SILVERWARE SORTING AND

ORIENTING SYSTEM

By

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SILVERWARE SORTING AND

ORIENTING SYSTEM

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Finally, I would like to give my special respects and appreciation to my family and friends for their indispensable support, love and encouragement over the years and would like to dedicate this work to my parents Sujatha R. Peddi, Ravi N. Peddi, and my brother Pranav Kumar R. Peddi.

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CHAPTER 1

INTRODUCTION

Automation is the art or technique of automatically controlling, and operating manufacturing or similar processes, taking the place of human observation, effort and decision. Automation offers reduced operating costs, improved efficiencies, and increased productivity, by replacing human operators, often working in difficult environments in tedious operations.

In this study, we consider automation of commercial dish-washing operations. This was motivated by such operations in a private 700 bed hospital in the mid-western U.S., which operates 3 two-hour dish-washing shifts everyday, each processing up to 600 trays of dishes (Johnson, 1993; Russel, 1994; Hashimoto, 1995; Yeri, 2003; Nagaraj, 2003). Each tray typically consists up to four silverware pieces, amounting to 2,400 pieces per shift, and hence 7,200 pieces per day. Identification, inspection, sorting and orientation of these pieces after washing is a tedious and labor-intensive process, in a hot and humid environment, providing an opportunity for cost effective automation. While this description of need seems straightforward, solving the problem is difficult. Carefully reviewing the work done by others specifically addressing the problem of automatic sorting and orientation of silverware, we located a number of patents.

1.1 Patent Search

A search of U.S. Patents through 1996 was initially conducted by Shen (1997). She found that while there were 13 U.S. Patents dealing with silverware sorting filed prior to and including 1996, none of them had been commercialized, and that there appeared to be substantial room for improvement. In the work herein, a search was conducted for U.S. Patents filed after 1996, using the keywords "silverware sorting", "sorting and flatware", and U.S. Patent Classification No. 209/926 (CCL/209/926, i.e. the search string CCL/[class]/[subclass], which means that we are looking for patents with "Current US, Classification" (CCL) of class "Classifying, Separating, and Assorting Solids" (209), with subclass "Silverware Sorter" (926)). After preliminary screening of patents produced from the search, 5 relevant U.S. Patents were located, in which there were three different methods to sort and orient the silverware, while the other two patents were extensions of prior patents. The summaries of these patents are presented in the order of the issue time of the patent.

U.S. Patent 5,655,663 "Self-separating flatware and method for sorting same", Aug. 12, 1997.

Inventors: **Spradlin; Lyndon D.** (9N176 Rte. 59, Elgin, IL 60120)

Appl. No.: **498680**

Filed: **July 3, 1995.**

Abstract

Flatware that can be quickly and easily sorted when placed in a liquid solution, the flatware includes spoons, forks and knives. The spoons have a generally uniform buoyancy so as to float at a first level in the liquid solution, the forks have a generally uniform buoyancy so as to float at a second level in the liquid solution, and the knives have a generally uniform buoyancy so as to float at a third level in the liquid solution. The flatware floats at different levels in the liquid solution which provides the separation of the spoons, forks and knives in the liquid solution and enables the retrieval of the separated flatware in a sorted fashion.

19 Claims, 2 Drawing Sheets

U.S. Patent 5,931,307 "Self separating flatware and method for sorting same", Aug. 3, 1999.

Inventors: **Spradlin; Lyndon D.** (9N176 Rte. 59, Elgin, IL 60120)

Appl. No.: **814079**

Filed: **March 10, 1997**

Abstract

Flatware that can be quickly and easily sorted when placed in a liquid solution, the flatware encompasses three classes, spoons, forks and knives. The spoons have a generally uniform buoyancy so as to float at a first level in the liquid solution, the forks have a generally uniform buoyancy so as to float at a second level in the liquid solution, and the knives have a generally uniform buoyancy so as to float at a third level in the liquid solution. The flatware floats at different levels in the liquid solution which provides the separation of the spoons, forks and knives in the liquid solution and enables the retrieval of the separated flatware in a sorted fashion. An additional method of sorting and removing the flatware from the liquid solution includes mixing in a prescribed amount of salt solution to the liquid solution and/or raising the temperature of the liquid solution a predetermined amount. The change in specific gravity of the liquid solution and/or the rise in temperature would enable one to make each class of flatware float to a top surface in the liquid solution at different intervals.

19 Claims, 3 Drawing Sheets

Summary

Patent “5,655,663” proposes using three classes of flatware comprising of spoons, forks, and knives, each having varying buoyancy so as to float at three different levels in the liquid solution they are placed in, and enabling the retrieval of the separated flatware in a sorted fashion. The extension of the authors work came as a Patent “5,931,307”, wherein a prescribed amount of a salt solution is mixed into the liquid solution, and temperature is raised to a predetermined amount causing it to change the specific gravity, which helps each class of flatware float to a top surface in the liquid solution at different

intervals. This idea cannot be applied to the principal problem in our study, mainly because particles present on unclean flatware may react with the liquid causing the specific gravity to vary and also we cannot determine whether the flatware is clean or not.

U.S. Patent 5,996,809 "Flatware sorting machine", Dec. 7, 1999.

Inventors: **Chiasson; Robert H.** (c/o East Coast Industries, Inc. 2532 Main St., Concord, MA 01742)

Appl. No.: **852088**

Filed: **May 7, 1997**

Abstract

A flatware sorting machine including a feed bin for holding unsorted flatware, a sorting system for sorting the flatware, and a flatware pick-up and transport system for retrieving the flatware from the feed bin and transporting them to the sorting system.

16 Claims, 12 Drawing Sheets

Summary

This patent provides a method to sort and orient the flatware. Orientation was accomplished by a rotating feed bin which initially orients the unsorted flatware to all lie in the same general direction, and a magnetic-based flatware pick-up and transport system which transfers the flatware one piece at a time from the feed bin to a sorting system which includes two sorting stations: a first station which sorts all handle end down flatware and a second sorting station which sorts all handle end up flatware. This system is not appropriate for our flatware solution as it cannot identify unclean silverware.

U.S. Patent 6,237,779 "Utensil sorting apparatus", May. 29, 2001.

Inventors: **Boyer; Jay M.** (1250 S. 900 East, Springville, UT 84663)

Appl. No.: **487836**

Filed: **January 19, 2000**

Abstract

A utensil sorting apparatus simultaneously sorts and/or orients a plurality of utensils, such as spoons, forks, and knives. A first movable conveyor is movably disposed over a first template having at least one first aperture sized to receive there through only the spoons. The first conveyor sequentially moves the utensils through at least three locations, including a receiving location, a sorting and orienting location, and a discharge location. A bar may be disposed laterally across the first aperture in the first template at a location configured to correspond to a midpoint of the spoon. The center of gravity of the spoon causes the spoon to pass over one side of the bar to orient the spoon as it passes through the aperture. The apparatus has a first stage, including the first template and first conveyor, to separate the spoons, and a second stage, including a second template and a second conveyor, to separate the forks from the knives.

