Dec. 5, 1961 J. F. HUTTER ET AL 3,011,634

METHOD AND APPARATUS FOR SORTING MATERIALS

Filed March 3, 1958 4 Sheets-Sheet 1

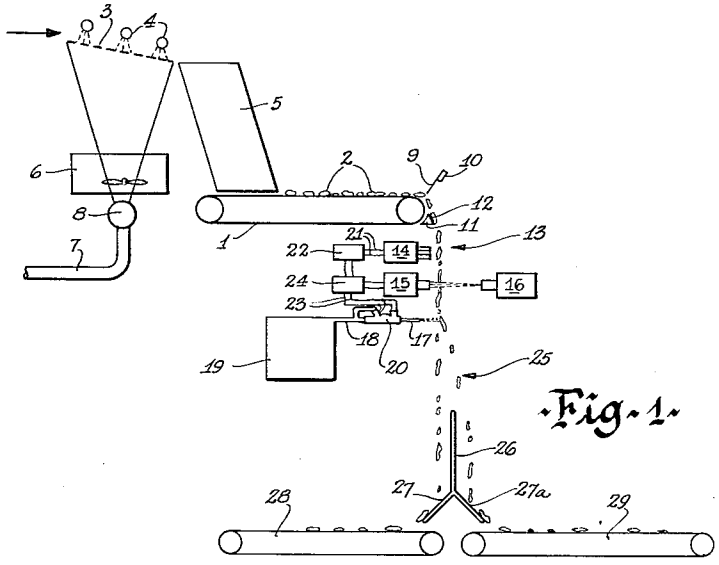


Fig. 1

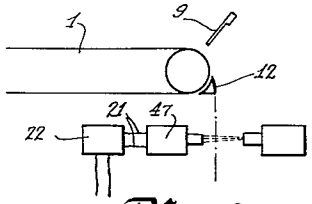


Fig. 2

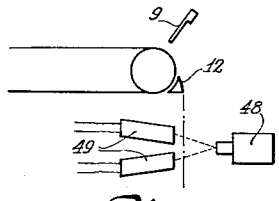


Fig. 3

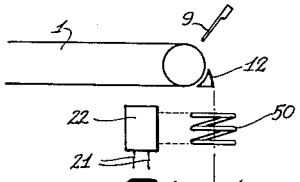


Fig. 4

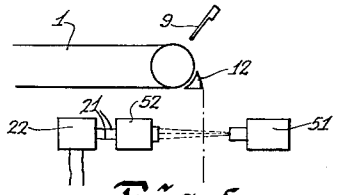


