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EXAMINING SORTING SYSTEM WITH MULTIPLE REJECTION MEANS

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4 Sheets-Sheet 2

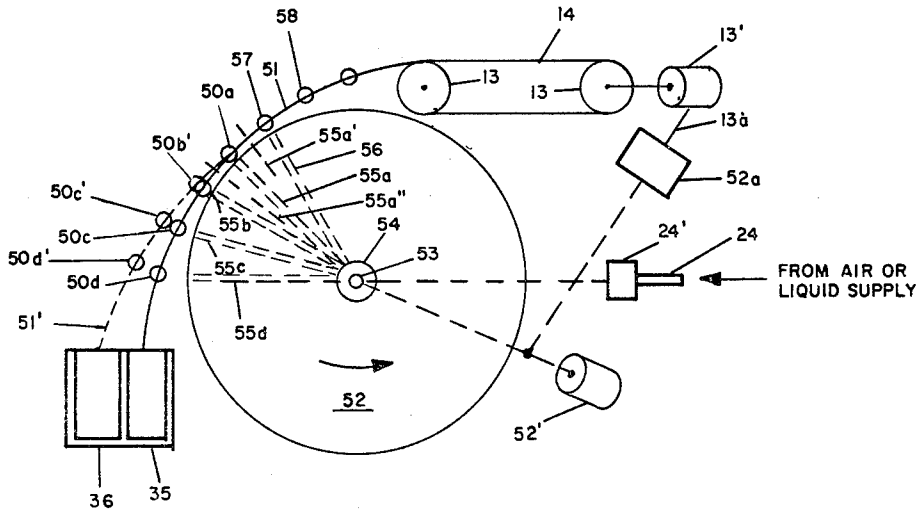


FIG. 6

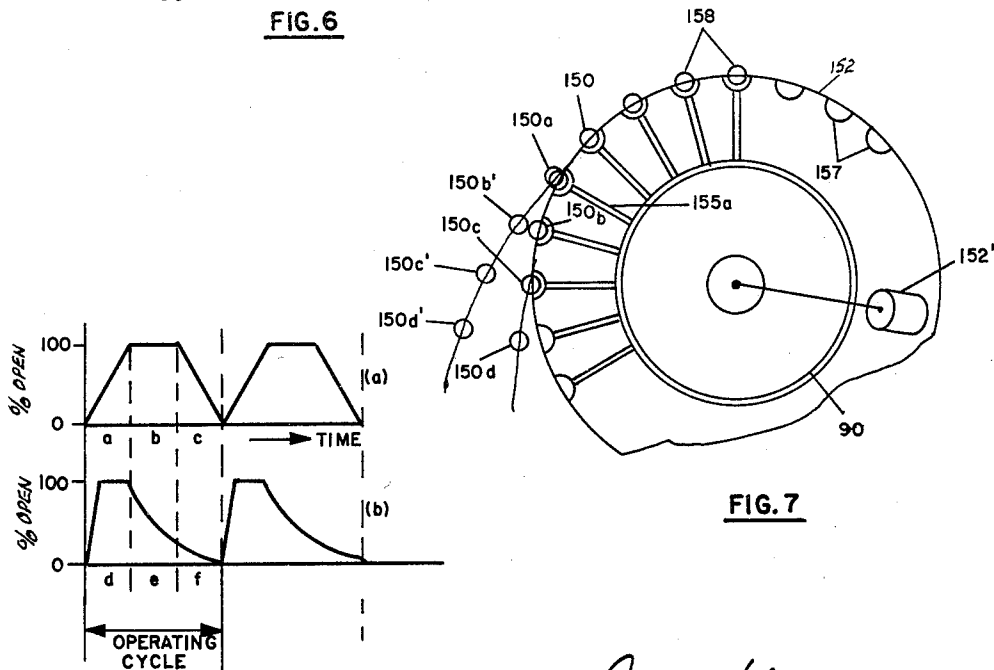


FIG. 7

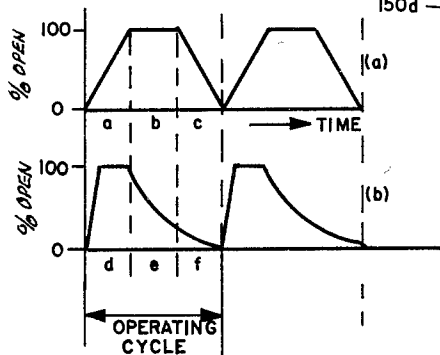


FIG. 4

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EXAMINING SORTING SYSTEM WITH MULTIPLE REJECTION MEANS

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ABSTRACT OF THE DISCLOSURE

In this examining sorting system with a single linear array of objects, high speed rejection is accomplished by the use of a plurality of rejectors each adapted to operate on an object at the rejection position. The minimum period of the cycle of operation is greater than the time interval between the passage of successive objects, so that successive rejectable objects are rejected by successive rejection means.