27 Claims, 5 Drawing Sheets

U.S. Patent 6,460,707 "Utensil sorting apparatus", *Oct. 8, 2002.

Inventors: **Boyer; Jay M.** (1250 S. 900 East, Springville, UT 84663)

Appl. No.: **825494**

Filed: **April 3, 2001**

Abstract

A utensil sorting apparatus simultaneously sorts and/or orients a plurality of utensils, such as spoons, forks, and knives. A movable conveyor is movably disposed over a template having a plurality of first aperture sized to receive therethrough only the spoons. The conveyor sequentially moves the utensils through locations, including a receiving location, and a sorting location.

20 Claims, 6 Drawing Sheets

Summary

Patents “6,237,779”, and “6,460,707” discusses using certain types of templates to sort silverware that has been conveyed individually to the slots. However, there are significant problems that render this idea inappropriate for our problem:

1. The silverware must be separated and fed into the devise one at a time.
2. This system will just sort the silverware. Orientation of silverware would need to be performed in another system.

Automation of commercial dishwashing involves automatic singulation, identification, inspection, sorting, orientation, placement of silverware and dish pieces, and wrapping. Silverware is usually processed as a batched mixture of knives, forks, spoons, soupspoons, and possibly other pieces. After dishwashing, silverware must first be singulated, a process of segregating each piece of silverware from the mixture. A prototype silverware singulating mechanism was designed and constructed by Hashimoto (1995), which consisted of a vibrating feed-hopper, into which the mixed batch was fed, and a magnetic conveyer that pulled single pieces from the bottom of the hopper.

Identification, and then inspection, follow singulation. Yeri (2003) designed and constructed a machine vision system to determine the type and orientation of silverware pieces, together with a rudimentary inspection system. Lolla (2005) improved on Yeri's results, focusing mainly on inspection.

After identification and inspection, the major challenge lies in reliably sorting the silverware at high processing rates. Nagaraj (2003) designed and constructed a serial sorting system which could process 34 pieces of silverware per minute, but it lacked robustness and reliability. The goal in the work herein is to design and construct a sorting and a orienting system to process 55 pieces per minute, with maximum efficiency. This system is to work in conjunction with the singulating machine (vibration hopper) designed by Hashimoto (1995) and the machine vision system designed by Yeri (2003). A conceptual flow diagram of the overall process is given in Fig. 1.1 where arrows indicate direction of silverware flow. The "return" loop indicates that pieces unrecognized by the vision system are returned to the singulating machine.

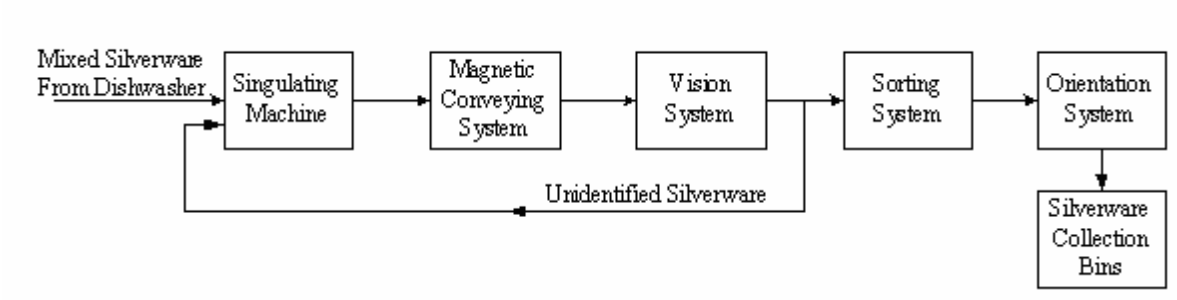

Fig. 1.1 A Flow Diagram of Silverware Sorting System

1.2 Design

The goal in this work is to design, construct and test an automated system to sort, orient, and place in bins four types of silverware: knife, fork, spoon and soupspoon. The dimensions of the pieces used in the study are given in Table 1.1, and Fig. 1.2 shows top views of each piece. Sorting, orienting, and collecting is initiated by placing the individual silverware pieces on a plastic stationary base plate, which feeds fast moving magnetic strips moving under the stationary plate. This is part of a complete system that includes material handling, inspection, identification, sorting, orientation and collection of the silverware into 9 bins, two each for clean knife, fork, spoon, soupspoon, and one for dirty pieces.

SILVERWARE	LENGTH (in)	MAXIMUM WIDTH (in)
Knife	8.66	0.78
Fork	6.3	0.98
Spoon	6.14	1.25
Soup Spoon	6.10	1.65

Table 1.1 Dimensions of Silverware Pieces Used in This Study.