Fig. 5

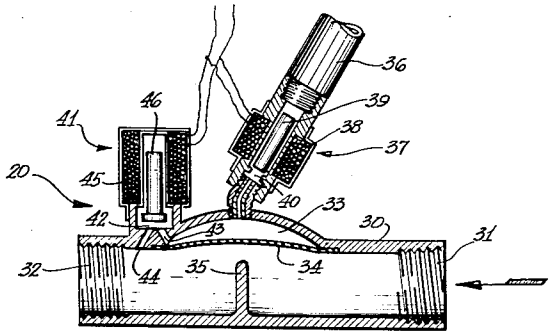


Fig. 6

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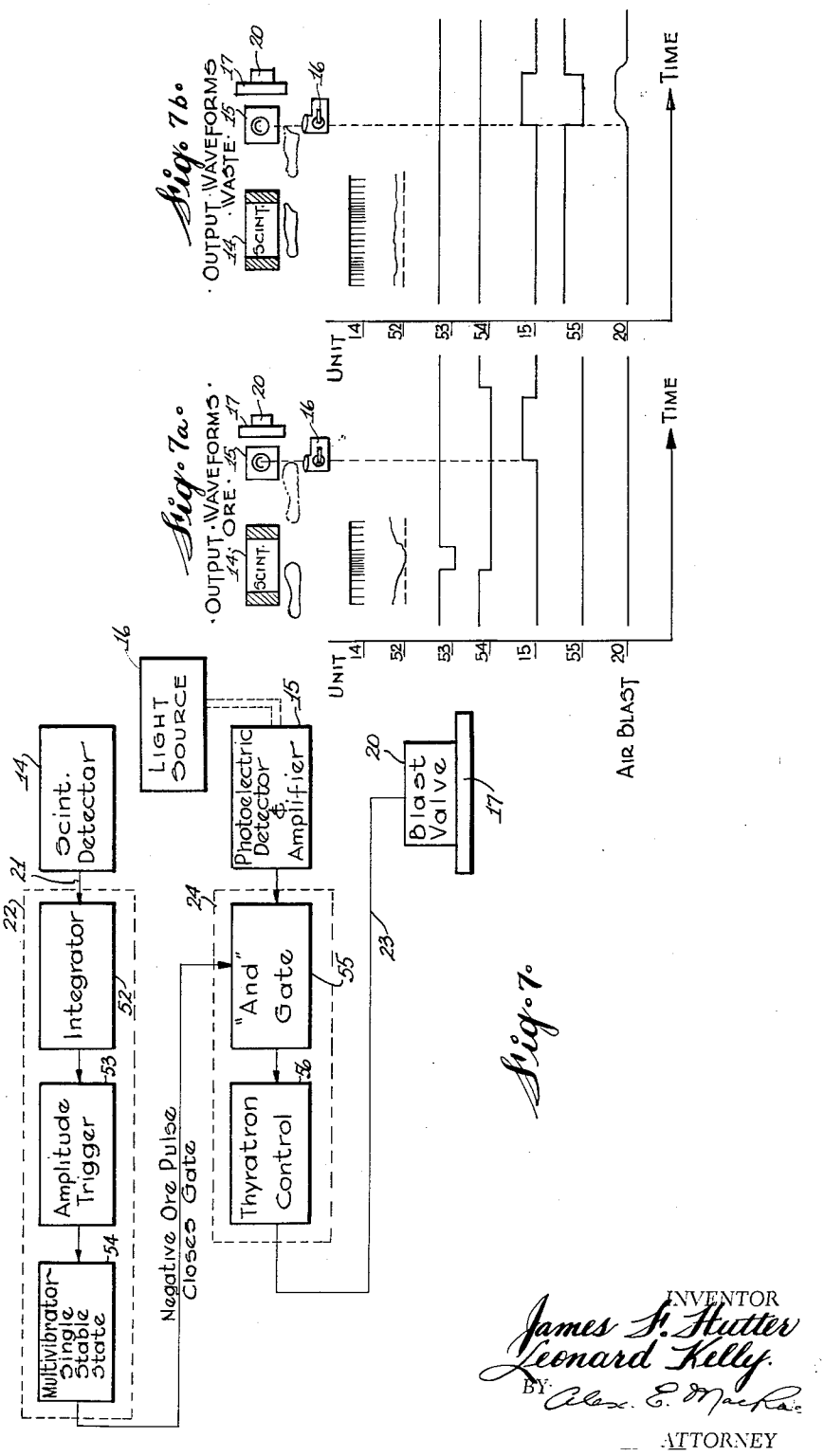


Fig. 7.

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METHOD AND APPARATUS FOR SORTING MATERIALS

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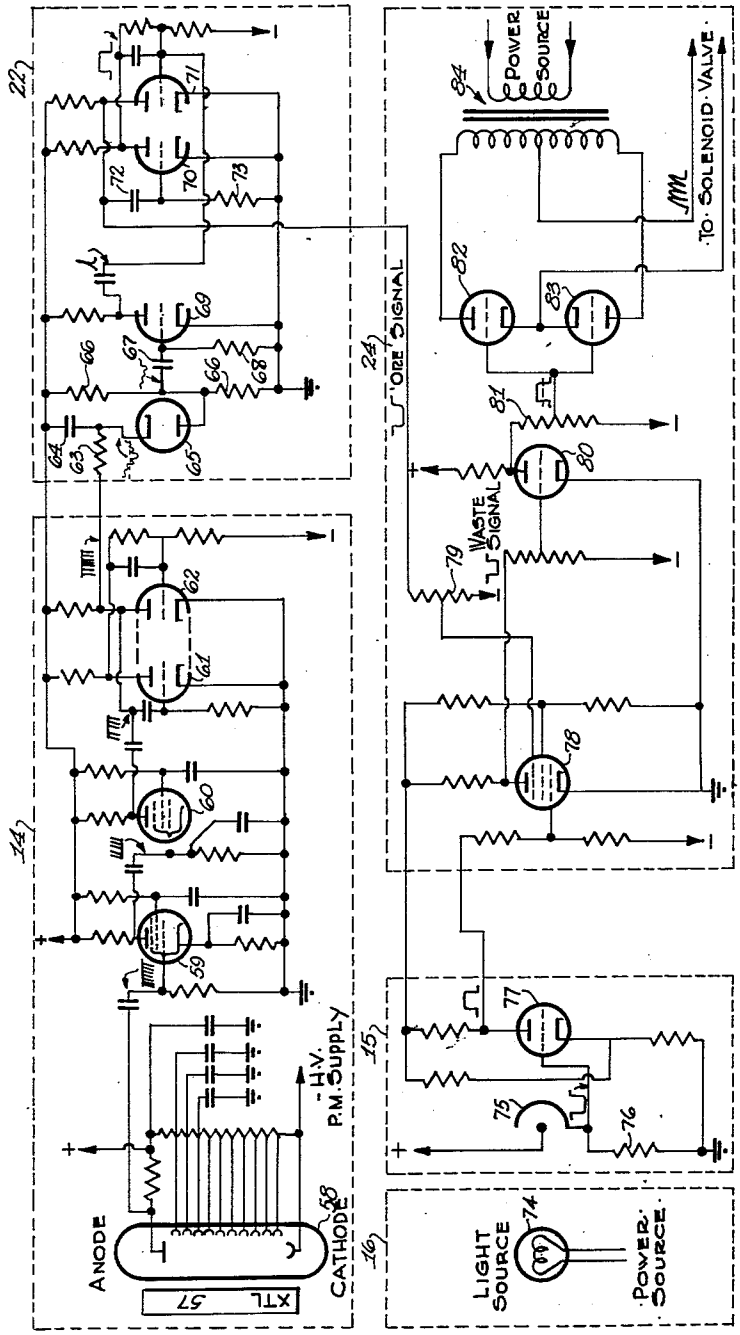


