 will be seen to include longitudinally spaced banks of three different subassemblies mounted within a common housing 18. The first of these is the energy source 36 which is connected through the bottom wall 38 of the housing and constitutes, in the particular form shown, an ordinary incandescent lamp bulb positioned to shine down on the elements of the mixture passing single file therebeneath on the segregating conveyor. Such a lamp will radiate energy up into the ultraviolet near-blue end of the invisible light spectrum at about 0.2μ , down through the visible light range and well down into the infrared at about 2.5 to 3.0μ . As will appear presently, the sorting function can be carried out with nearly perfect results by sampling the reflectances within the somewhat narrower bands of $0.6 - 1.3\mu$ and $1.4 - 2.2\mu$ thus leaving out the shorter wave lengths in the blue end of the spectrum as well as the ultraviolet, and also the longer wavelengths in the infrared end of the spectrum.

The next element in the differential discriminators located in housing 18 is the optical subassembly 40 of the electro-optical detector that has been indicated in a general way by numeral 42 and which will be described in detail presently in connection with FIGS. 5, 6 and 7. As revealed in FIG. 4, one detector 42 is provided for each lamp bulb 36 located immediately downstream thereof where the visible and radiant energy reflected from the mixture of aligned elements passing therebeneath will be reflected up into the optical subassembly 40. The detector 42, in addition to the optical subassembly 40, includes the photo cell sensors 44A and 44B (FIGS. 5 and 8) of the electromechanical subassembly that has been referred to generally by numeral 46 and which both sorts the potatoes from the foreign objects and triggers the sorting gates.

Now in FIG. 5, the optical subassembly will be seen to include a downwardly directed collector lens 48 housed in a tubular lens mount 50 that receives the light reflected from the elements of the mixture moving therebeneath and directs same onto a pair of sandwiched beam-splitting grids 52 disposed at a 45° angle relative to said light path. Collector lens 48 is a simple double-convex lens and, as previously mentioned, it needn't even be of good optical quality as precise resolution and definition are not nearly as important here as they would be in an image-producing optical instrument. In fact, it would seem that this is an ideal application for plastic lenses which are both inexpensive and rugged while providing moderately good quality.

In FIGS. 6 and 7, it will be seen that the beam-splitting grids comprise mirrors having alternate transparent and silvered bands 54 and 56. Thus, as the reflected light impinges upon one of these grids, approximately half of it will pass on through while the other half will be reflected off at right angles.

In FIGS. 5 and 7, it will be noted that two grids are used in face-to-face sandwiched relation to one another. The housing 58 (FIG. 4) includes diagonally disposed channel 60 adapted to retain these grids and permit one to be adjusted relative to the other. In the particular form illustrated, the lower or nearer of the two grids 52F is fixed while the other 52M is

movable by means of adjustable stop 62 that engages the latter along its lower edge. The purpose of the overlapping grids is, of course, to permit one to vary the relative proportions of the light reaching each of the two photo cells 44A and 44B.

Once again with reference to FIG. 5, it will be noted that as the two beams leave the beam splitter 52, they each are passed through a pair of double-convex lenses 64A and 64B disposed at right angles to one another that further concentrate said beams and direct same on to their respective photo cells. Located directly in front of each photo cell in position to intercept the beam is a filter 66A and 66B. As is the case with any filter, these pass light within a certain band of the spectrum and block out the remainder. In this instance, they are mutually exclusive in that one passes the band from about 0.6μ to 1.3μ while the other passes the one adjacent thereto of around 1.4μ to 2.2μ . Filters capable of discriminating within the selected band widths are readily available commercially and at nominal cost. The detectors are lead sulfide photo conductive cells which exhibit a photosensitivity extending from about 0.5μ well up into the infrared range to at least 2.7μ . They are also not subject to failure by aging or mechanical vibration as are photomultiplier tubes which might be used in the visible range.