Two systems of selection of the sequence of operation of the plural rejectors are provided. The first system rotates the operation of each rejection means in sequence. The second system sends all signals to reject to a first rejector. If this first rejector is not in the course of its cycle of operation, it accepts the signal and operates to reject the required object. If the first rejector is within its operating cycle, and thus is not in condition to operate on a second object, the signal then goes to a second rejector, and so on, until a rejection means is found that is in condition to operate.

To obtain a long enough time of action of the rejection force, when the time between the passage of successive objects past the rejection point is small, this invention contemplates scanning or sweeping the rejection force in line with the object along its path. Successive operation of successive rejection means takes care of successive objects until the first rejection means completes its operating cycle and is ready to act on another object. To obtain rapid operation of a slow acting rejector it is contemplated to scan or sweep the rejection force across the path of the objects.

This rejection system can operate in a circular or a linear path, and can be electromechanically, pneumatic or hydraulic.

This invention is concerned with the sorting of objects. More particularly it is concerned with the rejection of specific ones of the objects in an array of objects which are being sorted. It is further concerned with increasing the effective speed of rejection of such objects, and thus the effective speed of sorting of such objects.

The sorting of granular materials such as grains, seeds, fruits, etc., is well known. Much of the art involves electro-optical inspection and concerns the particular kind of optical system and photo-electric sensor systems used to inspect the materials and to determine which object of an array of objects is to be rejected. This invention is not as much concerned with that part of a sorting system, as it is with particular apparatus and methods of removing or rejecting objects selected for rejection by the electro-optical portion of the system.

In most operating systems in use, today, a single column or array of objects, generally similar to each other, is directed in operating relation to an electro-optical system which examines the optical properties of the objects passing in the moving column and when an anomalous or defective object is observed, it sends a rejection signal to a rejection control means which controls a rejection means. Such rejection means is generally an air valve,

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which, after a predetermined time delay after the signal from the inspection means, opens and emits a jet or pulse of air which is timed to strike the selected object just when it comes opposite the rejector. This jet or pulse of air exerts a transverse force on the object causing it to be deflected sideways and to follow a new path, diverging from its original path, such that it is finally received in a container different from that into which the undeflected or unrejected objects are received.

Depending on the number of objects passing the rejector per unit of time, the time interval during which the anomalous selected object is in the range of the rejector pulse is quite small. Thus, the ejector must have very particular properties: (1) it must be capable of being controlled precisely in time of operation, and (2) it must be controllable precisely in duration of operation so that the pulse initiated for one object in the array will not continue, for example, to act on a succeeding object in the array.

These requirements have placed a serious limitation on the speed of sorting such that the time interval between the passing of successive objects must be greater than the time between successive possible operations of the rejection means.

It is therefore an object of this invention to provide an electro-optical sorting system in which the speed of operation of the system is not limited by the speed of action of an individual rejector.

Also, it will be clear that when the objects have considerable mass, and the time during which the air pulse can act is very small, the transverse force on the object is very small, perhaps insufficient to effectively move it out of its original path, unless the pressure and rate of flow of air in the pulse or jet is very high. This makes for large, slow-acting valves, and therefore defeats the purpose of speeding up the sorting process.

It is therefore another object of this invention to provide an electro-optical sorting system in which the time duration of action of the force of the air jet is lengthened without affecting adjacent objects, to the end that a much lower pressure and flow of air can be used to deflect an object of large mass.

It is also an important object of this invention to provide a rejection means which is slow-acting and can, in addition to being a pneumatic system, also be a hydraulic and/or mechanical system.

This invention provides these and other objects and advantages by scanning or moving the rejection means longitudinally, in a plane, which intersects the path of the object. The movement of the rejection means is timed so that its pulse or jet is directed to a single object for a considerably longer period of time, which may be 5 to 10 times, or more, the time interval provided by conventional systems. However, since a single rejector stays with a single object for a time interval which may be as long as the transit time past a fixed point of several objects, it is necessary to provide a plurality of rejectors, each of which scans a single object, but each of which scans a sequential object. By this means, the required speed of action of the rejector is further reduced in proportion to the number of rejectors, or conversely, the rate of throughput of objects through the system can be increased in proportion to the number of rejectors in use. The rate of throughput can be increased even further, in that the rejectors are not required to operate rapidly.

These and other novel uses, benefits and objectives of my invention will be more clearly described and understood in connection with the attached drawings, in which:

FIGURE 1 is a schematic illustration of one embodiment of my invention in which a plurality of control

means are sequentially activated to provide a high rate of rejector operation.