Fig. 8

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METHOD AND APPARATUS FOR SORTING MATERIALS

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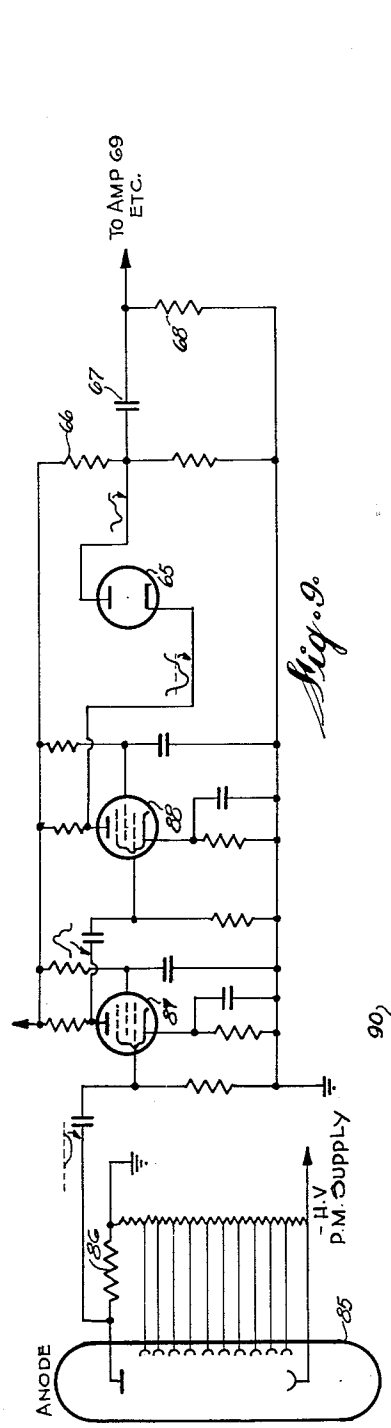


Fig. 9.

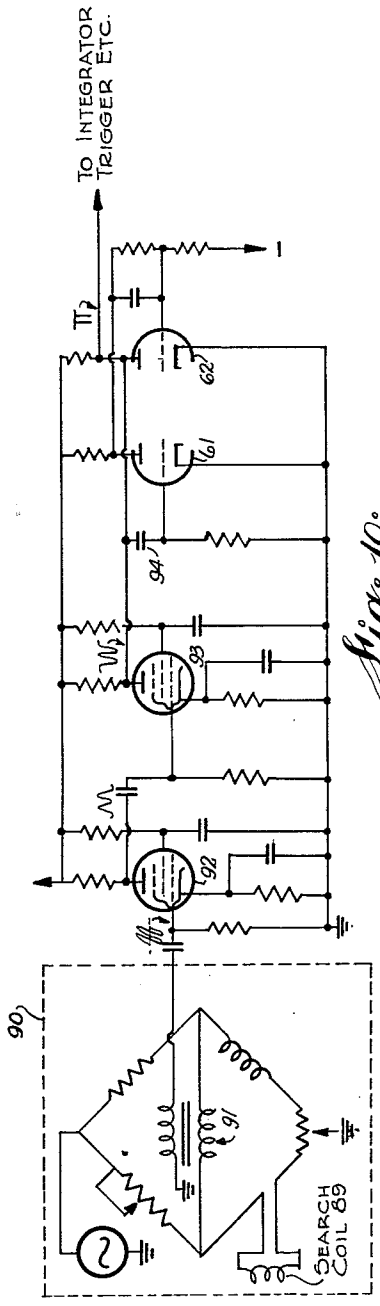


Fig. 10.

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METHOD AND APPARATUS FOR SORTING MATERIALS

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Filed Mar. 3, 1958, Ser. No. 718,874
9 Claims. (Cl. 209—74)

This invention relates to a method and apparatus for sorting materials.

In many mining operations the valuable minerals are distributed very unevenly and meagerly within the rock mass which is broken as ore. This is so, for example, in the case of most uranium and gold ores where the ratios of ore mineral to gangue are in the order of 1:200 and 1:100,000 respectively. Many of the individual pieces of broken rock are, in fact, either completely barren or carry insufficient ore mineral to meet the cost of milling.

If it were possible to pick out and reject these low grade pieces, a saving equal to the difference between the cost of picking and the cost of milling could be achieved. Furthermore, if the underground operation could supply sufficient ore to replace the tonnage of rejected waste, the mill would continue to operate at capacity, but the grade of ore treated and value per ton would be effectively increased.

While visual hand sorting has been in the past a commonly used concentration measure, it is time-consuming and generally inefficient.

