Nov. 11, 1952 C. M. LAPOINTE 2,617,526

APPARATUS FOR SORTING RADIOACTIVE ORE

Filed May 31, 1949 2 SHEETS--SHEET 1

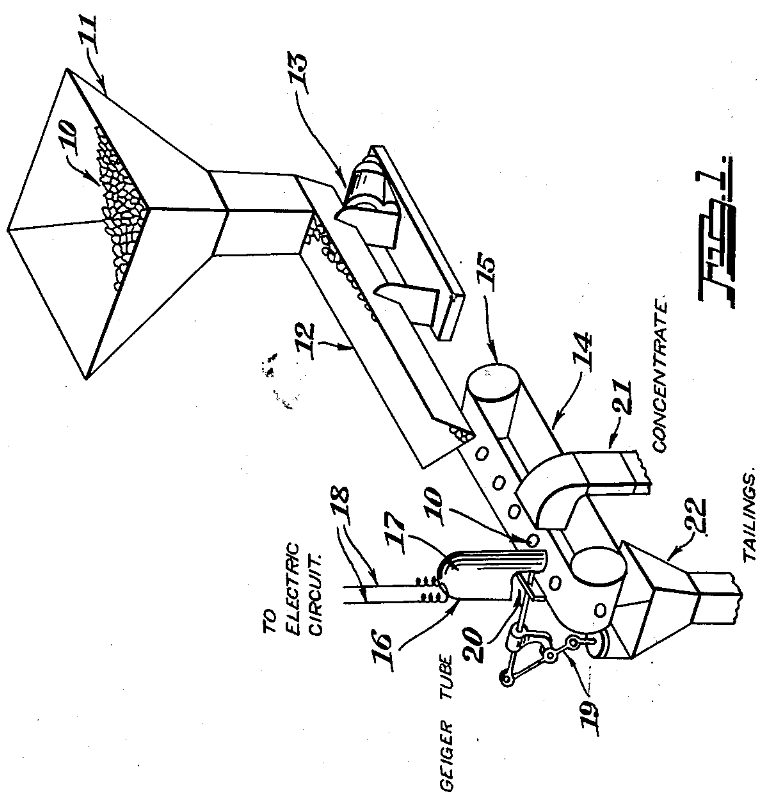

Fig. 1.