FIGURE 1a is a variation of FIGURE 1 in which the three rejection means are shown acting on the object in different planes.

FIGURES 2 and 3 show two methods by which a plurality of control means can be sequentially activated.

FIGURE 4 shows the time cycle of operation of a rejection control means.

FIGURES 5a, 5b, 5c, and 5d show schematic embodiments of a mechanical rejection system.

FIGURES 6 and 7 illustrate the principles of scanning the rejection force along the path of the object to gain a long-time application of the rejection force.

FIGURES 8 and 9 illustrate the principles of this invention in relation to a linear and a rotating system respectively.

FIGURES 10a, 10b, 10c and 10d illustrate the construction of pneumatic systems employing the principles of this invention.

Referring now to the drawings and in particular to FIGURE 1, I show schematically an examining sorting system in which a quantity of objects 10 are fed from a storage means 18 onto a feeder 17 and onto a moving belt 14. They are thrown off the belt 14 to follow a trajectory or first path 12, where an individual object 10 may occupy at successive intervals of time, successive positions 10d, 10c, 10b, 10a, etc. At some such position as 10d it is examined or scanned by a stationary electro-optical or other system 39 shown schematically as a lamp 34, and photo-electric sensor (PES) 31.

When the scanning means 39 finds an anomalous object which must be removed from the array before it falls into first receiving container 35, a signal is sent via line 30 to amplifier 29, switch 27 and to one of a plurality of valves 22 which control air supply 24 to an ejector orifice 20. When the signal is received, one of the valves opens and an air jet is delivered by orifice 20 to object 10a, causing it to be deflected to the side and to follow a divergent second path 11' into receiving second receptacle 36. The several valves can be connected into the same single orifice 20, or they can be connected to separate orifices, like conduits 20, mounted in vertical alignment, one under the other. Or they can be as shown in FIGURE 1a where the three valves are connected through separate orifices each of which impinges on the object 10a from a different direction. This permits rejection of a given object into any one of a plurality of paths all of which are considered to be a single second path and to lead to a single second receiving receptacle.

In normal operation, the objects can be on a belt, wheel or drum, or they can be in free fall in a single line, or in a plurality of parallel lines, forming a two-dimensional monolayer array, or sheet. For simplicity, consider only a single linear array. Normally when the velocity and spacing of the objects 10 in their path 11 is slow enough that an electromagnetic or similar valve 22 can be made to operate (that is, open, eject air, and close, and be ready for a second similar operation) within the time of transit of successive objects past orifice 20, then only one valve 22 is needed. However, when the time interval between successive objects becomes shorter than the operation time of the valve, a single valve will not be satisfactory.

Let us assume for example that the operating time for the valve is T and the time between transits of each object is t, then theoretically it will require $k=T/t$ valves to make the system work. However, when k becomes large, say 10 or more, it is not necessary to have 10 valves, for the following reason:

Assume that there are X% of potential rejects in the original mixture of objects, or $(100-X)=Y\%$ of good ones. On the average, the valve will have to operate $1/Y$ of the times that an object passes the ejector. The probability that two rejectable objects will occur in succession is $1/Y^2$, and so on, where $1/Y^n$ represents the prob-

ability that n rejectable objects will occur in succession. Let us assume that there are 1% of rejects. With three valves, the probability that four rejectable objects will occur in succession and that the fourth one will be missed, is one in one hundred million. Thus, it is not necessary to have a great many valves.

In FIGURE 1 I show three valves 22a, 22b, 22c connected in parallel to the air supply 24 and feeding through a common orifice or nozzle 20 through pipes 21. The individual valves are selected by means of switching 26, 27. FIGURE 2 shows schematically one way in which the individual valves may be selected, that is, in sequence. The signal comes by way of line 28 to amplifier 47 to operating coil 48. At the same time the signal goes to contact arm 27 and to one of the plurality of contacts 26 and thence to a corresponding one of the valve operating coils 40. On successive signals the stepping switch 27 is moved to successive contacts 26, so that a different valve is used on successive rejections. While I have shown the electromechanical stepping switch, there are today on the market many well known electronic equivalents of this device, which I mean to include in the class of switching systems that might be used in my invention.