An object of the present invention is to provide a method and apparatus for sorting materials in an inexpensive and efficient manner and with much greater speed than has heretofore been possible.

Another object is to provide a high speed method and apparatus for sorting materials which is readily adaptable to treatment of various types of materials such as ores.

The invention resides broadly in a method of sorting materials which comprises providing a stream of pieces to be sorted arranged in a substantially single row, receiving at a point opposite one portion of said stream value identifying radiations from certain of said pieces, directing an air blast across another portion of said stream to change the trajectory of pieces impinged thereby, and controlling the initiation and interruption of said air blast in response to said received radiations.

The invention will be described with reference to the accompanying drawing, in which

FIGURE 1 is a diagrammatic view of an arrangement of apparatus in accordance with the invention,

FIGURES 2 to 5, inclusive, illustrate diagrammatically modifications of a portion of the arrangement shown in FIGURE 1,

FIGURE 6 is a sectional elevation of a valve employed in association with the invention,

FIGURE 7 is a block diagram illustrating one system of electronic control,

FIGURE 7*a* is a diagram of the output wave forms in respect of a piece of ore,

FIGURE 7*b* is a diagram of the output wave forms of a piece of waste rock,

FIGURE 8 is a circuit diagram of one form of electronic control system,

FIGURE 9 is a circuit diagram of one form of optical radiation detection system, and

FIGURE 10 is a circuit diagram of one form of ferromagnetic detection system.

The invention will be described with particular reference to the concentration of ore, but it will be understood that it may be applied to the sorting of various types of materials.

Referring to FIGURE 1, **1** is a constant speed conveyor

belt arranged to receive a supply of rock pieces **2** from any suitable source. The rock pieces are preferably washed and roughly sized before delivery onto the belt or subjected to any other desired pre-treatment.

In the example illustrated, the rock is shown as fed onto a screen **3** where it is subjected to washing sprays **4** following which it falls into a surge bin **5**. The fines and wash water may be deposited in a repulper **6** and thence pumped through pipe **7** by pump **8** to the mill grinding circuit. The rock from the surge bin is deposited on the belt in a single row of pieces.

The rock pieces fall off the end of the belt **1** and it is desirable that the resulting falling stream of rock pieces continue in approximately their normal trajectory and that all the rocks are guided sufficiently to prevent rolling or pitching while in fall. To accomplish this a curved trajectory plate **12** and a flexible dampener **9** mounted on suitable frame members **10** and **11** are provided to ensure that the pieces of rock are discharge in a substantially vertically aligned row or stream of falling pieces with minimum rolling or pitching motion as indicated at **13**. The lower end portion of the dampener is located in the path of the row of rock pieces on the belt and in slightly spaced relation to the discharge end of the belt. The dampener is formed of semi-rigid or flexible material such as rubber or other suitable plastic composition for yielding engagement by the rock pieces.

It will be apparent that each piece will fall off the end of the belt and accelerate with a constant rate of change of speed, due to gravity, virtually regardless of size. This acceleration in free fall, while the succeeding rock piece is still in contact with the contsant speed belt, increases the separation between pieces in the falling stream.

The next stage of treatment may be termed the monitoring stage. This stage comprising the scanning of each piece in the falling stream by means of a monitoring device. The type of monitoring device will depend upon the mineral in the ore which it is desired to recover.

If the ore is of radioactive type, such as uranium ore, a sensitive, lead-shielded scintillator counter **14** is employed, this counter being mounted in laterally opposite relation to the falling stream, as shown in FIGURE 1.

Arranged below the counter **14** is a photoelectric cell **15** having a light source **16** located on the opposite side of the falling stream. Arranged below the cell **15** is an air blast nozzle **17** connected through a pipe **18** to an air receiver **19** and controlled by a valve **20**.

An electric circuit **21** connects the counter **14** to the cell **15** through a suitable electronic device **22** which may include an integrating device, time delays, and memory circuits, as required by the particular application, the arrangement being such that the photoelectric cell circuit is broken whenever the radioactive impulses in the detector exceed a predetermined number during the time of rock passage past the detector.

Any suitable arrangement of the type well known to an expert in the electronic field may be employed. One such type of arrangement is illustrated by way of example in FIGURE 7. As indicated therein, the output of gamma radiation counter **14** in the form of pulses of constant amplitude and duration are fed through electric circuit **21** to electronic device **22**, which includes an integrating circuit **52**, trigger circuit **53**, and delay circuit **54**.

The pulses from counter **14** are integrated and produce a voltage related to the pulse rate, which in turn is functionally related to the radioactive mineral content of the passing rock fragment. This varying voltage is applied to trigger circuit **53**, causing a very rapid change of state whenever the input voltage falls below a predetermined amount. The negative going wave-form at the output of trigger circuit **53** is amplified and inverted, and the leading

edge positive spike so produced serves to trigger over single stable state multi-vibrator **54**. The output of S.S.M. **54** in the quasi-stable state is negative, an ore decision therefore results in a negative pulse the duration of which is determined by the on-time of S.S.M. **54**.