INVENTOR -
Christian M. LaPointe
BY- Smart & Biggar.
Attys -

Nov. 11, 1952 C. M. LAPOINTE 2,617,526

APPARATUS FOR SORTING RADIOACTIVE ORE

Filed May 31, 1949 2 SHEETS—SHEET 2

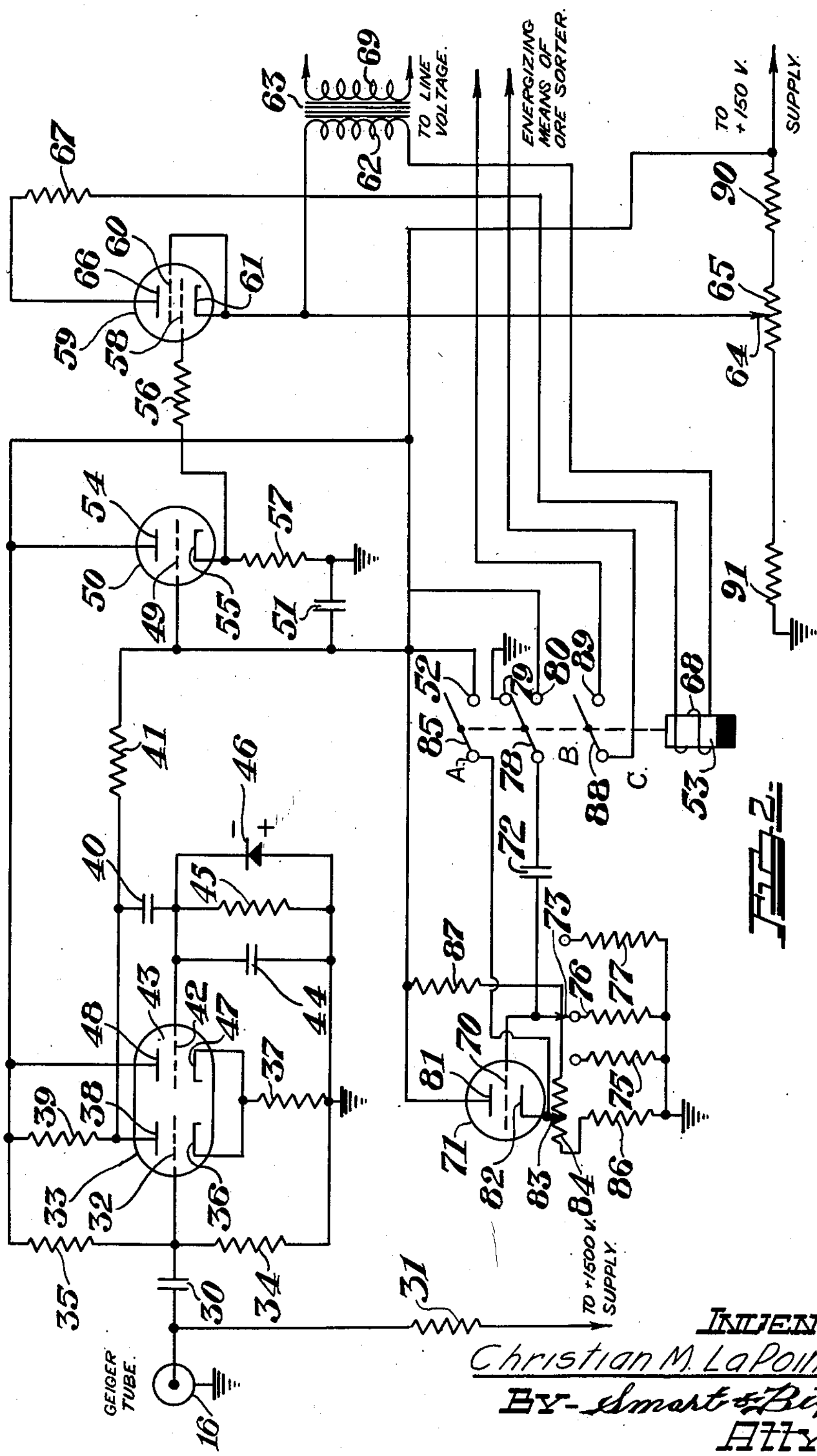

FIG. 2.

INVENTOR
Christian M. LaPointe
BY- Smart & Biggar
ATTYS.

Patented Nov. 11, 1952 2,617,526

UNITED STATES PATENT OFFICE

2,617,526

APPARATUS FOR SORTING RADIOACTIVE ORE

Christian M. Lapointe, Port Radium, Northwest Territories, Canada, assignor to Eldorado Mining and Refining (1944) Limited, Ottawa, Ontario, Canada, a Crown company of Canada

Application May 31, 1949, Serial No. 96,336
In Canada June 1, 1948

4 Claims. (Cl. 209—72)

1

The invention relates to the sorting according to degree of radioactivity of particles of ore having a radioactive component.

In sorting processes it is necessary to carry out a preliminary separation of waste material so that what actually reaches the final stages of the concentration processes has as high an assay value as possible. In dealing with radioactive ores this preliminary treatment is favoured by the fact that devices sensitive to radioactivity, such as Geiger tubes, are available and it is possible to effect separation of particles high in uranium, for example, by crushing the ore, sizing it, and passing it in front of a Geiger tube. This may be done by hand, but this is of course expensive and the result may be inconsistent. According to the invention there is provided apparatus for automatically effecting this preliminary separation.

Ores containing potassium exhibit radioactivity due to a radioactive isotope of potassium, and when in sized form, may be sorted by a sorter according to the invention to collect together particles having a high assay value in potassium.

According to the present invention, apparatus which automatically sorts sized particles of radioactive ore according to degree of radioactivity comprises a feeding mechanism for arranging the particles singly in spaced apart relationship on a conveyor, a detector of radioactivity in close proximity to the conveyor and adapted to provide a series of voltage pulses indicative of the radioactivity of the particles carried by the conveyor, a condenser, connections between the detector and the condenser for charging it at a rate proportional to the rate of formation of the voltage pulses, resistor means for dissipating the charge of the first condenser at a constant rate, a sorter adapted upon energization to segregate a particle of ore from the remainder of the ore on the conveyor, and electron tube means operative in response to a predetermined magnitude of charge of the condenser to energize the sorter and to supply a voltage to the condenser to maintain at least the predetermined magnitude of charge for a predetermined time.