In FIGURE 3 I show a different system of selection. In this system a relay 43 is placed in parallel with each of the valve coils 40, or conversely each of the valve mechanisms carries a contact similar to that of the relays. The relays have an arm 44, a back contact 45 and a make contact 46. When the signal comes in on line 28 it goes to arm 44c, to back contact 45c thence to relay coil 43c and to valve 40c. Valve 40c operates and relay coil 43c pulls in and arm 44c connects to contact 46c and thence to arm 44b, contact 45b and thence to relay 43b and valve 40b. The relay 43c is timed to open (and connect arm 44c to back contact 45c) after valve 40c becomes ready for its next operation. If the next signal on line 28 comes before relay 43c opens, the signal is switched to relay 43b and valve 40b, and the controls are switched by arm 44b to contact 46b, to arm 44a contact 45a, and thence to relay 43a and valve 40a. If the third signal comes before relay 43c opens, the signal will be switched to relay 43a and valve 40a, and so on. In the system of FIGURE 3, the valve 40c always takes the signal and operates first, the other valves only operate if successive signals occur, while valve 40c is within its operating cycle and before it can return to operating condition. The major load is on valve 40c and less load and fewer requirements are placed on the other valves which can be of lesser operating qualifications. On the other hand, in the circuit of FIGURE 2, each of the valves gets the same service and must be of equal quality and capability.

In the cycle of operation of a valve as shown in FIGURE 4a there is a total cycle time made up of an opening time a, as required to fully open, a remain open time b, and a close time c, during which the valve closes. The total operating cycle is the sum of $a+b+c$. In the systems of FIGURES 2 and 3, the remain open time b, and the open and close times a and c, must likewise be as short as possible so that the jet of air does not affect adjacent objects leading and following the desired object.

From FIGURE 4a it is clear that if there is to be no interference between the operation of the rejector and succeeding objects, the time spacing between objects must be equal to or greater than the operating cycle of the rejector. However, consider FIGURE 4b. Here the operating cycle is the same, but the time of major jet opening is effectively (d), which is (for this assumed example) about one-third of the duration of the operating cycle. Thus, while a first rejector is operating during period (d), a second one can start a third of a cycle later (e), and a third one still later (f). Thus the time interval between successive objects can be cut to one-third of the operating cycle. Also, as is described elsewhere in this specification, it is possible to scan or sweep the rejection force or air jet across the path of the array of objects. In this way, the actual contact of the air jet with a single

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object is only a fraction of the duration of the complete operating cycle, depending on the speed of sweep or scan. Thus, with multiple rejectors, it is possible to have the interval between the passage of objects in the array as small a fraction of the operating cycle as desired.

I show in FIGURE 6 an embodiment of my invention in which a multiplicity of valves are used in which the precision of timing of the individual valves is reduced, and in which the valves remain open for a time larger than t , without affecting adjacent objects.

I do this by causing the rejection force means to move (or scan or sweep) in a path substantially parallel to the path of the object, or at least along a path in a plane passing through the path of the object. The movement of the rejection force means is timed to be synchronous with the movement of the object. A force exerted on the object by the force means continues to be exerted on the object over a considerable portion of its path. Thus a relatively weak force can be exerted for a relatively long time to exert a large impulse on the object, causing a large change in momentum.

In FIGURE 6 the belt 14 is shown schematically throwing the objects off along path 51. Consider the successive positions 50a-50d of object 50. A rotating means 52 which may be a disc, for example, is driven by motor means 52' at such a speed that a radius element 55a on the disc remains pointed toward object 50 while it travels between positions 50a-50d. If a jet of air from line 24, valve 24' and passage 55a is directed against object 50 at position 50a, the force can be applied continuously until the object reaches position 50d. The object under the continuing force of the air jet will be deflected sideways and will follow the second path 51' and instead of falling into first receiving container 35, it is deflected into second receiving container 36. Because of the long duration of the air jet action, larger masses can be deflected by the same air jet, or conversely, weaker jets of less pressure can be used. Also, because the long duration of the jet action, it is not too critical whether the valve opens at 55a' or 55a''. The jet is synchronized by the jet scanner 52 to the motion of objects along path 51.

One way of synchronizing the motion of the jets to the motion of the objects is, of course, to place them on the same moving system. This is shown schematically in FIGURE 7 in which the wheel, disc, or drum 152 is shown with individual pockets or depressions 157 into which individual objects 158 can be placed. This sort of system, in which the objects to be scanned are placed in prepared positions on a moving system are well known in the art, and the particular details of how such a carrier is constructed is not important in this invention and will not be discussed further. So, if each depression 157 holds an object 158 and a jet conduit 155 leads from a common hub area 90 to each of the depressions, proper control of air to a given conduit can provide a direct force against an individual object for as long a period as desired, while the carrier 152 is moving.

Of course, as shown in FIGURE 6, if the spacing between individual objects on the belt is reasonably the same, they will be approximately equally spaced in the path 51 and control of the speed of the carrier 52 to the speed of the belt will permit synchronization of the air jets and the objects. This is simple gearing and drives 13a and gear means 52a between motors 13' and 52' will permit this synchronization.