Referring next to FIG. 8, the electromechanical subassembly 46 that both differentiates between the potatoes and the stones and soil clods and triggers the mechanism that actuates the sorting gates and sorts the latter. We have the two photo cells 44A and 44B each connected in series with a current-limiting resistor 68 in a simple bridge circuit. A D.C. power supply 70 represented in the form of a pair of 12 V. batteries connected to provide a total potential of 24 V. from +12 V. to -12 V. powers the circuit and the lamp 36.

When a stone or a soil clod passes beneath one of the discriminators 16, the amount of energy reflected therefrom in the 0.6 to 1.3μ band is not materially different than that reflected from the same object in the 1.4 to 2.2μ band. Accordingly, the photo cells 44A and 44B will both be rendered moderately conductive but to about the same degree so that the ratio of their conductances will be about 1:1. The resistors forming the other side of the bridge may be so chosen that, under this condition the bridge output, when connected as illustrated across a conventional electronic operational amplifier 70, will cause a slightly negative potential to be applied to the amplifier and nothing further happens.

If, on the other hand, a potato is detected by a discriminator, the photo cell measuring the reflected energy in the 0.6 to 1.3μ band will be rendered highly conductive to the strong reflections in this area, whereas, conversely, the other cell measuring the reflectance in the 1.4 to 2.2μ band will be even less conductive than with stones and soil clods due to the strong tendency of potatoes to absorb energy in the infrared end of the spectrum above 1.4μ . Now, instead of a slightly negative condition, the bridge sees a condition of strongly positive imbalances as the ratio of reflectances translated into photo cell conductances causes the conductance of cell 44A to be considerably greater than that of cell 44B. Obviously this positive imbalance will be impressed across the amplifier 70.

The bias thus impressed across amplifier 70 will be amplified several hundred times depending upon the value of resistor 72 which may be of the variable type shown, but may also well be a fixed resistor. The resulting amplified voltage is impressed across the base of a transistorized power circuit that has been broadly indicated by numeral 74 and which functions to control the current to a solenoid which has been similarly identified by numeral 76. In the particular embodiment illustrated, a time-delay 78 is interposed between the amplifier 70 and power output 74. The diode in this time-delay serves to isolate the amplifier 70 from the output circuit 74 after the voltage at the amplifier output terminal drops below the voltage on the time-delay capacitor. In this way, since the output impedance of the amplifier is low, the solenoid will actuate the sorting gate in a very few milliseconds after a potato is sensed, but gate retraction after the potato passes beyond the field of

view of the optical assembly may be delayed as desired by varying the value of the time-delay resistor. This allows the potato sufficient time to roll onto the gate before retraction commences.

The electromechanical subassembly 46 described above is located as shown in FIG. 4 in the main discriminator housing 18 and is connected to both the energy source 36 and the optical subassembly 40, the photo cells 44 providing the connection with the latter subassembly. Ambient sunlight could, if desired, be used as the energy source in place of lamp 36 although the latter is preferred because it obviously can be depended upon to shine when the sun is obscured by cloud cover and also because of its relatively constant energy output. It should, perhaps, also be mentioned that the circuit of FIG. 8 is, by no means, the only one that could be used but rather it is intended as being merely representative of one such circuit that has been found quite satisfactory. For instance, the circuit shown is designed to ignore the stones and soil clods and respond to only the potatoes. As such, the mechanism is ideally suited for use under conditions where the undesirable elements, namely, the stones and clods, preponderate over the potatoes as is often the case. Other foreign materials, such as dead vines and trash will thus also be sorted from the potatoes. On the other hand, should conditions exist where the harvest is relatively free of foreign objects, it might be better to sense the stones and clods and actuate the gates to remove same while ignoring the potatoes. This, of course, can easily be done and it would require only minor modifications in the apparatus and circuitry above described such as could easily be accomplished by one of ordinary skill in the mechanical and electronic arts.