The ore is preferably sized in the form of particles about eight to fifteen millimetres in diameter which are spaced on the conveyor by at least five centimetres. For this size and spacing, the preferred conveying speed is about three to ten metres per minute.

The detector of radioactivity may be a Geiger

2

type tube preferably shielded from extraneous gamma radiations and cosmic radiations. Radioactive excitation of the Geiger tube produces a series of negative voltage pulses which are amplified and converted to positive pulses by an electron tube circuit. The positive pulses charge a condenser at a rate proportional to the rate of formation of the pulses, and a resistor is connected to dissipate the charge of the condenser at a constant rate. The charge on the condenser is used to control electron tube circuits which control the operation of the sorter and produce a voltage of predetermined duration and magnitude for supplementing the charge on the condenser and so stabilizing the operation of the sorter.

The invention will be further described by reference to the attached drawings which illustrate an embodiment of it, and in which:

Figure 1 is a pictorial view of apparatus according to the invention, and

Figure 2 is a schematic diagram of the electric circuit for energizing the sorter.

As shown in Figure 1, particles 10 of radioactive ore are placed in a hopper 11 and are discharged into a vibrating trough 12 of a feeding mechanism 13. The trough 12 is so shaped that the particles 10 feed from it one at a time and fall onto a belt 14 of a conveyor 15. The belt 14 runs at a speed which is so determined that the particles 10 are carried singly in spaced apart relationship. A Geiger tube 16 is fixed above the conveyor belt 14 in close proximity to it so that radioactive emanations from the particles 10 will excite the tube. Lead shielding 17 about the Geiger tube shields it from extraneous radiations and the leads 18 electrically connect the tube 16 to the circuit shown in Figure 2.

A kicker type sorter 19 is mounted beside the conveyor belt 14 so that when operated by energizing means (not shown) its kicker 20 will push an ore particle from beneath the Geiger tube 16 into a chute 21 leading to a bin for concentrated ore. Another chute 22 is at the end of the belt 14 to guide particles of ore which are carried past the Geiger tube 16 to a bin for tailings.

The radius of curvature of the bottom of the trough 12 may be about ⅛ inch for small ore particles of about eight to fifteen millimetres in diameter. The dihedral angle between the trough walls should be about 90° for this size ore. For larger ore particles the radius of curvature of the bottom of the trough should be greater than ⅛ inch. For ore particles smaller than about eight millimetres in diameter the dihedral angle of the walls of the trough 12 should be about 75°. These angles facilitate the desired orderly feeding of the ore particles.

The ore particles 10, sized to proper screen sizes are fed singly from the vibrating trough onto a belt 14 which moves at such a speed as to properly space the particles thereon. Particles of about eight to fifteen milimetres in diameter should remain under the Geiger tube about ⅓ to ½ second for good performance. Thus the particles 10 should be spaced about 5 centimetres or more apart on a belt which runs at a speed of about 3 to 10 metres per minute. Larger particles should remain longer under the Geiger tube, for example, particles 50 millimetres in diameter should be spaced by about 15 centimetres with a correspondingly faster belt speed.

The Geiger tube used is preferably a beta tube since a tube for gamma radiations is usually not sufficiently sensitive except for very radioactive particles of ore. Alpha radiation tubes may be used in certain cases.

Two types of Geiger tubes may be used. For small particles of ore, smaller than about eight to fifteen millimetres in diameter, the end-on type of tube may be used. It is usually a cylindrical glass tube closed at one end with an aluminum window, containing a copper cathode and a tungsten anode. This type of tube is filled with a mixture of argon and ethyl alcohol vapour at 20 centimetres of mercury pressure and its operating voltage is around 1500 volts. For coarser material, two or more thin-walled glass type tubes may be used. In the latter type of tube the cathode may be a copper spiral, or a thin silver deposit on glass and the anode is a fine tungsten wire. In this type the filling and operating voltage are the same as for the end-on type.