While I have shown rotating systems in FIGURES 6 and 7 it is possible to provide a similar type of control in a linear system. In FIGURE 8 I show schematically a linear carrier 95 which may be a table or belt moving with a velocity v . As part of this system, a separate parallel system, is a carrier 101 moving parallel to 95 at the same velocity v . A given force means 99, shown opposite object 96, is shown in the a , b and c positions. The force means 99 begins to act on object 96 in posi-

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tion 96a, continues to position b where 96 is displaced sideways to position 96b, and eventually to position 96c, where it is off the carrier 95 and follows a separate path. This linear type of system will be discussed more fully in connection with FIGURE 5.

It will be clear that while I show in FIGURE 7 a wheel or drum rotating about a horizontal axis, it is possible also to provide a horizontal table (with a vertical axis of rotation) with at least one circular row of depressions such as 107, 108, 109, etc. of FIGURE 9. These might be on a circle 111 close to the edge 110 of the table 105. Additional rows of depressions to hold objects 113, 114, etc. may be provided with a corresponding row 117 of openings 115, 116 through the table 105. These openings are large enough to pass the objects. Thus a force against an object such as 113 in row 112, for example, will move the object radially outward as the table turns, causing it to fall through a corresponding opening 115 in circle 117.

All of these systems shown in FIGURES 6, 7, 8 and 9 require precise control of the air jets as the carrier revolves and I will discuss this feature. In FIGURES 10a, 10b, 10c, 10d, I show schematically a stationary circular hub 122, and a closely fitting annular ring 120 rotating with as small a radial gap 123 as possible. The outer ring 120 corresponds to the wheel 52 and has radial conduits 121. As shown in FIGURES 10a and 10c these lead inward from the radial portion 121 via transverse portions 127 and radial portions 128, so that an individual jet conduit 121a connects to a cavity portion 124a, in the inner hub. This is fed with air (for example) via pipe 125a. As the outer ring 120 turns, the pipe 121 is alternately connected through cavity 124 to the air supply 125 and alternately cut off by the narrow gap 123, which presumably will pass very little air.

As the outer ring 120 turns farther, adjacent jet conduits 121b, 121c, 121d, etc. will come into connection with their cavities 124 and air supplies 125, etc. The conduits 121a, 121b, 121c, 121d, etc. are tangentially spaced equal to the spacing of the objects, and as they come into the angular position of the cavity portions 124, they too will deliver jets of air if the lines 125 have air pressure, that is, if their valves 129 are open. The valves 129 are controlled by means illustrated in FIGURE 2 or 3, so that if the particular object in line with jet pipe 121b, for example, is to be rejected, the valve 129b will open, cavity 124b will be pressurized and when pipe 128b is exposed to the air pressure in 124b, air will flow through 128b, 127b and 121b, forming the jet that will displace that object.

It will be clear that the valve 129b can stay open during the time that ring 120 turns through an angle d , which for the case of 4 valves can be at least 4 times the angle between adjacent objects.

The stationary hub 122 may have one set of cavities 124, one for each valve. In that case the outer ring 120 has jet conduits spaced apart by the spacing between objects. The sequence of jet conduits 121a, 121b, 121c, 121d, etc. is repeated around the ring to repeatedly connect the 4 valves to successive jet conduits.

It is also possible to have more than one cavity, such as 124 and 224 shown. Then, by opening valve 229 instead of 129, the rejection of the object is delayed and it is caused to follow a different rejection path.

I remarked earlier, that the angle d is at least equal to the number of valves times the angular spacing of objects. If the valve operation is timed to be complete in the time of transit of angle d , then the first valve will be ready after the other 3 have operated and angle d should be equal to 4 times the angle of one object spacing. However, if one is satisfied that the probability of having 5 or more defective objects in sequence is low enough that it is not necessary to have the first valve ready to operate in the 5th sequence, then the angle d can be increased to any desired value,

with a consequent greater deflecting power of the rejection system, or conversely the spacing between objects can be reduced, thus increasing the throughput.

In all of the embodiments shown so far, I have shown a pneumatic system, calling for a compressed air source, air control valves and air jets. It will be clear that when I speak of air as the control fluid, I mean any compressed gas. However, since air is the cheapest it will undoubtedly be most desirable to use compressed air to control the ejection of objects.

For heavy objects where a greater force is required to displace them from their path, a jet of liquid such as water may be used. This might be advantageously backed up with the compressed air for example, so as to maintain hydraulic pressure, or by a compressor on-line, as is well known in the art. In this description and in the claims, when I use the words fluid, air or air jet, I mean to include also the use of other gases, and also the use of liquids, such as water.

It will be clear also that since the time duration of the action of the force means is greater, it is possible to use mechanical means, as well as electrostatic or electromagnetic means to apply the force to the object. An example of a mechanical system is shown in FIGURES 5a and 5b.

