Jan. 22, 1957 E. H. BICKLEY 2,778,497

BALL SORTER

Filed June 15, 1953 2 Sheets-Sheet 1

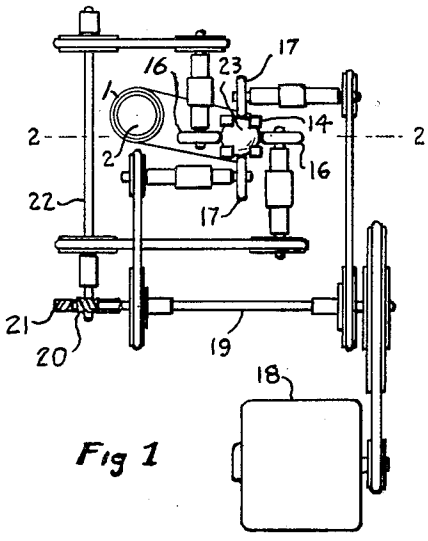


Fig 1

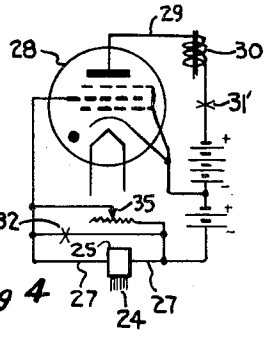


Fig 4

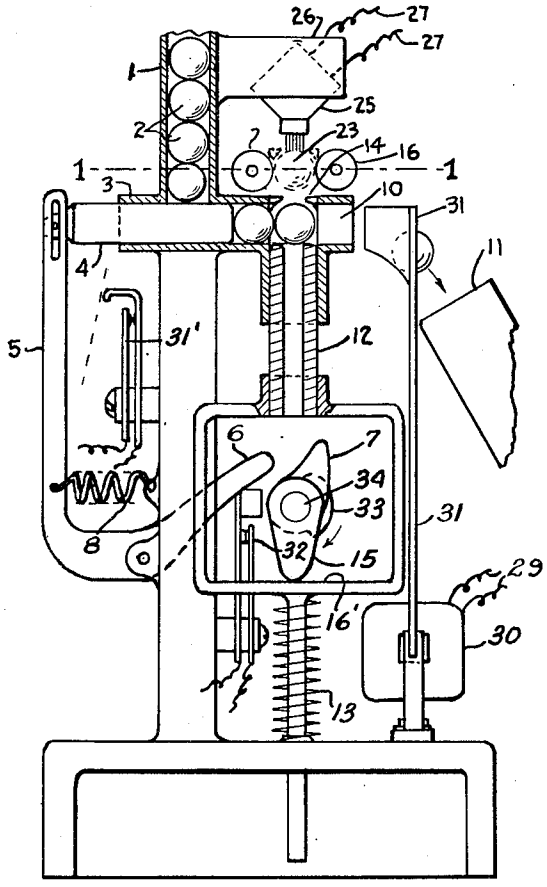


Fig 2

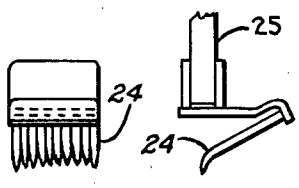


Fig 5 Fig 6

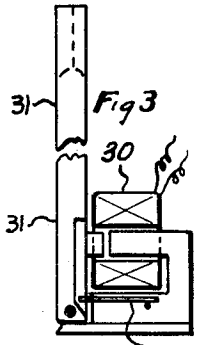


Fig 3

INVENTOR.