As each piece of rock continues its fall it breaks the beam of the photoelectric unit for a length of time proportional to the length of the piece, and a positive-going pulse is generated by the photoelectric detector and associated amplifier **15**, in response to the interruption of the light beam. This pulse is fed to blast control circuit **24** which functions essentially as an electronic relay. A negative going output wave form from "and" gate **55** is inverted and passed to thyratron **56** only when the input from photoelectric detector **15** and the gate control signal from S.S.M. **54** are both positive. This condition occurs only when a piece of waste rock is interrupting the light beam. Thyratron **56** will pass current and energize valve **20** in response to this positive-going control signal, releasing a blast of high pressure air through nozzle **17**. Because the length of blast is governed by the length of time the light beam is broken, the piece of waste rock will receive a blast of air lasting the full period it is opposite the nozzle, regardless of size. This force applied to the piece of rock gives a new trajectory as indicated at **25**, FIG. 1.

If the piece of rock is "ore," i.e., contains sufficient mineral to warrant further treatment, S.S.M. **54** is triggered over during the rock passage past detector **14** and the resulting negative control signal by closing gate **55**, prevents the photoelectric circuit from firing thyratron **56** and energizing the air valve. No blast of air is discharged through nozzle **17**, and the piece of rock therefore continues in its normal path undisturbed. The on-time of S.S.M. **54** is adjusted so that an ore decision obtained from the leading edge of the longest piece of rock will close gate **55** until the trailing edge of that rock has passed the photoelectric detector.

FIGURE 8 illustrates one obvious example of the circuitry involved in the arrangement set forth. A scintillation crystal or phosphor **57** is optically coupled to photomultiplier **58**. The output from photomultiplier **58** is in the form of negative going pulses produced by scintillations whose rate of occurrence is dependent on the radiation field in the crystal. These negative pulses are fed through amplifier inverters **59** and **60** to trigger a conventional single stable state multivibrator (S.S.M.) consisting of triodes **61** and **62**, the "at rest" condition of which is with triode **61** fully conducting. The trigger pulses produce rectangular negative constant-duration pulses at the plate of triode **62** which are integrated by resistor **63** and capacitor **64** to produce a varying voltage at the cathode of diode **65** related to the radiation intensity.

If this varying voltage falls below the voltage on the diode plate which is connected to divider **66**, the diode conducts and a negative pulse is R-C coupled by capacitor **67** and resistor **68** to the grid of normally conducting amplifier inverter **69**. A positive pulse is thus produced at the plate of triode **69** whenever the radiation intensity exceeds a predetermined level, and is applied to a gating S.S.M. consisting of triodes **70** and **71**.

The negative going output signal produced at the plate of triode **71** whenever the S.S.M. is triggered over has a duration determined by the time constant of capacitor **72** and resistor **73**. It is used as a delayed gating signal, and inhibits the action of the photocell/airblast circuit now to be described.

Light from lamp **74** normally falls on phototube **75**. If the light is interrupted, the voltage developed across resistor **76** will be decreased. This negative going pulse is amplified and inverted by triode **77** and applied to the control grid of pentode **78**.

Pentode **78** is an "and" gate. A positive signal on the control grid will allow the tube to conduct and pass a negative pulse only if the gating signal on the suppressor grid is also positive. In this case the suppressor grid is tied to a voltage divider **79**, the top end of which is connected to the plate of triode **71**. Values are chosen to develop a "gate closed" signal only when triode **71** is conducting, i.e. when the gating S.S.M. is triggered over. If a deficiency of radiation pulses from the photomultiplier allows the normal "gate open" positive signal to remain on the suppressor of pentode **78**, the tube conducts in response to the positive control grid signal, and a negative voltage is developed at the plate. This negative signal after inversion in triode **80** is applied to the top of divider **81** which normally holds the grids of thyratrons **82** and **83** cut off. One of the thyratrons immediately fires. Power to operate the solenoid air blast valve is supplied through transformer **84** and controlled by these thyratrons arranged in a conventional full-wave rectifier arrangement.

The overall action of the circuit is thus to control the air blast in response to an interruption of the light beam, if such control is not inhibited by the overriding action of the radiation detector circuit. This simple electronic system demonstrates how the basic functional requirements may be fulfilled using conventional circuitry. The fundamental concept calls for a physical property monitor to produce a reject/accept decision, and a separate timing control to actuate an air blast rejection mechanism.

It will be apparent that FIGURE 8 merely demonstrates the basic principles of an obvious electronic control system suitable to carry out the functions described, and that various refinements and elaborations thereof may be effected by those skilled in the art for the purpose of detecting a physical property by monitoring natural or induced quanta or radiation, such as gamma rays, neutrons, and primary or secondary X-rays.

Below the nozzle **17** is arranged a divider or splitter plate **26** located between the normal path or trajectory **13** and the trajectory **25**. At the base of plate **26**, a slide **27** receives the concentrated ore in the normal path and directs it onto a conveyor or the like **28** for conveyance to a point of further treatment, and a slide **27*a*** receives the waste rock pieces and directs them onto a conveyor or the like **29** for discharging to waste.