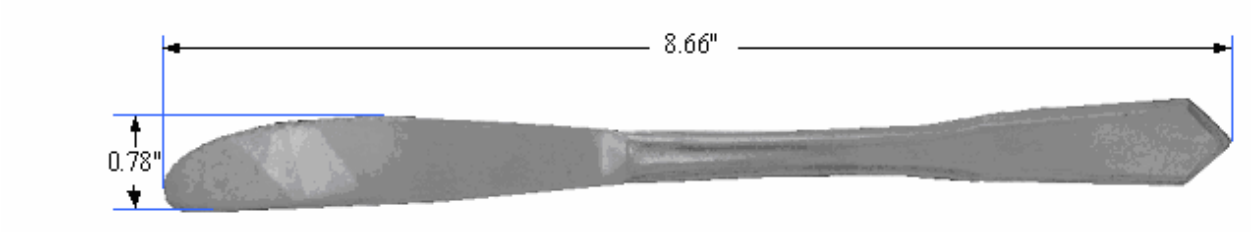

Fig. 1.2 (a) Knife

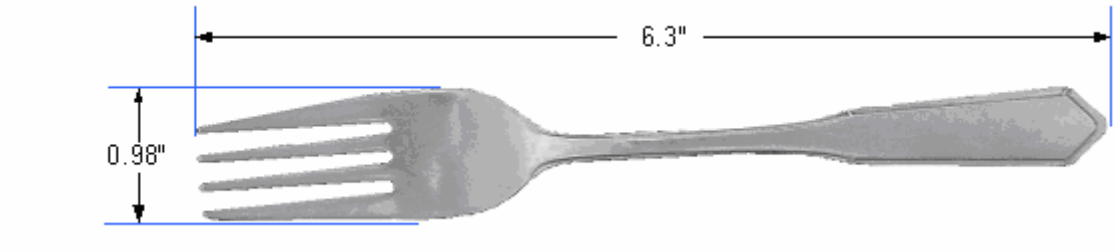

Fig. 1.2 (b) Fork

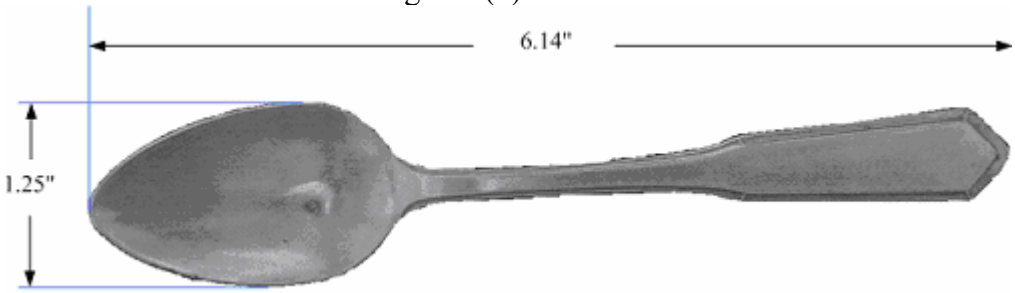

Fig. 1.2 (c) Spoon

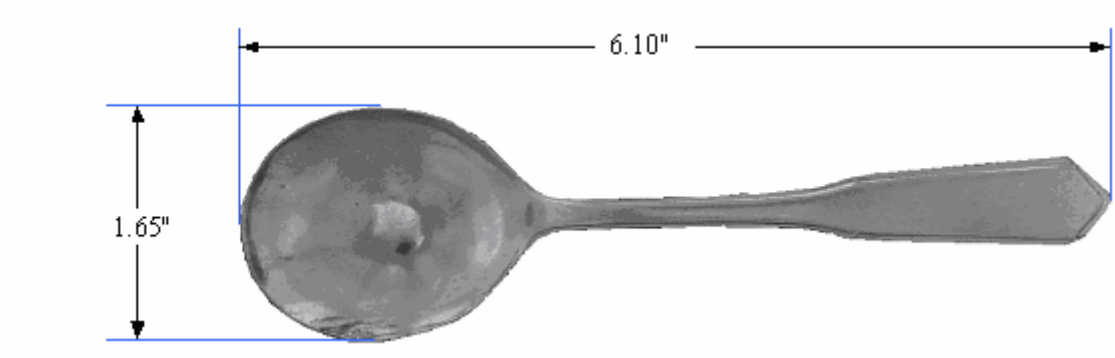

Fig. 1.2 (d) Soupspoon

Fig. 1.2 Silverware Pieces Used in This Study.

1.3 Preliminary Concepts

The initial idea for a silverware sorter came from the work of Hashimoto(1995), Latvala (1999), and Loisson (1999). Various following innovative ideas led to designs that fashioned a series of modifications to enhance workability, the latest version of which is from the work of Nagaraj (2003). A silverware sorter designed and constructed by Nagaraj (2003), illustrated in the Fig. 1.3, was designed to scrape silverware from a magnetic conveyer belt, using a machine vision system by Yeri (2003) to identify and orient silverware pieces.

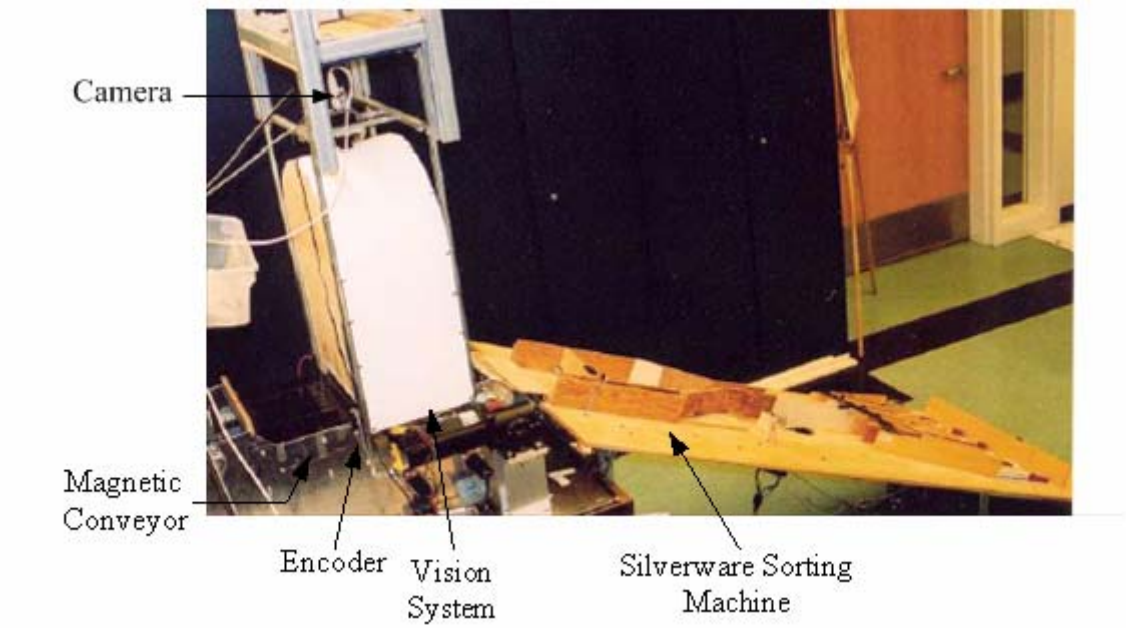

Fig. 1.3 Silverware Sorting Machine along with Machine Vision System

(Nagaraj, 2003; Yeri, 2003)

The silverware conveyor utilized two parallel, continuous driven chains, between which permanent magnets were fixed. A plastic sheet, made of High Density Poly Ethylene (HDP), was positioned directly over a length of the chain. The silverware to be sorted was placed on the plastic sheet, underneath which magnets moved. Due to magnetic

attraction, each silverware was dragged along the plastic sheet. During the course of silverware motion along the sheet, a machine vision system, with camera taking pictures from the top, (Fig. 1.4) captured an image of each of each piece and transmitted these to a computer, which through specially designed software, identified the piece and its orientation, determined whether it was clean or dirty, and sent this information to the sorting system. The identified silverware was fed into the sorting system. Unidentified objects were flagged by the vision system, and a corresponding signal was used to cause the unidentified objects to be reintroduced to the vibrating hopper.