Everett H. Bickley

Jan. 22, 1957 E. H. BICKLEY 2,778,497

BALL SORTER

Filed June 15, 1953 2 Sheets-Sheet 2

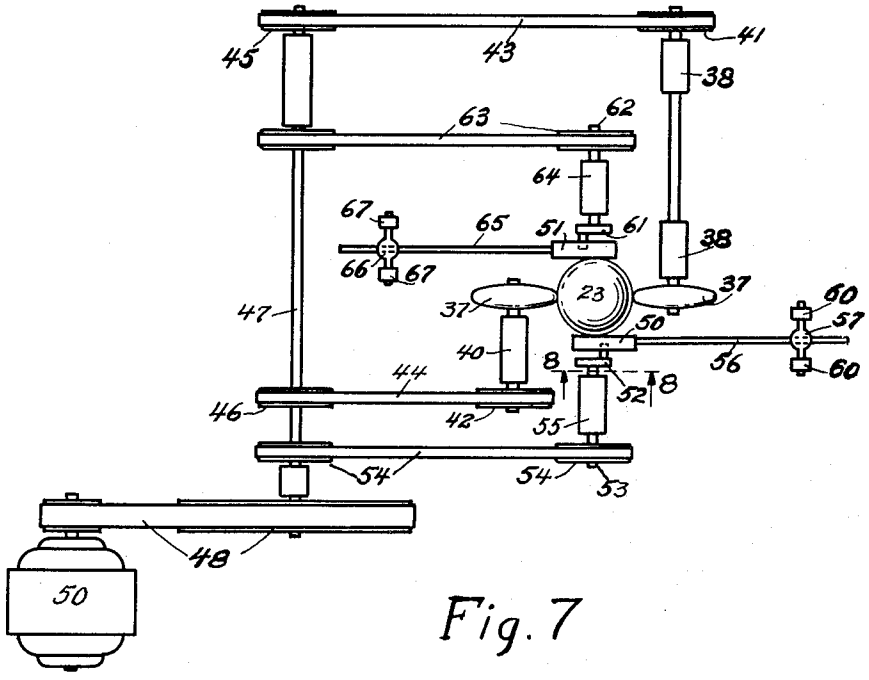


Fig. 7

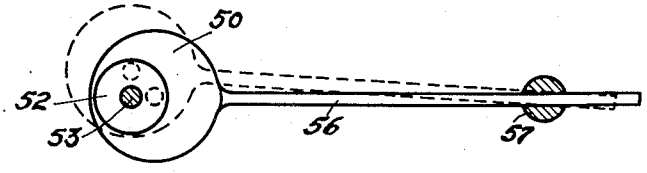


Fig. 8

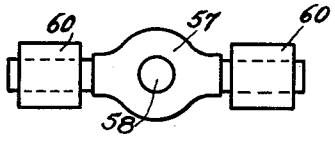


Fig. 9

INVENTOR.

Ernest H. Bickley

United States Patent Office

2,778,497

Patented Jan. 22, 1957

2,778,497

BALL SORTER

Everett H. Bickley, Narberth, Pa.

Application June 15, 1953, Serial No. 361,516

20 Claims. (Cl. 209—72)

The present invention relates generally to sorting apparatus capable of segregating articles of like characteristics from other articles of different characteristics, and more particularly to the sorting of imperfectly finished balls for bearings or other articles from perfectly finished balls or articles.

Balls for bearings are usually made of steel, which has been forged and rough ground, hardened and finished by fine grinding to a high polish. In the course of manufacture defects in materials and operations cause flaws in the balls. These flaws are fire cracks from hardening, sand or other particles imbedded in the steel, rough spots, soft spots, flats, and rust on the surface. The soft spots and flats are of a different texture than the balance of the surface of the ball, and thus accidental impact with something very sharp will produce a trouble making nick on the ball surface. All of these defects are detrimental to the life of a ball bearing, and it is important that these be segregated from the good balls, if satisfactory service is to be obtained from the finished bearing. The selection or sorting out of these defective balls has heretofore been done by girls and visual inspection. This is a difficult and tiresome operation.

An object of the invention is to sort out defective balls from good balls automatically and rapidly.

Another object is to provide an apparatus for detecting imperfections in the surface of antifriction members, whereby visual inspection by sorting operators is unnecessary.

A further object is to provide an electrical pick-up system for complete surface scanning of a ball to detect any imperfection however minute in combination with means for causing all imperfect balls to be separated from all balls having perfect surface finish, such scanning and separation taking place as balls to be inspected are fed successively to an inspection point.