A carrier means 135 is translated longitudinally in the direction 150 by means not shown but well known in the art. On this carrier are a plurality of spaced depressions 137 of which only one is shown for convenience. In these depressions are objects to be scanned and accepted or rejected. One object 136 is shown. A push rod 139 is mounted in frame 138 which is part of the carrier 135. This push rod 139 is opposed by spring 139' and pushed to the extreme position against roller 141 and pushing surface 140. The roller 141 is carried on arm 142 which is hinged at pin 144 to bracket 143 fastened to the carrier. As shown in FIGURE 5b, the arm 142 is flexible and when the arm is attracted by electromagnet 148 with current applied to coil 149, the arm assumes dotted position 142' and roller 141 assumes position 141' where it is in the plane of the cam 145. The cam 145 is stationary, while the arm, roller and push rod move with the carrier. Thus as the carrier 135 moves to the right from the position shown, if there is no current applied to coil 149, the roller 141 slides past the cam 145 and nothing happens. On the other hand, if, while the carrier is moving to the right a current is applied to the coil 149, the roller is deflected to a position over the cam and as the roller progresses into the zone 146, it rolls up the cam surface, pushing the push rod which moves transversely and pushes the object transversely until it reaches the dotted position 136' and falls off the edge of the carrier. Once the roller starts running along the cam, the pressure between the cam and the push rod spring prevents arm 42 from springing back from position 142' to position 142 until the roller passes zone 147 on the cam. Then the pressure is removed and the arm 142 springs back out of line with the cam.

Each successive depression in the carrier contains an object with its push rod roller arm and roller. As they successively come into the position shown, a signal current to coil 149 (the magnet is fixed in relation to the cam) or no signal, determines whether that particular object is to be rejected or not rejected. The rejection force lasts for as long as the roller takes to pass zone 146. The rejection force is controlled by a low power signal to the coil 149. This takes little current since there is no load on the arm and roller at the time it is pulled sideways. Once the arm is pulled over and the roller is running on the cam, the magnet current can be reduced to zero. Thus a single magnet fixed in position relative to the cam (which acts as a relay or valve), can be used to control the rejection of all objects.

By making the rate of rise of the cam 145 in zone 146 low, the rate of motion of the push rod can be made as slow as desired, which is a desirable property in a

mechanical system. However, if the sorting is to be rapid, that is, if there is to be a high throughput, there must be a high velocity in the direction 150, and the action of magnet 148, 149 will then be more rapid.

It is possible to make the coil 149 of the magnet in two parts. One part is energized with a constant adjustable DC current, while the other part comes from the amplifier, in the form of a pulse. The DC current is not enough to pull the arm over to the side where the roller contacts the cam. However, the sum of the DC and the pulse of current is enough to pull the arm over, and the DC component is sufficient to hold the arm over once the pulse has been applied and the arm has been pulled over. If desired, the DC part can be by means of a permanent magnet. Thus, the pulse acts as a trigger, aiding the permanent magnet to pull the arm over, where the permanent magnet holds it in position so that the roller will contact the cam. The permanent magnet then becomes part of the individual arms-force means, while the pulse magnet is a single control means which is made to operate with each force means that comes by. If a permanent magnet is used to hold the arm in line with the cam, then a suitable guide or cam can be used to release the arm from the hold of the permanent magnet after the force means has passed the cam 145, as would be well known in the art.

If desired, the magnet can be part of the carrier, one for each arm or each object, and the coils can be switched sequentially as they approach the cam 145. This permits a slower acting magnetic system, but of course requires many more magnets and controls.

In FIGURE 5b I show a small hydraulic or pneumatic cylinder 157 fed by air line 158 from a control valve. The piston 156 and piston rod 155 are adapted to push on arm 142 to position the roller 141 over the cam 145. As in the use of the magnetic arm actuator, of FIGURE 5b, the pneumatic actuator of FIGURE 5b can be provided at each object location, in which case the actuator can be slow acting, or a single actuator can be provided which will selectively move any desired roller over the cam to bring into action the cam, push rod and rejection means.

In FIGURE 5d I show how the push rod 139 can be used to control an air valve 161 in air line 160. The valve 162 is seated under pressure of spring 167, but is lifted when the roller 141 rides up the cam 145. The opening of valve 162 permits fluid from line 160 to flow through nozzle 165 as a jet 166 to blow the object 136 out of seat or depression 137 in carrier 135. The use of a fluid valve with its force multiplication permits the use of a lower rise cam and shorter stroke push rod and therefore faster acting mechanism. Since the force to be exerted by the roller 141 and arm 142, is smaller, they can be smaller and lighter and thus a smaller and faster acting magnet system or pneumatic system can be used to control the position of arm 142 and roller 141.