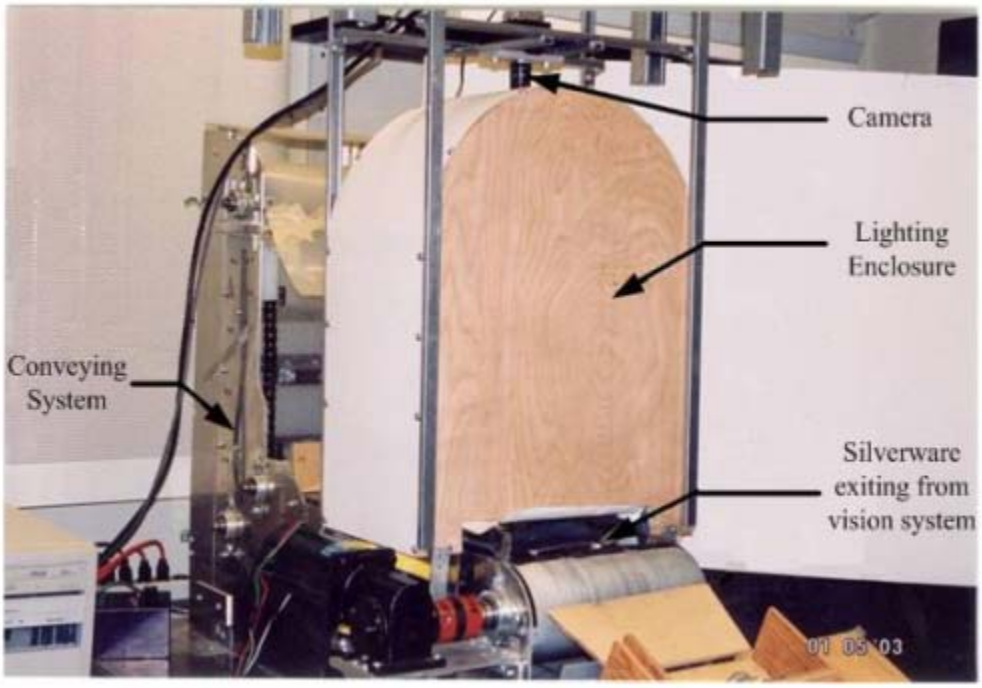

Fig. 1.4 Initial Setup of Machine Vision System (Yeri, 2003)

Proper orientation of the silverware was achieved by a rotating orienter (Fig. 1.5) actuated using a stepper motor and sensor control, which employed information obtained from the images provided by the machine vision system (Nagraj, 2003). After the oriented silverware passes via gravity along a sliding plane through the orienter, an infrared position sensor ensured that the orienter returned to its original/neutral position.

This oriented silverware then entered a rotating sorting chute actuated by a stepper motor, which rotated the silverware piece so as to slide through the proper channels to reach its correct collection bin.

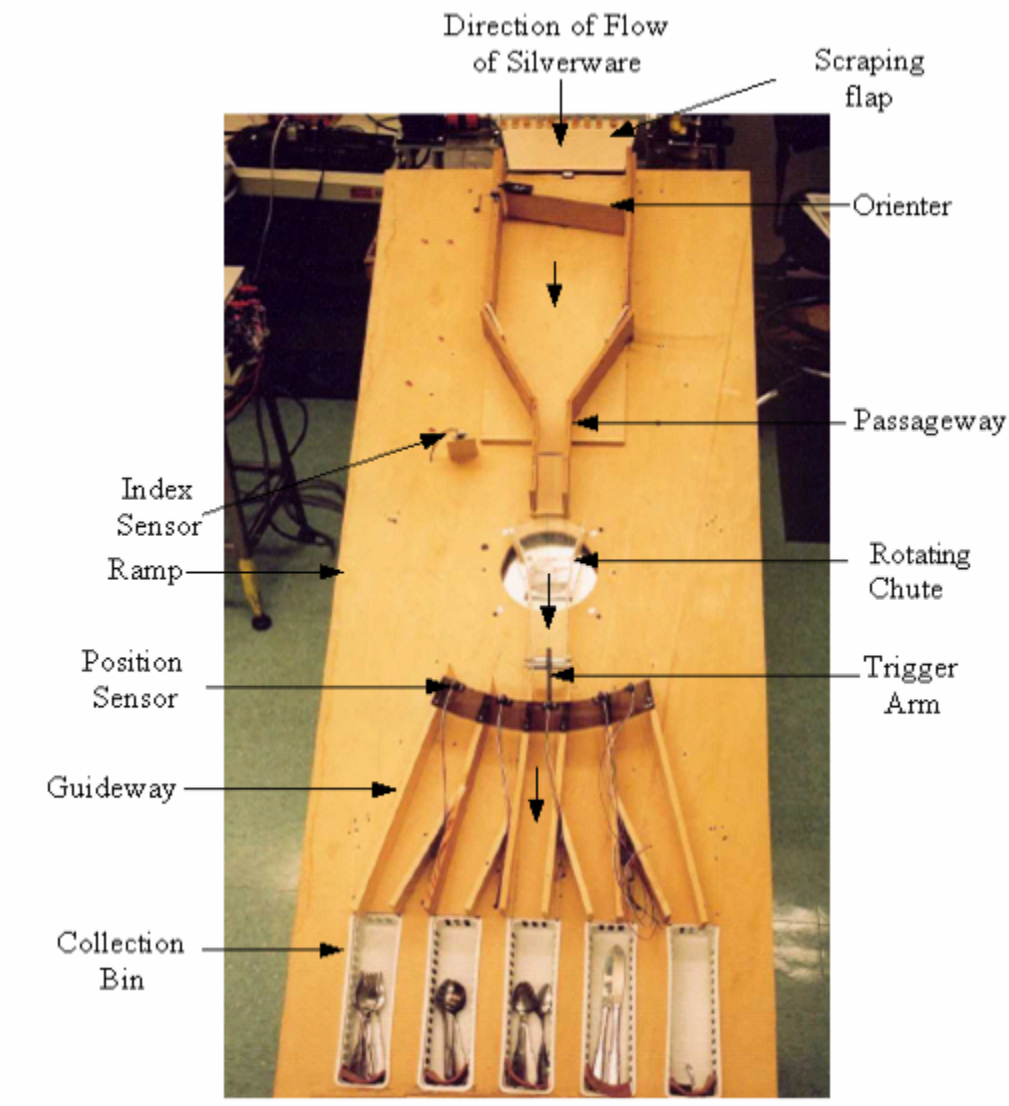

Fig. 1.5 Initial Setup of Silverware Sorting Machine (Nagaraj, 2003)

In order to control the devices, Nagaraj (2003) used a data acquisition board PCI 6035E, National Instruments, which had two 12-bit analog output channels, 16 analog input channels, 8-bit digital input-output pins. An application programming software package was used, called NI DAQ from National Instruments, which comes with NI

DAQ board and can act as an interface between DAQ application and the DAQ board. The software code was written in Microsoft VC++.

After testing Nagaraj's (2003) system, it was determined that this approach was unsuitable due to low processing speed, usage of many components, excessive complexity, insufficient reliability, and high costs. This system also occupied large floor space. It could process a maximum of 34 pieces per minute, but not without some mis-placement and mis-orientation. Accordingly, it was determined that a different approach was needed, which led to the work hearin.

1.4 OBJECTIVE

The purpose of this thesis is to describe the design and construction of a new, more efficient silverware sorting, orienting, and placement system, and provide data and information on experiments and performance. The target for this project is to sort, orient, and place 55 pieces per minute of silverware with high accuracy. It is assumed in this work that all silverware pieces are of ferrous material, capable of magnetization.