Finally, with reference to FIGS. 1 and 2, the mounting and operation of the sorting gates 20 will be set forth in detail. The normal or unactuated position of these sorting gates is that shown in full lines in FIG. 2 where each such gate is inclined downwardly toward lateral conveyor 22. Thus, each rock and soil clod that leaves the discharge end of the segregating conveyor 14 traveling rearwardly, will drop through the gap between the end of conveyor 14 and the upraised end of the sorting gate 20. At such time as a potato is detected, solenoid 76 will actuate to pull gate 20 down into its downwardly inclined position shown in broken lines in FIG. 2 where the potato will roll gently down onto lateral conveyor 22 and be transferred to a suitable potato-retrieval unit (not shown) moving alongside thereof.

In operation, the absence of a potato under the detector results in no gate motion, thus stones, clods, or other debris pass off the end of the channeling conveyor and drop onto the ground or possibly a conveyor which would collect and dispose of the foreign materials. When a potato passes under the detector, the gate is actuated immediately (within a few milliseconds) to the left closing the gap which previously existed between the end of the gate and the channeling conveyor. The potato then passes onto the gate which, after an electronically controlled time delay to assure that the potato has sufficient time to be deposited on the gate, then begins to retract to its original position carrying the potato with it. If there is another potato immediately following, the electronic actuating signal will be renewed and the retraction will not occur, or if it has commenced, will stop and the gate is reactuated immediately. The purpose of this arrangement is to eliminate the necessity for a potato to completely cross the gate before the gate retracts to its unactuated position thus allowing considerably faster cycling than would be possible if the potato was required to clear the gate before retraction.

A pair of longitudinally spaced frame members 78 and 80 extend transversely across the unit between the discharge end of the segregating conveyor and lateral conveyor 22. A U-shaped bracket 82 pivotally mounts solenoid 76 between the frame elements and the core 84 of said solenoid is pivotally attached to a corner at the base of a triangular member 86. The other corner at the base is pivotally attached to one of the frame elements in fixed position by clevis 88 while a similar

clevis 96 attaches the third corner to the underside of the gate. Link 92 is similarly attached for pivotal movement between the other frame element and the plate by clevises 90 and 94.

Upon actuation of the solenoid 76, its core 84 will retract and rock the triangular plate 86 downwardly and to the right in FIG. 2 until it assumes the broken line position. As the forward pivot on the underside of the gate 96 moves backward upon actuation of the solenoid, the rear pivot 90 is restrained by link 92 causing it to swing upwardly and backwardly into a position causing the gate to be angled downwardly less sharply than prior to actuation. As this occurs, the plate will rock backwardly from its full line position into its broken line one. Solenoid 76 would be of the ordinary spring-return type which would instantly resume its full line position the moment the current to its coil was cut off.

As a matter of fact, the repeated energizations of the several solenoids 76 in the unit would probably constitute an excessive drain on the limited electrical power available in a field unit of this type; therefore, from a practical standpoint, the sorting gates 20 should probably be actuated by either hydraulic or pneumatic servo-motors controlled by solenoid-operated valves of the well-known type. Hydraulic power is usually available in farm machinery anyway and cutting down the power requirements to that necessary for actuation of a solenoid valve would seem to be a wise decision. Pneumatic power is even preferable to the hydraulic because it is simpler, cheaper and faster acting, the latter being especially important insofar as actuating the gates is concerned. Here again, power is available from the internal combustion engine of the harvester or tractor to operate the compressor required for pneumatic power. Thus, for the sake of simplicity, the solenoid 76 has been shown as the direct actuator of the gate 20 when, in actuality, this would probably not be the case. The substitution of either a hydraulic or pneumatic solenoid-triggered gate-actuating system would, of course, be a simple matter for one skilled in these arts and call for the exercise of no inventive faculties.