Comparing FIGURE 5 with FIGURE 10, it will be seen that the cam 145 of FIGURE 5 corresponds to the cavity 124. As in the case of FIGURE 10 where a plurality of such cavities are provided, each under the control of a separate valve 125, it is possible in FIGURE 5 to have a plurality of cams, on separate parallel alignments. Adjacent rejection push rod assemblies 138, 139, 140 would be in alignment with adjacent objects and have their rollers 141 in alignment with adjacent cams, and have separate operating magnets. Thus a plurality of operating magnets would control the rejection of adjacent objects as in the case of a plurality of valves in FIGURE 10, controlling the rejection of adjacent objects.

While I have shown in FIGURE 5 a carrier which operates in a linear manner, it will be clear to one skilled in the art that the principles of the embodiments of FIGURE 5 can be applied equally well to a rotary system as to the linear system. The important condition is that there be a moving carrier and a fixed cam, and a rapidly acting means to tie the cam to the carrier. In FIGURE 5 this means is the roller 141, arm 142 and push rod 139. These

must be fast acting only if a single actuator coil 149 or piston rod 155 is used to determine whether the cam is to be connected to the carrier (that is, whether the object is to be rejected), or not. Of course, other means to tie the rejection force to the cam can be used as might be devised by one skilled in the art.

Assume that the period of the cycle of operation of the plural rejectors is (as indicated above) T and the time between successive passages of objects in the path is t . Assume further, for convenience of discussion, that $T/t=3$, and that there are three rejectors, all acting at the same rejection point in the path. It is necessary to scan the rejection force, otherwise the operation of one rejector may also cause the rejection of the object preceding and following the object to be rejected.

As indicated in FIGURES 6 and 10 there is considerable advantage in scanning the rejection force along the path of the object, since this permits application of the rejection force to the object during the complete operating cycle of the rejector. However, it is possible to scan the rejector across the object path instead of along the object path. This permits making the time of action of the rejection force as short as desired (by making the speed of scan or sweep as rapid as desired) irrespective of the length of the operating cycle of the rejector.

Such a transverse scan or sweep can be provided by the apparatus of FIGURE 10 simply by changing the plane of rotation to be transverse to the path of the objects. This is shown schematically in FIGURE 10d. Successive objects in the array would be acted upon by successive rejectors as in the scan parallel to the path. Although the preferable plane of scan across the array is substantially perpendicular, it is possible to get satisfactory results by varying from the 90 degree angle to possibly 90 degrees plus or minus 45 degrees.

In the system of FIGURE 10 where successive rejector nozzles 121 spaced along the ring 120 are directed to different cavities 124 in the central hub 122 and to valves 129, the method of switching of the valves is different from those shown in FIGURES 2 and 3. The switching can be by means of a commutator 200, FIGURE 10d, made up of a plurality of segments 201 equal in number to the number of orifices 121 in the ring 120. A single contact brush 202 connects the control means to the commutator segments and sequential segments are connected to sequential valves. For example, segments 1, 5, 9 etc. would be connected to valve #1, segments 2, 6, 10 etc. to valve #2 and so on. In this system the sequence of operation of the valves is in accordance with the sequence of objects in the array. Assuming $T/t=4$, and that there are four valves, if every fourth object is to be rejected, only one rejector would be used.

While I have illustrated my invention by a number of embodiments, it will be clear that there are a large number of variations and combination of embodiments that might be conceived by one skilled in the art. For example, if, with a rapid throughput of objects a longer time is required to optically scan the objects, the optical means can be scanned along the path of the objects and so on.

I claim:

1. In a sorting apparatus system in which a moving array of objects is forced to follow a predetermined first path leading to a first collecting container, an inspection means is provided to inspect each of said objects, and having control means responsive to said inspection means to cause electrophysical rejection means to operate at a pre-selected rejection point in said path to remove one object of said array of objects from said path, and to cause said object to follow a single second path leading to a single second collecting container, the improvement comprising, a plurality of electrophysical rejection means each adapted to operate separately upon the same selected object in said path to effect its removal from said path, and to cause said object to follow said single second path, and

selection means responsive to said control means to select a single one of said plurality of rejection means to operation on said selected object.

2. Apparatus as in claim 1 in which each of said plurality of rejection means operates in the same rejection plane to reject said objects, said first path lying in said rejection plane.

3. Apparatus as in claim 1 in which each of said plurality of rejection means operates in a different rejection plane to reject said object, said first path lying in each of said rejection planes.

4. Apparatus as in claim 1 in which said selection means includes means to select each of said plurality of rejection means in sequence.

5. Apparatus as in claim 4 including stepping switch means adapted at each control operation to step to a new position of said stepping switch means to connect said control means to a different rejection means.