CHAPTER 2

INITIAL EXPERIMENTS

Since the system designed by Nagaraj (2003) had some success using sliding along an inclined plane, we elected in an initial approach to maintain this basic feature. After a number of brainstorming sessions, we decided to try a system of stacked inclined planes. The identified silverware was scraped from the plastic sheet in the conveying system designed by Hashimoto (1995) and directed onto the appropriate inclined plane and sorted accordingly. The concept is illustrated in Fig. 2.1, in which the identified silverware slides by gravitational force along one or more of the appropriate inclined planes.

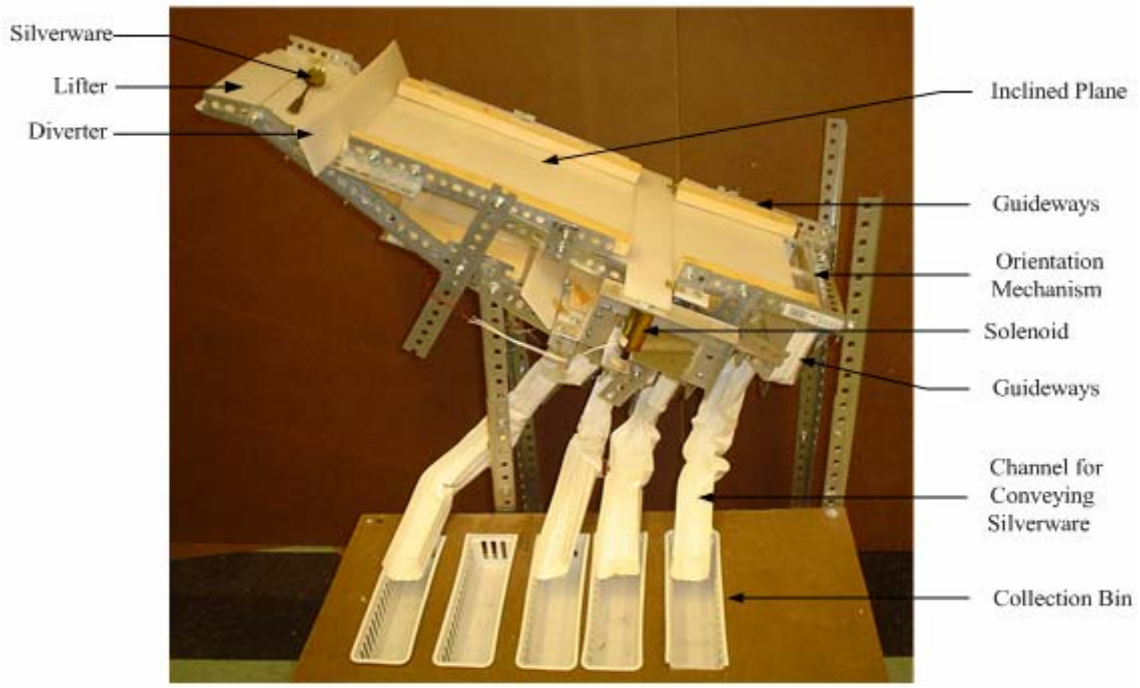

Fig. 2.1 Experimental Silverware Sorting System

A top view of this system is pictured in Fig. 2.2, which shows a plane inclined at an angle 30° to the horizontal bordered by guideways, along which silverware slides. This idea was implemented using a commercially available 0.4 inch thick HDMW (High Density Molecular Weight) sheet for the inclined planes and diverters, providing a smooth surface for silverware to slide smoothly.

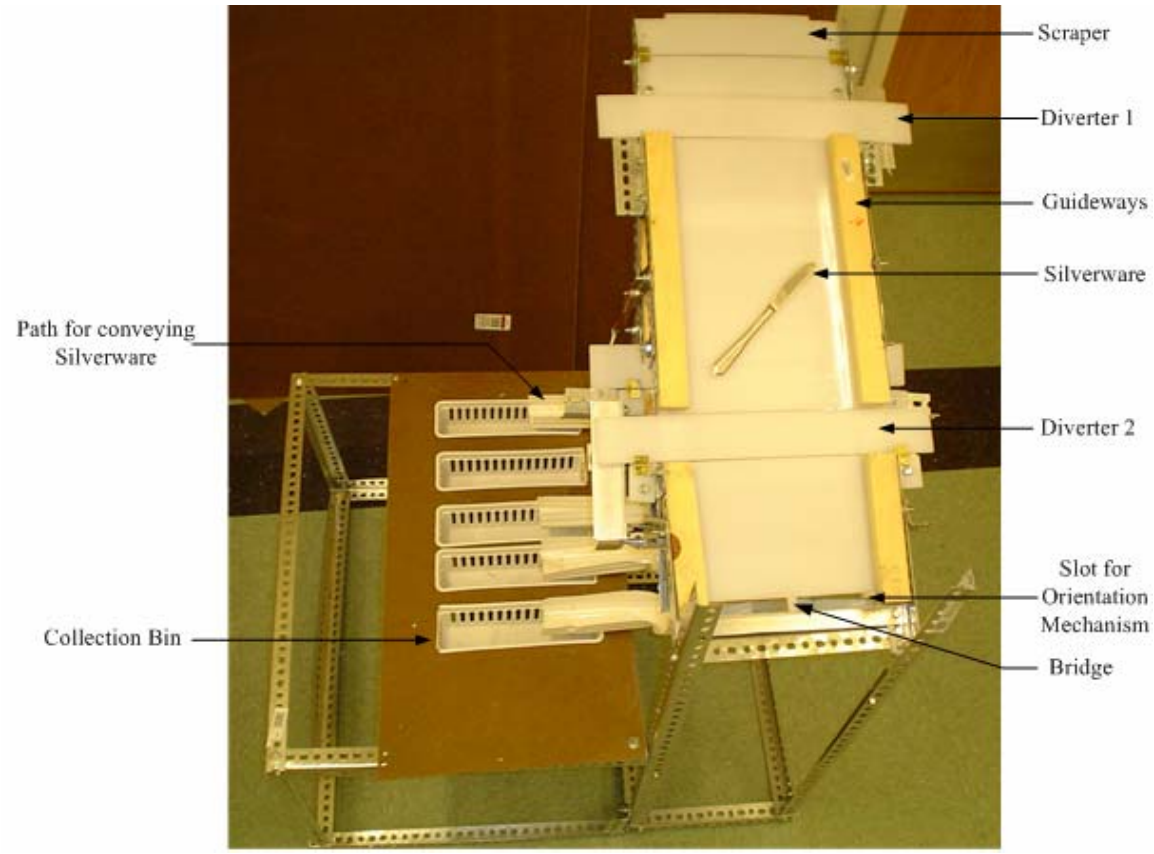

Fig. 2.2 Results in Silverware Sorting System

Along the incline, “pop-up” diverters are provided to divert the silverware to it’s appropriate incline, as shown in Fig. 2.2. According to the type of the silverware, the appropriate solenoids are actuated to operate the scrapper and appropriate diverters. The signal to the appropriate solenoid is obtained from the vision system immediately after the identification of the silverware piece.