Either type of Geiger tube is placed so that the window into the lead shielding around the tube is as close to the belt 14 as is possible and yet permit free passage under the tube of the particles 10 on the belt. A supplementary Geiger tube may be placed under the belt.

The hopper 11 containing the radioactive ore 10 should be shielded with lead or concrete from the Geiger tube 16 to protect the tube from gamma radiations emanating from the mass of radioactive ore 10. The concentrate bin should also be shielded from the Geiger tube by interposing lead or concrete between the bin and the Geiger tube and providing a tortuous path for the concentrate particles in the chute 21.

The electric circuit connected to the Geiger tube 16 by the leads 18 is shown schematically in Figure 2. This circuit upon receiving indications from the Geiger tube 16 that a particle of radioactive ore of desired strength is beneath the tube, produces a control voltage which energizes the sorter 19.

In Figure 2, the Geiger tube 16 is connected to ground and to one side of a blocking condenser 30 as well as by a series connection through a resistor 31 to the positive side of a 1500 volts direct current supply (not shown). The other side of the condenser 30 is connected to the grid 32 of a triode tube 33, to ground through a resistor 34 and to the positive side of a 150 volts direct current supply (not shown) through a resistor 35. The cathode 36 of the tube 33 is grounded through a resistor 37. The plate 38 of the tube 33 is connected to the 150 volts positive supply through a resistor 39, to a condenser 40 and to a resistor 41. The other side of condenser 40 is connected to the grid 42 of a triode tube 43 and to ground through a network consisting of a condenser 44, a resistor 45, and a crystal diode 46. The cathode 47 of the tube 43 is connected to ground along with the cathode 36 of tube triode 33 through the common resistor 37. The plate 48 of the tube 43 is connected directly to the 150 volts positive supply. The other side of the resistor 41 is connected directly to the grid 49 of the triode tube 50; to one side of a condenser 51, and to a contact 52 of pair A of the contacts of a relay 53. The other side of the condenser 51 is connected to ground.

The plate 54 of the tube 50 is connected directly to the 150 volt positive supply. The cathode 55 of the tube 50 is connected to a resistor 56 and to ground through a resistor 57. The other side of the resistor 56 is connected directly to the grid 58 of a gas tetrode tube 59.

The screen grid 60 of the tetrode tube 59 is connected to the cathode 61 of the same tube. The cathode 61 is also connected to one side of the secondary winding 62 of a transformer 63 and to the moveable arm 64 of the manually adjustable variable resistor 65. The plate 66 of the tube 59 is connected in series with a resistor 67 and the relay 53 magnetizing coil 68 to the other side of the secondary winding 62 of the transformer 63. The primary winding 69 of the transformer 63 is connected to a line voltage of 115 volts alternating current.

The grid 70 of a triode tube 71 is connected to a condenser 72 and the moving arm 73 of a selector switch which connects the grid 70 to ground selectively through a resistor 75, a resistor 76, or a resistor 77. The other side of the condenser 72 is connected to the moving arm 78 of the single pole double throw contacts B of the relay 53. The arm 78 in the "off" position is connected to ground by a contact 79 and in the "on" position to the 150 volts positive supply by a contact 80. The plate 81 of the triode 71 is connected to the 150 volts positive supply. The cathode 82 is connected to the moving arm 83 of a manually adjustable variable resistor 84 and to the moving arm 85 of the A pair of contacts of relay 53.

One end of the variable resistor 84 is connected through a resistor 86 to ground and the other end through a resistor 87 to the 150 volts positive supply.

The C pair of contacts 88 and 89 of the relay 53 are connected in series with an external circuit to the energizing means (not shown) of the sorter 19.

The 150 volts positive supply is connected to the variable resistor 65 through a resistor 90. The other end of the variable resistor 65 is connected to ground through a resistor 91.

The triodes 33 and 43 are shown combined in one envelope, and the triodes 50 and 71 may be similarly combined. A suitable double triode type of tube is the 6SN7GT. The tetrode 59 is a gas filled type such as the 2050 type and the crystal diode 46 may be a IN34 type.