While various types of quick-acting valves are suitable for use as the electrically actuated valve **20**, a satisfactory form of such valve is illustrated in FIGURE 6. As shown, the valve includes a body **30** having an inlet **31** and discharge **32**. The valve is of the diaphragm type and includes a diaphragm chamber **33** and a diaphragm **34** movable into engagement with a partition member **35** to close the valve and out of engagement therewith to open the valve. Chamber **33** is in controlled communication with air under pressure in pipe **18** through conduit **36** by means of a solenoid valve **37** having a solenoid **38** and a plunger **39** arranged to close or open port **40**. Chamber **33** is also in controlled communication with the downstream side of valve body **30** by means of a solenoid valve **41** having a chamber **42**, a port **43** leading from chamber **42** to diaphragm chamber **33**, a port **44** leading from chamber **42** to the downstream side of body **30**, and a solenoid **45** with plunger **46** arranged to simultaneously close and open ports **43** and **44**.

Valve plunger **39** is normally biased in open position, solenoid **38** being in de-energized condition, to open port **40** and place diaphragm chamber **33** in communication with air under pressure through conduit **36**. Valve plunger **46** is normally biased in closed position, solenoid **45** being in de-energized condition, to close ports **44** and **43**. The air under pressure in the diaphragm chamber **33**, because of the greater area of the diaphragm **34** as compared with the effective area of member **35**, will thus actuate the diaphragm and close main valve **20**. On energization of solenoids **38** and **45**, plunger **39** will be moved to close port **40** and thus interrupt communication of the chamber **33** with air under pressure through conduit **36**, and plunger **46** will be moved to open ports **44** and **43** and thus place the diaphragm chamber **33** in com-

munication with the outlet end **32** of the valve body passage. Thus, the pressure in diaphragm chamber **33** will be immediately dissipated and the pressure of air in the valve body passage will move the diaphragm away from member **35** for substantially instantaneous opening of the valve body passage and passage of air under pressure therethrough from pipe **18** to nozzle **17**.

It will be apparent that the method described may be applied to the treatment of any material which has a physical quality related to its value and which can be translated into electrical energy.

FIGURE 2 illustrates a modification of the invention suitable for use in the treatment of material such as rock wherein the ore and waste are of different colors. As shown, instead of the scintillation detector **14**, a photoelectric cell **47** having a sensitivity peak at a particular portion of the color spectrum is employed. The remaining portion of the circuit may be substantially the same as shown in FIGURE 1.

FIGURE 3 illustrates a modification suitable for use in the treatment of material such as rock containing mineral which fluoresce when exposed to a certain wave length of ultraviolet light. As shown, an ultraviolet light source **48** is provided together with a photoelectric cell **49** sensitive to fluorescent light. Again, the remaining stages of operation remain substantially the same.

A type of monitor readily available for detection of optical radiation is illustrated in the circuit of FIGURE 9.

The response of photomultiplier **85** follows a function of the incident light flux and develops an output across resistor **86**. After amplification in stages **87** and **88**, the signal output is fed to amplitude discriminator diode **65** which triggers a gating S.S.M. exactly as in the previously described radiometric system. A photoelectric cell may be used instead of the photomultiplier tube if desired.

Narrow-band light filters and appropriate choice of photo cathode will increase the differential response to a particular wavelength and allow very sensitive discrimination of the diffuse light reflected from various colored articles.

If illuminated with ultra-violet radiations of a certain wavelength, some materials, for example scheelite, may be made to fluoresce, re-radiating energy as visible light of a certain color or wavelength which may be monitored by the circuit of FIG. 9. In this case visible light must be filtered from the light source and ambient light held to a minimum.

FIGURE 4 illustrates a modification which is useful in the treatment of materials such as rock containing minerals having magnetic properties. In this form of the invention, a coil of wire **50**, with or without an induced magnetic field, constitutes the monitor. As shown, the coil is positioned whereby the rock stream falls through or near it. It will be apparent that a rock falling through coil **50** and having therein a mineral with magnetic properties will produce an electric current capable of controlling the subsequent photocell-air blast stage in desired manner.

A simple monitor circuit available for distinguishing ferromagnetic materials from non-ferromagnetic materials is shown in FIG. 10. Stationary search coil **89** constitutes one arm of an A.C. balanced bridge circuit **90**. A piece of ferromagnetic material passing through the energized loop disturbs the field in its vicinity and causes an unbalance current to flow through coil **91** across the arms. Inductive coupling transmits this signal to the grid of amplifier **92**, where the negative excursions produce positive-going pulses at the plate. Pentode **93** amplifies and inverts these pulses, and the negative-going output pulses are applied through capacitor **94** to trigger a S.S.M. composed of triodes **61** and **62** as in the radiometric system. Thereafter the integrating, gating and timing circuits may be as described previously and as shown in FIG. 8.