At the bottom end of the top inclined plane oriented at 30° to the horizontal, a slot is provided for knives to be oriented and sorted. This slot was designed with width and length, $1/8^{th}$ of an inch longer than the maximum width and length of the knife, as shown in Fig. 2.3. A bridge is provided through the middle of the slot, which enables the heavier handle of the knife to fall through first, providing consistent "handle down" orientation. The knives that fall through the slot in the above described fashion, slide through a smooth pathway under the influence of gravity to reach the knife collection bin.

A similar system is used for forks. As they slide along the top incline, Diverter 2 is opened by its solenoid, causing the fork to drop to a second inclined plane oriented at 45° to the horizontal. The fork then falls through its orientation slot at the end of this incline, with a bridge placed to cause it to fall handle down. The oriented fork passes along the channel and is collected with the handle oriented downwards into the fork collection bin.

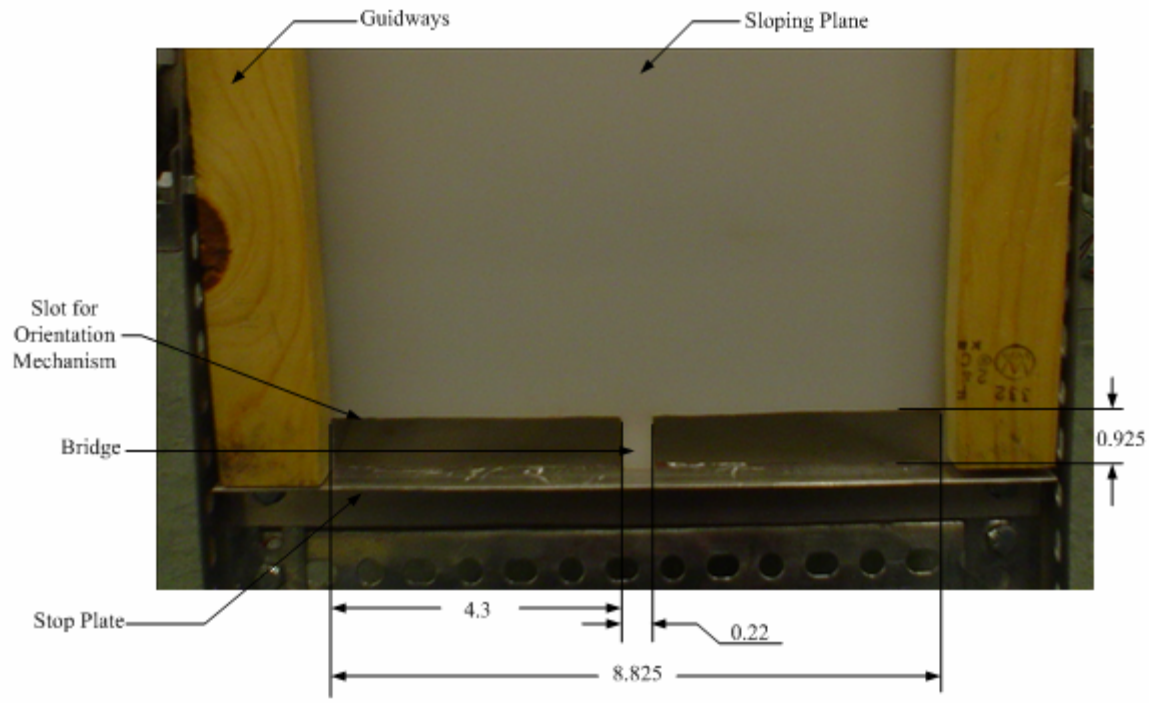

Fig. 2.3 Orientation Mechanism for Knives

If the object detected is, a spoon or a soupspoon, Diverter 1 present in the top incline opens, causing it to fall to the 45° incline. It continues to slide and falls through an orientation slot designed for spoons, handle down. A soupspoon is handled in similar fashion along its own pathway to its handle-down orientation slot. Thus, all silverware pieces are diverted along separate pathways to reach their respective collection bins.

The formulae to calculate the dimensions of the orienting slots are:

Width of the slot =

$$\left(\frac{\text{Maximum Width of silverware head} + \text{Maximum Width of silverware tail}}{2}\right) \times 1.05$$

Length of the slot = (Maximum length of the silverware) ×1.05

Using the formulae mentioned in the previous page, the dimensions of the orienting slots are calculated as shown in Table 2.1.

Silverware	Length of slot (inches)	Width of slot (inches)	Thickness of bridge (inches)
Knife	8.70	0.80	0.22
Fork	6.50	0.80	0.22
Spoon	6.30	1.02	0.22
Soupspoon	6.20	1.30	0.22

Table 2.1 Dimensions of the Orienting Slot

A variety of tests were conducted with this apparatus, from which we concluded that the lengths of the inclined planes were excessive, such that silverware tended to rotate during sliding, as shown in Fig. 2.2. As a result, silverware jammed at the slot entrance and did not fall through. Moreover, soupspoons tended to roll, as well as rotate, causing jams. The best solution for modifications appeared to be decreasing the length of the inclined plane. However, to maintain speed, the inclination angle would need to increase. This would, in turn, increase the rolling of soupspoons, such that this modification was not feasible. Accordingly, it was decided to abandon this approach and search for a better alternative.

2.1 Discussion of an Alternative Approach:

Alternative approach to conveying silverware through the sorting system might be to remove permanent magnets and magnetize each silverware piece as it drops on a ferrous, but non-magnetized conveyor. Silverware pieces could then be de-magnetized when they exit the sorting system.

Advantages of such an approach would be

1. No need for separate sorting and orienting system, as the silverware riding on the conveyor will be demagnetized when their respective collection bins has been reached, such that it falls into the collection bin
2. Less number of components

Disadvantages would be

1. Complexity in system design
2. Difficult to build the system that will demagnetize the silverware quickly when its collection bin has reached
3. Increase in overall cost of the system
4. High power consumption to magnetize and demagnetize silverware
5. Potential residual magnetism in silverware, which is not acceptable

We felt that the disadvantages overweighed the advantages, such that this approach was not pursued.

CHAPTER 3

SILVERWARE SORTING SYSTEM

As we began a second effort to create a new sorting, orienting, and collection system, discussions with Yeri (2003) indicated a need to improve the method of conveying silverware pieces through the vision system enclosure. The sliding of silverware along the HDPE (High Density Polyethylene) surface in Hashimoto's (1995) apparatus, caused by moving magnets underneath, produced jittering of the silverware, resulting in poor quality camera images. Accordingly, we elected to incorporate solving this problem into our efforts to design a more efficient sorting, orienting, and collecting system. The long HDPE sliding surface was removed to avoid sliding by having each piece attained to a moving magnet.