The circuit functions as follows: The tube 33 is normally conducting. The direct current voltage of the grid 32 with respect to ground is about 15 volts positive which is approximately the same as the direct current voltage of the cathode 36 with respect to ground. When the Geiger tube 16 is actuated by radio-active emission from a radioactive particle 10 (Figure 1), a succession of short negative voltage pulses are generated by the Geiger tube 16 causing the grid 32 to become negatively charged and causing the plate 38 voltage to rise, resulting in positive voltage pulses passing through the condenser 40 to the grid 42 in the tube 43. The tube 43, which is normally nonconducting (due to the relative grid 42 to cathode 47 potential biasing it to cut-off), is caused to conduct electricity by the positive voltage pulses appearing at its grid pin 42. This increase in current through the tube 43 results in an increased voltage across the cathode resistor 37 common to both of the triodes 33 and 43. This, in turn, has the effect of increasing the grid 32 to cathode 36 voltage (bias) which decreases the plate 38 current of the tube 33 and consequently increases the amplitude of the positive pulses appearing at the plate 38. The crystal diode 46 is connected between the grid 42 of the tube 43 and ground to keep the grid 42 from becoming excessively negative due to the discharging action of the condenser 40. The positive pulses from the tube 33 are also delivered through the resistor 41 to the grid 49 of the tube 50. A series of these pulses coming in rapid succession, as when the Geiger tube 16 is excited by a radioactive particle 10, builds up a charge on the condenser 51 at a rate proportional to the rate at which voltage pulses are formed by the Geiger tube 16, and this charge is dissipated by leakage at a constant rate back through the resistors 41, 39, 35, 34, 90, 65 and 91 to ground; the net charge on the condenser 51 being the resultant at any time of the charge being added due to excitation of the Geiger tube 16 and this constant leakage loss. Conduction through the tube 50 at any time is controlled by the charge on condenser 51, and the cathode to ground voltage of the tube 50, which depends on conduction through the tube, controls the gas tetrode tube 59.

There is provision for varying the voltage on the cathode 61 of the gas tetrode tube 59 by the potentiometer bleeder circuit comprising the fixed resistors 90 and 91, and the variable resistor 65 (sensitivity control). The function of this part of the circuit is to provide for the adjustment of the sensitivity of the response of the gas tetrode tube 59 to voltage at its grid 58. The sensitivity control 65 is adjusted so that as a result of random radiations affecting the Geiger tube 16, the sorter 19 will operate no more than an average of about five to fifteen times per minute. Decreasing the bias of the gas tetrode tube 59 increases the number of accidental kicks or operations of the sorter 19 due to random emanations resulting in dilution of the concentrate. Increasing the bias beyond that required for about five to ten kicks per minute due to random emanations decreases the sensitivity of the sorter so that low or medium grade particles may be missed by it.

The transformer 63 is used to supply 60 cycle alternating current voltage to the plate 66 of the gas tetrode 59 by a series connection through the magnetizing coil 68 of the relay 53.

The manually adjusted control 84 sets the conduction period of the gas tetrode tube 59 in the following manner. Moving the arm 83 of the variable resistor 84 so as to increase the total cathode 82 to ground resistance increases the cathdoe 82 to ground voltage of the triode tube 71 until it is only slightly less than the grid 49 to ground voltage of the triode 50. When the gas tetrode 59 is initially actuated by a rapid succession of voltage pulses from the Geiger tube 16, the relay 53 in the plate circuit of the gas tetrode tube 59 closes the three sets of contacts A, B and C in the following sequence: The single pole single throw set A closes first connecting the cathode 82 of the tube 71 to the grid 49 of the tube 50. The single pole double throw set B closes next, delivering a positive voltage pulse from the 150 volt supply through the condenser 72 to the grid 70 of the tube 71. The tube 71 acts as a cathode follower with a resultant increase in its cathode 82 voltage which is fed to the grid 49 of the tube 50. The closer the static cathode 82 voltage of the tube 71 can be made to approach the static voltage (bias) of the grid 49 of the tube 50, the voltage on which varies in a random manner according to stray radioactive emanations affecting the Geiger tube 16, the longer will be the positive pulse delivered to the grid 49 of the tube 50 for any given time constant as determined by the values of the condenser 72 and the resistors 75, 76 or 77. However the length of the pulse delivered to the grid 49 should be only that necessary to actuate the relay 53 reliably. If the pulse is too long, the ore particles 10 will pile up in front of the kicker 20.