FIGURE 5 illustrates a modification wherein the varying penetration powers of materials towards X-rays depending upon density and atomic weight is employed to effect the monitoring stage. As shown, **51** is a source of X-rays and **52** a photoelectric cell of either fluoroscope or radiation-sensitive type. The photocell-air blast stage may remain the same as in other modifications.

It will be apparent that the method and apparatus described results in great speed of treatment with high productivity. Moreover, the equipment involved is relatively inexpensive with low cost of operation and maintenance. The various components of the equipment are of standard type. Inertia associated with purely mechanical devices is substantially eliminated in the present method and apparatus. In conventional belt picking methods of sorting, the friction between the materials and the rubber of the belt is not comparable to the equivalent friction of the present invention involving the force of the air blast opposed by air.

It will be understood that the separation of trajectories in the present method is variable depending upon the force of air employed and the distance between the nozzle and the splitter plate.

An important safety feature of the present invention resides in the fact that, if for any reason the mechanism should fail, all of the material under treatment goes to the valve side of the splitter. It will also be apparent that sizing and spacing of the pieces is not a critical condition in treatment in accordance with the present invention.

Elimination of hand picking is an important feature in the handling of radioactive materials in order to avoid contamination.

In the monitoring stage, there is a substantially constant distance between the monitoring head and the pieces regardless of their size.

It will be appreciated that the timing of the air blast is precisely controlled by the photocell rather than by the monitoring device. The duration of the blast may be reduced to act only during part of passage of a piece of material if circumstances should render this step desirable.

Use of an air blast eliminates any necessity of touching the pieces by mechanism in the separation stage. Thus, there are no wearing parts except in the control valve. The force of the air blast is proportional to the size of the piece and is virtually unaffected by the shape of the piece itself.

We claim:

1. A method of sorting a mass of pieces of material to accept therefrom those of said pieces having a physical property related to value and to reject the remainder of said pieces which comprises providing a gravitationally falling stream of said mass of pieces arranged in a substantially single row, monitoring said physical property as said stream passes one point of its travel to detect said acceptable pieces, translating said monitored physical property into a first electrical signal, optically monitoring the transit time of each said piece in said stream past another point of its travel, deriving a second electrical signal directly related to said transit time from said optical monitoring step, directing an air blast having a time and duration responsive to said second electrical signal across said stream at another point of its travel to change the trajectory of pieces impinged thereby, and further controlling said air blast in response to said first electrical signal.

2. A method of sorting a mass of pieces of material to accept therefrom those of said pieces having a physical property related to value and to reject the remainder of said pieces which comprises providing a gravitationally falling stream of said mass of pieces arranged in a substantially single row, monitoring said physical property as said stream passes one point of its travel to detect said

acceptable pieces, translating said monitored physical property into a first electrical signal, optically monitoring the transit time of each said piece in said stream past another point of its travel, deriving a second electrical signal directly related to said transit time from said optical monitoring step, directing an air blast having a time and duration responsive to said second electrical signal across said stream at another point of its travel to change the trajectory of pieces impinged thereby, and inhibiting said air blast in response to said first electrical signal to permit continuance of certain of said pieces in unchanged trajectory.

3. A method of sorting a mass of pieces of material to accept therefrom those of said pieces having a physical property related to value and to reject the remainder of said pieces which comprises providing a gravitationally falling stream of said mass of pieces arranged in a substantially single row, monitoring said physical property as said stream passes one point of its travel to detect said acceptable pieces, translating said monitored physical property into a first electrical signal, optically monitoring the transit time of each said piece in said stream past another point of its travel, deriving a second electrical signal directly related to said transit time from said optical monitoring step, directing an air blast having a time and duration responsive to said second electrical signal across said stream at another point of its travel to change the trajectory of pieces impinged thereby, and inhibiting said air blast in response to said first electrical signal to permit continuance of said acceptable pieces in unchanged trajectory and changing the trajectory of said rejectable pieces only by said air blast.

4. A method of sorting a mass of rock pieces some of which contain valuable amounts of radioactive mineral to accept therefrom those of said pieces containing said valuable amounts of radioactive mineral and to reject the remainder of said pieces which comprises providing a gravitationally falling stream of said mass of pieces arranged in a substantially single row, receiving radioactive mineral-identifying radiations from rock pieces as said stream passes one point of travel to detect said acceptable pieces, translating said radiations above a predetermined intensity into a first electrical signal, optically monitoring the transit time of each said piece in said stream past a lower point of its travel, deriving a second electrical signal directly related to said transit time from said optical monitoring step, directing an air blast having a time and duration responsive to said second electrical signal across said stream at a still lower point of its travel to change the trajectory of pieces impinged thereby, and inhibiting said air blast in response to said first electrical signal to permit continuance of said acceptable pieces in unchanged trajectory and changing of the trajectory of said rejectable pieces only by said air blast.