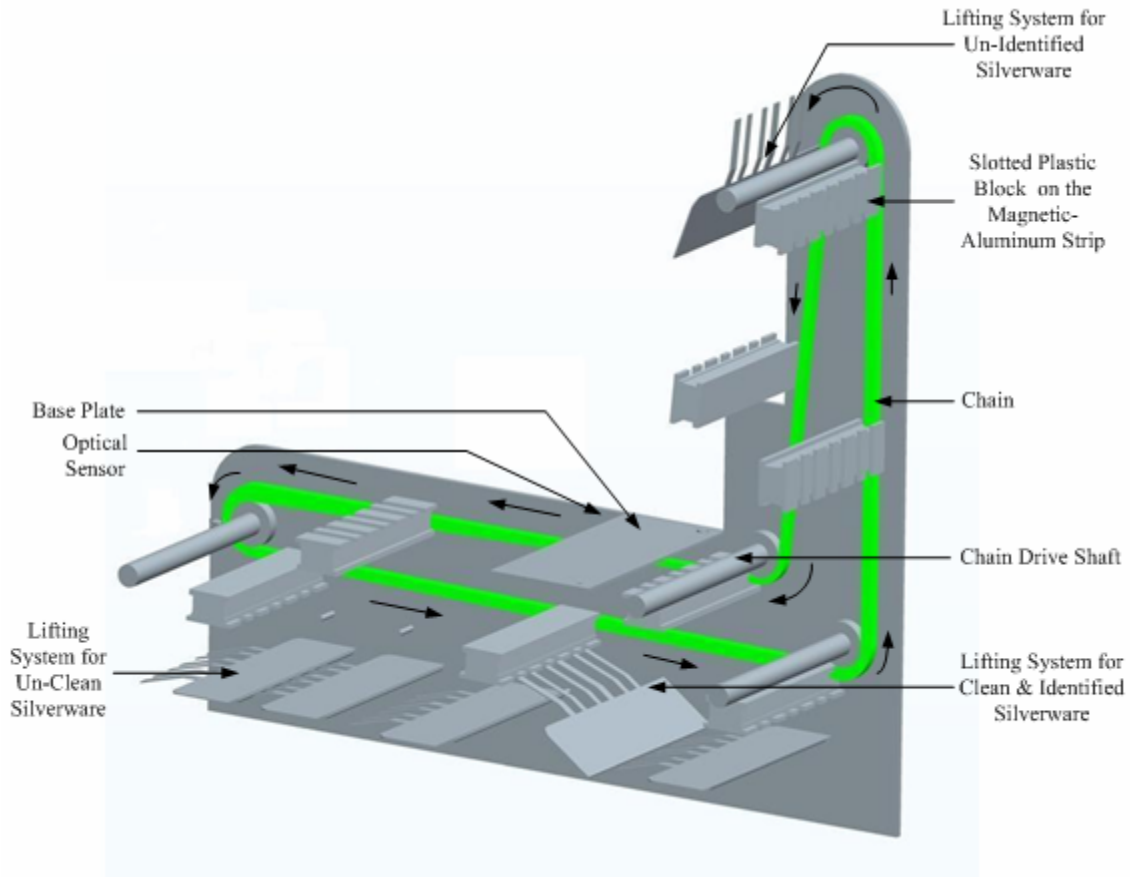

Fig. 3.1 Silverware Sorting System

The basic idea of the new system is illustrated in Fig. 3.1, arrows indicating the direction of the motion of chain. The vibrating hopper singulator by Hashimoto (1995) was retained, and silverware would be discharged onto a short plastic base plate with magnets moving underneath. Silverware would slide a short distance along this plate, under the influence of the moving magnet. However, before entering the vision system enclosure, it would transition from sliding on the plate to moving with the magnet. A special slotted plastic block attached to the magnet would support the silverware pieces. After inspection, pieces would be lifted off the plastic block, either to be sorted or returned to the vibrating hopper. The various components that play a major role in the new system are discussed and described in detail below.

3.1 Base Plate

A short plate was located above the chain drive at the base of the machine at the discharge of the vibrating hopper singulator (Hashimoto, 1995). It was made of 1/8″ thick High Density Molecular Weight (HDMW) plastic sheet, and was bolted to the supporting structure through holes in one end, as shown in Fig. 3.2.

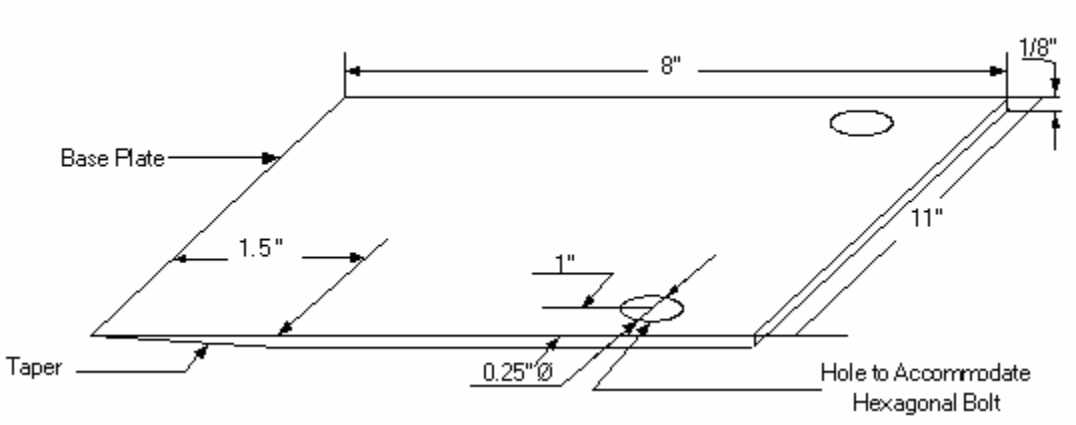

Fig. 3.2 Base Plate

The other end of the sheet was tapered so as to facilitate smooth transition of the silverware sliding along the short base plate to the top of a slotted plastic block riding on the moving magnets. Also, due to fixing of the sheet at one end and tapering of the sheet at the other, the sheet behaves like a cantilever beam. When the silverware passes over the tapered end, the combination of the weight of the silverware and magnetic attraction forces by the magnets beneath, causes the plate to bend slightly aiding in smooth transfer of the silverware onto the slotted plastic block attached to the magnet.

3.2 Slotted Plastic Block

From the system designed by Hashimoto (1995), there are three permanent magnets placed in a row on the top of an aluminum strip, shown in the Fig. 3.3. The three

magnets are fixed to the aluminum strip using four round headed machine screws, washer, and nuts underneath. There are two holes each drilled into the aluminum strip equidistant from the ends on either side to fasten it to the chain drive.