In another embodiment of the invention two Geiger tubes with separate electric circuits and ore sorting mechanisms may be mounted beside the conveyor belt. The electric circuit of one Geiger tube may be adjusted so that it will respond and operate its ore sorting mechanism only for high activity ore and the electric circuit of the second Geiger tube which would follow the first may be set to operate on lower activity ore particles. This would permit the automatic concentration of ores of two different degrees of radioactivity in one run through the apparatus.

In such a tandem arrangement the sensitivity control 65 in the high activity ore electric circuit should be set so that the kicker would not operate as a result of random radiations striking the Geiger tube. This would result in only high grade ore being selected by this sorter.

The sensitivity control 65 of the second ore sorter should be set so that as a result of random radiations affecting the Geiger tube, the kicker will accidentally operate no more than about five to ten times per minute.

It is to be understood that these settings depend upon the grade of concentrate desired. If low activity ore is being mined, the setting would probably have to be higher than five to ten accidental kicks per minute.

I claim:

1. Apparatus for automatically sorting sized particles of radioactive ore according to degree of radioactivity comprising a feeding mechanism for arranging the particles singly in spaced apart relationship on a conveyor, a detector of radioactivity in close proximity to the conveyor and adapted to provide a series of voltage pulses indicative of the radioactivity of the particles carried by the conveyor, a first condenser, connection between said detector and said first condenser for charging said first condenser at a rate proportional to the rate of formation of said voltage pulses, resistor means for dissipating the charge of said first condenser, a sorter adapted upon energization to segregate a particle of ore from the remainder of the ore on the conveyor, a first electron tube having at least a cathode, a control grid and an anode; a connection from said control grid to said first condenser for applying voltage due to the charge of said first condenser to said control grid; a second electron tube having at least a cathode, a control grid and an anode and

adapted to be conducting only when the voltage on its control grid exceeds a predetermined magnitude; the control grid of said second tube being connected to the anode-cathode circuit of said first tube so as to obtain a voltage which varies in a positive direction for an increasing charge on said first condenser; and a relay operative by the current in the anode circuit of said second tube, said relay upon operation completing the connections between the sorter and a source of current for energizing it and making a connection between said first condenser and a source of voltage of predetermined magnitude and duration.

2. Apparatus as defined in claim 1 in which the second electron tube is a gaseous tube of the thyratron type.

3. Apparatus as defined in claim 1 in which the source of voltage of predetermined magnitude and duration for connection to the first condenser by the relay comprises a third electron tube having at least a cathode, a control grid and an anode, the voltage to be supplied to said first condenser being obtained across a first resistance in the cathode circuit of said third tube, said relay being arranged to connect in series the control grid of said third tube and a second condenser to a source of positive D. C. voltage, a second resistance connected from the control grid of said third tube to ground, said second condenser and said second resistance being selected so that upon operation of said relay said third tube remains conducting long enough for said first resistance to supply said voltage of a predetermined magnitude and duration.

4. Apparatus as defined in claim 3 in which the relay comprises a first set of switch contacts for applying to the first condenser the voltage across the resistance in the cathode circuit of the third electron tube; a second set of switch contacts for completing the series connection between the control grid of said third electron tube, said second condenser and the source of positive D. C. voltage; and at third set of switch contacts for connecting the sorter to its source of current; the sequence of operation of said first and second sets of contacts being such that the first set makes contact before the second and third sets.

CHRISTIAN M. LAPOINTE.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
2,063,485	Carris	Dec. 8, 1936
2,096,427	Gulliksen	Oct. 19, 1937

OTHER REFERENCES

Jesse: "Process Monitor, Mark 10, Model 20," U. S. Atomic Energy Commission document MDDC 194, August 17, 1946, 1 page, 1 blueprint. Technical Information Division, AEC. Oakridge, Tenn. (Copy in S. L.)

Miyazaki: Determination of Radioactivity with a Counter, Chemical Abstracts, vol. 41, p. 5011 (1947). Copy in Scientific Library.