5. Apparatus for sorting materials which comprises a conveyor for pieces of material to be sorted having a discharge end for discharging said pieces in a gravitationally falling stream, the space below said discharge end being substantially unobstructed to provide a substantially vertical path for free fall of said stream, a monitoring device arranged opposite said path for generation of a first electrical signal in response to a physical property related to value in certain of said pieces as they move past said monitoring device, a photoelectrical device arranged opposite said path below said monitoring device for generating a second electrical signal related to the transit time of each said piece in said stream as it moves past said photoelectric device, an air blast nozzle arranged opposite said path below said photoelectric device and directed across said path, means for supplying air under pressure to said nozzle, a valve controlling flow of air from said air supplying means to said nozzle, an electrical connection between said valve and said photoelectric device to open said valve in response to said second electrical signal and cause a blast of air from said nozzle for changing the trajectory of pieces impinged thereby, and an electrical connection between said valve and said monitoring device to close said valve in response to said first electrical signal and interrupt said blast of air.

6. Apparatus for sorting materials which comprises, a conveyor for pieces of material to be sorted having a discharge end for discharging said pieces in a gravitationally falling stream, the space below said discharge end being substantially unobstructed to provide a substantially vertical path for free fall of said stream, a monitoring device arranged opposite said path for generation of a first electrical signal in response to a physical property related to value in certain of said pieces as they move past said monitoring device, a photoelectric device arranged opposite said path below said monitoring device for generating a second electrical signal related to the transit time of each said piece in said stream as it moves past said photoelectric device, an air blast nozzle arranged opposite said path below said photoelectric device and directed across said path, means for supplying air under pressure to said nozzle, a valve controlling flow of air from said air supplying means to said nozzle, an electrical circuit connecting said valve and said photoelectric device to open said valve in response to said second electrical signal and cause a blast of air from said nozzle for changing the trajectory of pieces impinged thereby, and an electrical circuit including said first electrical circuit connecting said monitoring device and said valve to close said valve in response to said first electrical signal and interrupt said blast of air.

7. Apparatus for sorting materials which comprises, a conveyor for pieces of material to be sorted having a discharge end for discharging said pieces in a gravitationally falling stream, the space below said discharge end being substantially unobstructed to provide a substantially vertical path for free fall of said stream, a device responsive to radiations of predetermined intensity arranged opposite said path to receive value identifying radiations from certain of said pieces as they move past said radiation responsive device, an optical monitoring device having a source of illumination and a photoelectric detector arranged on opposite sides of said path below said radiation responsive device, an air blast nozzle arranged opposite said path below said detector and directed across said path, means for supplying air under pressure to said nozzle, a valve controlling flow of air from said air supplying means to said nozzle an electrical connection between said detector and said valve to open said valve in accordance with the transit time of each said piece past said detector and cause a blast of air from said nozzle for changing the trajectory of pieces impinged thereby, and an electrical connection between said valve and said radiation responsive device to close said valve in response to reception of value identifying radiations in said radiation responsive device and interrupt said blast of air.

8. Apparatus for sorting materials which comprises, a conveyor for pieces of material to be sorted having a discharge end for discharging said pieces in a gravitationally falling stream, the space below said discharge end being substantially unobstructed to provide a substantially vertical path for free fall of said stream, a device responsive to radiations of predetermined intensity arranged opposite said path to receive value identifying radiations from certain of said pieces as they move past said radiation responsive device, an optical monitoring device having a source of illumination and a photoelectric detector arranged on opposite sides of said path below said radiation responsive device, an air blast nozzle arranged opposite said path below said detector and directed across said path, means for supplying air under pressure to said nozzle, a valve controlling flow of air from said air supplying means to said nozzle, electrical means for opening and closing said valve, an electrical connection between said detector and

said electrical means to open said valve in accordance with the transit time of each said piece past said detector and cause a blast of air from said nozzle for changing the trajectory of pieces impinged thereby, and an electrical connection between said radiation responsive device and said electrical means to close said valve in response to reception of value identifying radiations in said radiation responsive device, and interrupt said blast of air.

9. Apparatus for concentrating radioactive ore which comprises, a conveyor for rock pieces to be sorted having a discharge end for discharging said pieces in a gravitationally falling stream, the space below said discharge end being substantially unobstructed to provide a substantially vertical path for free fall of said stream, a scintillation counter responsive to radioactive radiations of predetermined intensity arranged opposite said path for generation of a first electrical signal in response to said radiations in certain of said pieces as they move past said scintillation counter, a photoelectric device arranged opposite said path below said scintillation counter for generating a second electrical signal related to the transit time of each said piece in said stream as it moves past said photoelectric device, an air blast nozzle arranged opposite said path below said photoelectric device and directed across said path, means for supplying air under

pressure to said nozzle, a valve controlling flow of air from said air supplying means to said nozzzle, electrical means to open and close said valve, an electrical connection between said electrical means and said photoelectric device to open said valve in response to said second electrical signal and cause a blast of air from said nozzle for changing the trajectory of pieces impinged thereby, and an electrical connection between said electrical means and said scintillation counter to close said valve in response to said first electrical signal, and interrupt said blast of air.

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