In the accompanying drawings, Fig. 1 is a plan of one form of ball rotating mechanism embodying one part of the invention, such plan being viewed on line 1—1 of Fig. 2; Fig. 2 is an elevation along line 2—2 of Fig. 1, showing the feeding mechanism and selecting device with the timing switches and the scanning crystal; Fig. 3 shows the actuating magnet of the selector at right angles to the view shown in Fig. 2; Fig. 4 is a schematic diagram of one form of control circuit; Fig. 5 is a front elevation of the scanning brush; Fig. 6 is a side elevation of the scanning brush and associated crystal pick-up; Fig. 7 represents a plan of a modified form of ball-operating mechanism for association with the surface scanning pick-up; Fig. 8 is a section on line 8—8 of Fig. 7; and Fig. 9 is an enlarged detail of the slide-rock rod bearing.

The feeding mechanism consists of a vertical tube 1 into which the balls to be sorted 2 are placed either manually or from a self-feeding hopper not shown. At right angles to the vertical tube 1 at its lower extremity is provided another tube 3. Within this tube is a plunger 4 of approximately the same size as the balls being

sorted. This plunger 4 is caused to reciprocate by the lever 5, the finger 6 and the cam 7, and the spring 8. With each reciprocation, the plunger feeds one ball from the tube 1 into the tube 3 and pushes this ball against the previously fed ball 9 so that said ball 9 is ejected through the tube 10 where it falls by gravity into the receiver 11. This completes the feeding mechanism.

The scanning mechanism consists of a reciprocating plunger 12 which lifts the ball at the plunger end 12 to the scanning position at the end of the forward stroke of the plunger 4, under the action of the compressive spring 13. The plunger 12 is of square section, and has a cage like construction on its upper end 14. This cage retains the ball loosely, and when the plunger 12 is drawn down by the cam 15 engaging the surface 16', the ball is likewise drawn down with it to the discharge position through the tube 10. In Fig. 2 the plunger 4 is shown in the act of ejecting, but pulled back the diameter of a ball. While the ball is in the upper or scanning position it is between the four rubber rollers 16 and 17. These rubber rollers are moved at two different speeds. The rollers 16 are moved slowly, and the rollers 17 are rotated rapidly. There is provided a motor 18 belt-connected with pulleys to the shaft 19 which is belt-connected with pulleys to drive the rubber rollers 17. An eccentric worm 20 on the shaft 19 drives the worm wheel 21 on the shaft 22. This shaft drives the rubber rollers 16 by means of belts and pulleys, with a result that the ball 23 being scanned rotates rapidly on an axis parallel to the shaft 19, and moves slowly on an axis parallel to shaft 22. An inspection of the top of the ball 23 will reveal every portion of the surface of the ball in a very short time. This completes the scanning. Instead of rotating the shaft 22, it may be oscillated or otherwise moved intermittently or varied in speed, in step with rotations of shaft 19.

The selecting mechanism consists of an exploring brush 24 comprising a plurality of pointed wires or probes mounted on the corner of a piezotronic crystal 25. This crystal is cut in such a way as to generate a voltage when it is deflected at the corner carrying the exploring brush 24. The crystal 25 is mounted on an extension of the frame of the machine 26. As the ball being scanned 23 is rotated in contact with the sharpened wires 24 any roughness, sand hole, fire crack, rust, nick, or unpolished depression will increase the friction or catch in the points of the wire or wires and deflect the crystal 25 thereby generating a voltage in the wires 27. This voltage is applied to the control grid of a gas-filled or mercury vapor-filled thyratron or radio tube 28 thereby causing it to fire, and conduct through its plate circuit 29 and selector magnet 30 a current sufficient to operate the deflecting lever 31 and move it to a position immediately whereby the scanned ball on its discharge from the tube 10 will strike it and be deflected into the reject receiver associated with the chute 11. The radio tube 28 is provided with a switch 31' in the plate circuit which is normally closed, but when the lever 5 discharges a ball through the tube 10, at the end of its stroke it strikes the switch 31' thereby momentarily stopping the flow of current in the radio tube 28 allowing the control grid to regain control of the circuit, the deflecting lever 31 then returns to its normal inoperative position. Since the crystal 25 is very sensitive to vibration and it would fire the radio tube when the ball was raised into contacting position, and also might fire the ball when the ball was lowered, it is necessary that the crystal be rendered inoperative at all times except while the ball is being scanned properly by the brush 24. I therefore provide a switch 32 normally closed, but provided with a cam 33 on the camshaft 34 so adjusted that the switch will be opened only while conditions are most favorable