6. Apparatus as in claim 1 in which said control means includes means to control said rejection means to operate in a predetermined sequence and said selection means includes means to select for operation the first one in said sequence which is in condition to operate to reject said object.

7. Apparatus as in claim 6 in which said selection means includes switch means which connects said control means to a succeeding rejection means in said sequence during the time that a preceding rejection means in said sequence is in its operating cycle.

8. Apparatus as in claim 1 including, first rejection means, second rejection means, selection means to connect said control means to said first rejection means, and switch means responsive to the operation of said first rejection means to switch said control means to said second rejection means during the time that the said first rejection means is in its operating cycle.

9. Apparatus as in claim 1 in which said selection means includes switch means which connects said control means sequentially to each of said plural rejection means in synchronism with the passage of individual objects in said array past said rejection point.

10. Apparatus as in claim 1 in which said electrophysical rejection means comprise fluid control means.

11. Apparatus as in claim 10 in which said fluid control means is pneumatic.

12. Apparatus as in claim 10 in which said fluid control means is hydraulic.

13. Apparatus as in claim 1 in which said electrophysical rejection means comprise electromechanical means.

14. Apparatus as in claim 1 in which each of said plurality of rejection means operates on said object at the same rejection point in said first path.

15. Apparatus as in claim 1 in which each of said plurality of rejection means operates on said object at a different rejection point in said first path.

16. In a sorting apparatus system in which a selected object in an array of objects moving along a predetermined first path is deflected from said first path by a rejection force applied to said object at a rejection point in said first path, causing said object to follow a path diverging from said first path, the improvement comprising first drive means to force said object to move along said first path at a predetermined velocity, control means including rejection force application means adapted to apply a rejection force to said object at said rejection point, second drive means to force said force application means to move along a second path at a predetermined velocity, the plane of said second path passing through said rejection point, and the time duration of action of said rejection force application means being greater than the time between the passage past a fixed point, of successive objects in said first path.

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17. Apparatus as in claim 16 in which said second path and said first path are both in the same plane, whereby said rejection means can act on a selected one of said objects for a full rejection cycle of operation over a substantial portion of the path of said object.

18. Apparatus as in claim 16 in which the plane of said second path is at an angle to said first path, whereby the rejection force of said rejection means can act on a selected one of said objects for a predetermined fraction of the rejection cycle of operation of said rejection means.

19. Apparatus as in claim 16 in which a plurality of rejection means are provided, each adapted to scan a force application means along said second path, and each is adapted to be applied selectively to a single object.

20. Apparatus as in claim 16 in which said first path and said second path are linked together mechanically.

21. Apparatus as in claim 20 in which said array of objects and said force application means are carried on the same movable means, whereby said objects and said force application means remain in substantially fixed geometric relation.

22. Apparatus as in claim 21 in which said force application means comprises mechanical means adapted to be moved substantially transversely to said first path by cam means moving relatively to said objects.

23. Apparatus as in claim 21 in which said force application means comprises fluid means controlled by cam means moving relatively to said objects.

24. Apparatus as in claim 16 in which said first path comprises a trajectory in free flight through space.

25. Apparatus as in claim 24 in which said first path comprises a curved trajectory in space and said second path comprises a circular path substantially parallel to a portion of said first path.

26. Apparatus as in claim 16 including means to control the time of application of said force, whereby said force can be applied to said object at different points in said first path, whereby said object can be forced to follow one of a plurality of paths diverging from said first path.

27. Apparatus as in claim 16 including means to control the time duration of application of said force, whereby said object can be forced to follow one of a plurality of paths diverging from said first path.

28. The method of operating a sorting system in which

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a moving array of objects is constrained to follow a first path, an inspection means inspects each of said objects and control means responsive to said inspection means including selection means controls the operation of one of a plurality of rejection means each of which is adapted to reject a specific object from said moving array in said first path and to cause said specific object to follow a single second path, comprising the steps of,

selecting one object in said array of objects to be rejected,

selecting one of said plurality of rejection means to perform said rejection,

sending the reject signal from said control means to said selected one of said plurality of rejection means, and

applying said selected rejection means to said selected object.

29. The method as in claim 28 including the steps of, examining the condition of a first rejection means to determine if it is within its cycle of operation,

if said first rejection means is within its cycle of operation, examining a second rejection means to determine if it is within its cycle of operation, and

if said second rejection means is not within its cycle of operation, applying said rejection signal to said second rejection means.

30. The method as in claim 28 including the steps of sending the first rejection signal from said control means to a first rejection means,

sending the second rejection signal from said control means to a second rejection means, and

sending the *n*th rejection signal from said control means back to said first rejection means.

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