What is claimed is:

1. The apparatus for sorting and separating potatoes from stones and soil clods which comprises:

segregating conveyor means locatable adjacent the potato flow path of a potato harvester in position to receive the harvested mixture of potatoes, stones and soil clods therefrom, said conveyor having the conveying surface thereof shaped to define a plurality of longitudinally extending parallel troughs separated by upstanding ridges, said troughs cooperating with one another and with the ridges therebetween to channel the mixture into separate lines having the individual elements thereof moving one-at-a-time toward the discharge end;

a transversely extending radiant energy source positioned adjacent the discharge end of the segregating conveyor adapted to radiate an uninterrupted band of both visible and infrared energy down atop each element of the mixture in each line;

a sorting gate located at the discharge end of each trough in position to intercept each element of the mixture issuing therefrom, said gate having two operative positions each adapted to deflect the elements impinging thereagainst along a different path;

optical means including a beam splitter positioned and adapted to gather the radiant energy reflected from each element in each line of the mixture and divide same into two discreet beams;

first filter means positioned and adapted to intercept the radiant energy in one of said beams and pass only that energy within the band that extends from the red down into the infrared-near-red end of the spectrum;

second filter means positioned and adapted to intercept the radiant energy in the other of said beams and pass only that energy within that band of the invisible spectrum that extends down from the infrared-near-red into the longer

wave length infrared;

discriminating means having a bridge with a pair of photo cell sensors connected therein, one of said sensors being positioned to intercept the filtered energy passing the first filter means and the second photo cell being positioned to intercept the filtered energy passing the second filter means, said bridge circuit being operative when connected to a D.C. power supply to compare the relative reflectances within the selected band widths of each element sensed in terms of the relative conductances of the photo cells and generate a signal whenever the ratio of said conductances exceeds a predetermined value; and, means connected to each sorting gate operative to shift the position thereof in response to a signal generated within the discriminator means associated therewith.

2. The sorting and separating apparatus as set forth in claim 1 in which: the source of radiant energy emits within a band including at least approximately 0.6μ up to approximately 2.2μ .

3. The sorting and separating apparatus as set forth in claim 1 in which: the first filter means passes energy within the band of approximately 0.6μ up to approximately 1.3μ and the second filter means passes energy between approximately 1.4μ and approximately 2.2μ .

4. The sorting and separating apparatus as set forth in claim 1 in which: the beam splitter comprises a pair of grids each having alternate transparent and reflecting bands arranged in relatively adjustable face-to-face relation so that the ratio of reflected to transmitted energy can be varied.

5. The sorting and separating apparatus as set forth in claim 1 in which: the segregating conveyor comprises a series of belts reaved in side-by-side parallel relation about longitudinally aligned pairs of pulleys, at least those pulleys at the discharge end being graduated in size to define the troughs.

6. The sorting and separating apparatus as set forth in claim 1 in which: one position of the sorting gate is downwardly and forwardly inclined so as to have an open gap between the leading edge of the latter and the discharge end of the segregating conveyor sized to pass stones and soil clods, and the second position thereof is downwardly and rearwardly inclined so as to form a continuation of said segregating conveyor.

7. The sorting and separating apparatus as set forth in claim 5 in which: three pairs of pulleys of different diameters cooperate with six pulleys of the same diameter to define a trough of steadily decreasing depth toward the discharge end.

8. The sorting and separating apparatus as set forth in claim 6 in which: the signal generated by the discriminating means is operative to shift the sorting gate associated therewith from its first into its second position.

9. The method for sorting and separating potatoes from stones and soil clods which comprises: channeling the mixture of potatoes, stones and soil clods into a plurality of parallel lines where the elements of said mixture can be examined one at a time, passing each element of the mixture beneath a source of radiant energy encompassing a band width that includes at least the red end of the visible spectrum on down through a substantial portion of the infrared end of the invisible spectrum, collecting the radiant energy reflected from each individual element of the mixture and dividing same into two discreet beams, filtering one of said beams so as to include only red through infrared-near-red energy and the other of said beams so as to include the remainder of the reflected infrared energy, sensing the energy reflected from each element within the selected bands and comparing the relative magnitudes thereof, and initiating a sorting function predicated upon the differences in relative reflectance magnitudes within said selected bands.

10. The method as set forth in claim 9 in which: the elements of the mixture are passed beneath a radiant energy source encompassing at least approximately 0.6μ up to approximately 2.2μ , and the first beam is filtered to pass energy between approximately 0.6μ and approximately 1.3μ .

* * * * *