for proper scanning. The cam shaft 34 is driven from an electric motor or other drive not shown. The three timing cams 7, 15, and 33 are mounted on the same shaft. A circuit sensitivity control 35 is provided so that the degree of roughness on the balls being sorted can be set, at which the radio tube 28 will fire.

A weak spring 36 is provided to throw the lever 31 back to the normal position after the current has ceased to flow in the plate circuit of the tube 28. I do not restrict myself to the exact construction shown; the rubber rollers 17 may be positioned at other angles to the position shown, with equal effect, and other modifications may be made without departing from the spirit of my invention.

In operation, the balls to be inspected are fed by gravity to drop one at a time into the tube in front of the plunger 4, and, as the finger 6 is now released from its cam 7, the spring 8 shifts the plunger 4 to the right, as viewed in Fig. 2, and thus transfers the ball to the cage or holder on the upper end of the plunger 12. This latter is now released from the cam 15 and rises under the action of the spring 13 to position the ball 23 for working contact of the rollers 16 and 17. When so positioned, one pair of rollers 17 operating at a relatively high speed spins the ball about a horizontal axis while the pair of rollers 16 turn the ball about an axis at an angle to the other axis.

Thus, with the pick-up 24 in a position corresponding to a point on the "equator," the turning and axis-shifting of the ball passes a succession of spiral paths under the pick-up brush 24 with the result that the entire peripheral surface of the ball is quickly and systematically scanned by the pick-up. In case a dent, crack or other imperfection is intercepted by the pick-up, the crystal is deformed to generate a voltage in the circuit wires 27 and fire the tube 28. As a result, the plate circuit 29 energizes the magnet 30 to shift the lever 31 to a position where the defective ball will be guided into a reject box or receiver 11. Following the aforesaid scanning, the shaft-controlled cams, which are contoured and mounted for synchronized timing, operate first to lower the plunger 12 to return the ball into the tube 10; second, to release the plunger lever 5 to the spring 8 to advance the plunger 4 and pick-up the next ball which in moving to position ejects the ball just returned from scanning; and third, utilizing the swing of the lever 5 to open the switch 31' and stop the current flow in the tube 28 so that the circuit is again under grid control. In connection with the feeding of the balls by the plunger 4, it should be noted that it is desirable to provide means to prevent more than one ball from discharging at a time, and this may be done by magnetizing the plunger 4 so that the ball will be moved into the path of the plunger 12 and held until wiped off of the plunger 4 by the rising plunger 12.

In order to produce a bending force in the piezotronic crystal to provide a signal when an irregularity is encountered in the ball, it is necessary to press the brush probes against the ball with a certain amount of pressure. I have found that the greater the pressure, the greater the signal bending force generated, when an irregularity is encountered. There is also generated a friction bending force in the crystal due to the friction between the probes and the normal polished ball surface. The former is desirable and the second is undesirable. In order to accentuate the former and diminish or eliminate the latter I mount the probes so that their point of contact on the ball lies on the center plane of the crystal and then tilt the crystal and probes or move them forward parallelwise against the direction of motion of the ball surface until the "friction" force approximates zero. By this method the "signal" force may be greatly increased over other constructions. The multiple wire probe has the added advantages that it does not tend to catch and damage itself if a deep irregularity is encountered. After a definite amount of force is reached the wire flexes and it releases itself. The inertia of the individual wires is so slight that they respond readily to high speed and small irregularities.

In the form of the invention shown in Fig. 7, the ball operating mechanism comprises rubber rollers 37 mounted to diametrically span a ball 23 being scanned and frictionally engage such ball to turn it about a horizontal axis. The two rollers 37 are respectively journalled in bearings 38 and 40 and driven by pulleys 41 and 42 through the medium of belts 43 and 44, and pulleys 45 and 46 keyed to the main driven shaft 47. This shaft 47 is driven by a belt and pulley drive 48 from a motor 50.

For causing the ball 23 to move during its rotation by the rollers 37 and continually change the axis of rotation so that complete area scanning can take place, two disk friction pads 50 and 51 are mounted to contact the ball 23 at opposite sides and be driven eccentrically.

Eccentric motion is imparted to the pad 50 by a crank 52 driven by a shaft 53, which receives its motion by pulley and belt mechanism 54 from the main shaft 47. A suitable bearing 55 is provided for the shaft 53. The pad 50 is carried upon the end of a rod 56 which is arranged to follow the rise and fall movement by providing an oscillatable bearing member 57 having a transverse hole 58 through which the rod 56 passes to have free endwise sliding movement. The member 57 is journalled in suitable bearings 60. The pad 51 is similarly mounted for eccentric operation including like operating means, namely the crank 61, shaft 62, pulley and belt mechanism 63, to the main shaft 47, shaft bearing 64 and pad mounting rod 65 slidable and oscillatable through its mounting member 66 journalled in bearings 67.

Thus, with a ball 23 brought into scanning position by the mechanism shown in Fig. 2, the ball 23 will be turned about one axis by the pair of rollers 37, while simultaneously the oscillating contact pads 50 and 51 coact to turn the ball about a different axis to produce the succession of spirals necessary to complete surface scanning. While only two forms of the invention are shown by way of example, the ball control mechanism is not to be limited to that specifically shown and described, because broadly the invention is for progressive scanning of a ball which would comprehend using a single pair of rollers arranged to be displaced axially by reciprocation synchronized with the rotation of the ball.

Having thus described my invention, I claim:

1. A sorting apparatus for bearing balls, comprising means for feeding bad and good balls to an inspection point for scanning one at a time, an electrical pick-up means for scanning each ball by surface contact to detect an imperfection on said surface, means for rotating said balls while being scanned, means to discharge each ball after inspection by said scanning pick-up, and electrical means responsive to pick-up contact with an imperfection indicating a bad ball to vary said discharge means, whereby bad balls are sorted from good balls.

2. A sorting apparatus in accordance with claim 1 wherein said rotating means turns said ball about two axes.

3. A sorting apparatus in accordance with claim 2 wherein said rotating means simultaneously turns said ball at one speed about one axis and at another speed about a second axis.

4. A sorting apparatus in accordance with claim 1 wherein said electrical responsive means includes a thyratron.

5. A sorting apparatus in accordance with claim 1 wherein said pick-up is a crystal.

6. A sorting apparatus for bearing balls, comprising a holder for supporting a ball for surface scanning at an inspection point, a crystal pick-up mounted to contact said ball and respond to a surface imperfection on said ball, means to rotate said ball while in said holder for surface scanning by said pick-up, means to discharge an inspected ball from said holder, means controlling said discharge means to deliver a good ball to one receiver,

a circuit responsive to pick-up voltage caused by a surface imperfection on a ball, and means actuated by said circuit response to vary said control means to deliver the bad ball to a different receiver from the good ball receiver.

7. A sorting apparatus in accordance with claim 6 wherein said responsive circuit includes a grid controlled gas rectifier tube.

8. A sorting apparatus in accordance with claim 7 wherein a means is operated by said control discharge means for reducing the plate potential of said tube to zero to stop the flow of current and reset the tube.

9. A sorting apparatus in accordance with claim 6 wherein means are provided for rendering said crystal pick-up inoperative when not being scanned.

10. A sorting apparatus for bearing balls comprising two pairs of rollers positioned to frictionally contact opposite sides of a ball to be inspected, a cage holder for a ball, a plunger mounting said holder for alinement with the space between said rollers, a tube for guiding balls one at a time to said holder, a plunger for delivering each ball into said holder, means for operating both plungers in timed relation to deliver a ball to said holder and move said holder into said roller space for scanning, means for operating one pair of said rollers at one selected speed, means for operating the other pair of said rollers at different speeds, a crystal pick-up mounted for surface contact scanning of said ball to respond to an imperfection on said surface, means to lower said plunger holder after a ball scanning, means to discharge the ball from the lowered holder, means to guide the discharged ball in one direction, and electrical means responsive to voltage developed by pick-up contact with a ball surface imperfection for varying said guiding means to discharge in another direction, whereby bad balls are sorted from good balls.

11. A sorting apparatus for bearing surfaces, comprising a means for feeding good and bad surfaced bearings individually to a scanning point, an electrical pick-up means at said scanning point for scanning by surface contact to detect imperfections on said surface, means for progressively moving said bearing surface under said pick-up means to cover all area elements and means responsive to the output of said pick-up to discharge said bearings from said apparatus, whereby bad bearings are sorted from good bearings.

12. A sorting apparatus in accordance with claim 11 wherein said pick-up comprises a plurality of hook-shaped points contacting approximately axially of the crystal.

13. A sorting apparatus in accordance with claim 12, wherein the width of said pick-up points divided by the number of traces between any two points plus the distance between the scanning traces is equal to the progressive scanning pitch of the ball movement.

14. In a selection device comprising a feed, a scanner, and variable discharge, said discharge being actuated in accordance with irregularities in the surface of the articles being selected, a scanning pick-up comprising a plurality of individually resilient exploring probes mounted on a common holder, means for moving said probe and said articles respectively one to the other, and means for progressively altering the relative direction of the scanning trace to substantially cover all desired areas of said article.

15. In a selection device in accordance with claim 14, exploring probes mounted with their axes at an angle to the center plane of the crystal and their points approximately in the neutral plane of the crystal.

16. In a selection device in accordance with claim 15, the axis of the crystal and probe points leaning from the perpendicular sufficiently to compensate for normal surface friction between the ball and the probe points.

17. A sorting apparatus for sorting balls comprising feeding, scanning and selective discharging elements, said selective discharging element being controlled by said scanning element whereby all balls of like surface characteristics are brought together, said scanning element including a plurality of exploring probes for contacting the surface of said balls, ball rotating means, and progressive axis of rotation altering means, whereby said exploring probes follow an interlaced pattern of traces to substantially cover the entire ball surface.

18. A machine for sorting bearing balls, comprising means for feeding the balls to an inspection point, means for rotating each ball as positioned at said point, ball surface contacting means for detecting a surface imperfection on a positioned ball, and means responsive to operation of said contacting means by an imperfection for sorting the detected ball from perfect surfaced balls.

19. A machine for sorting bearing balls according to claim 18, wherein the ball rotating means turns the ball about two axes.

20. A machine for sorting bearing balls, comprising means for feeding the balls to an inspection point, ball surface contacting means for detecting a surface imperfection in a positioned ball, means progressively causing a variable relation between said contacting means and said ball, whereby all the surface of said ball is wiped by said scanning means, and means responsive to operation of said contacting means by an imperfection for sorting the detected ball from perfect surfaced balls.

References Cited in the file of this patent

UNITED STATES PATENTS

1,992,027	Green	Feb. 19, 1935
2,023,662	Blood	Dec. 10, 1935
2,051,695	Glacy	Aug. 18, 1936
2,593,958	Aller	Apr. 22, 1952
2,660,304	Box et al.	Nov. 24, 1953
2,701,055	Strom	Feb. 1, 1955
2,738,197	Stevens	Mar. 13, 1956