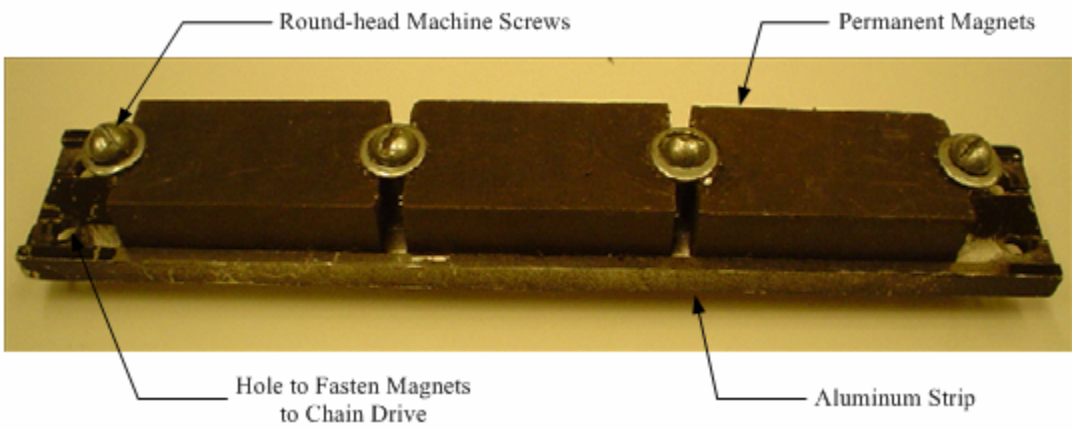

Fig. 3.3 Magnets on Aluminum Strip

We designed a slotted plastic block to be fastened on top of the magnets mounted on the aluminum strip. The purpose was to support the silverware, with passage ways, or slots, such that a fingered lifting mechanism could slide under the silverware, through these slots, and lift the silverware pieces off the block. The length and width of the block are slightly greater than the maximum length and width of the silverware pieces used. The thickness was selected so as to accommodate recesses in the bottom to provide relief for the machine screws of the aluminum-magnetic strip and to provide for slots for the lifting system, as shown in the Fig. 3.4.

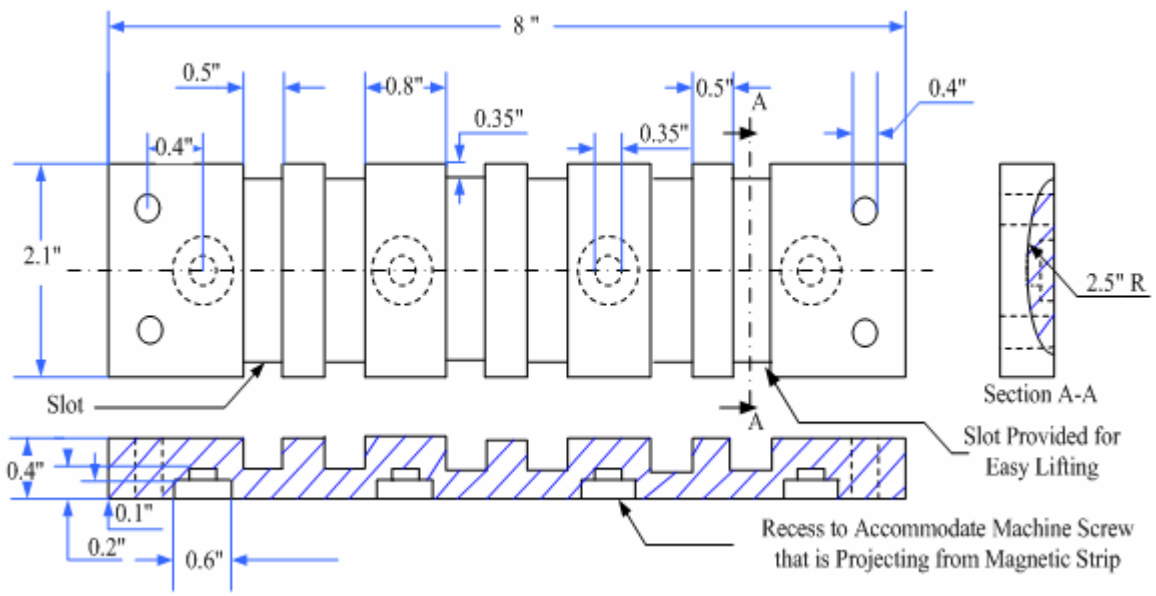

Fig. 3.4 Slotted Plastic Block

The slots were made to facilitate the removal of the silverware using the lifting system. The radius of curvature of the top of the magnetic strip as it traverses around a pair of sprockets is 2.5″. Accordingly, the radius of curvature of the slots in the plastic block is 2.5″, which eases lifting of the silverware from the block onto the sorting system. This lifting is illustrated in Fig. 3.5.

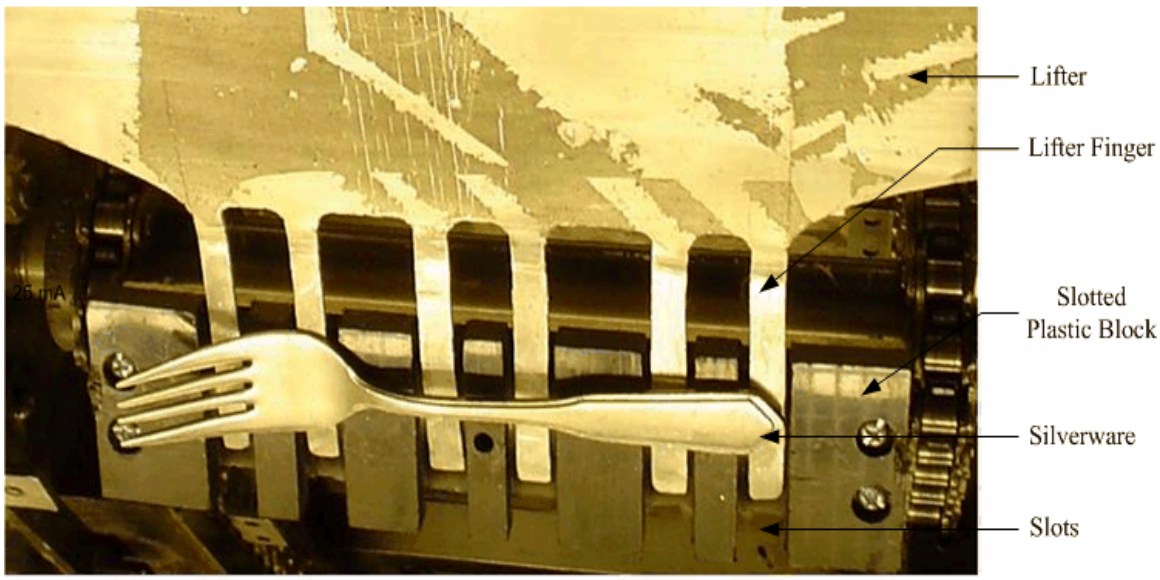

Fig. 3.5 Lifting System

An assembly of the slotted plastic block and the magnetic strip is shown in the Fig. 3.6. The magnetic strip is attached to the slotted plastic block using a nut-bolt arrangement and a spacer on either end. The spacer provides a tight contact between the block and the aluminum strip, and it also prevents bending of the plastic block, which was found to occur when spacers were not used.

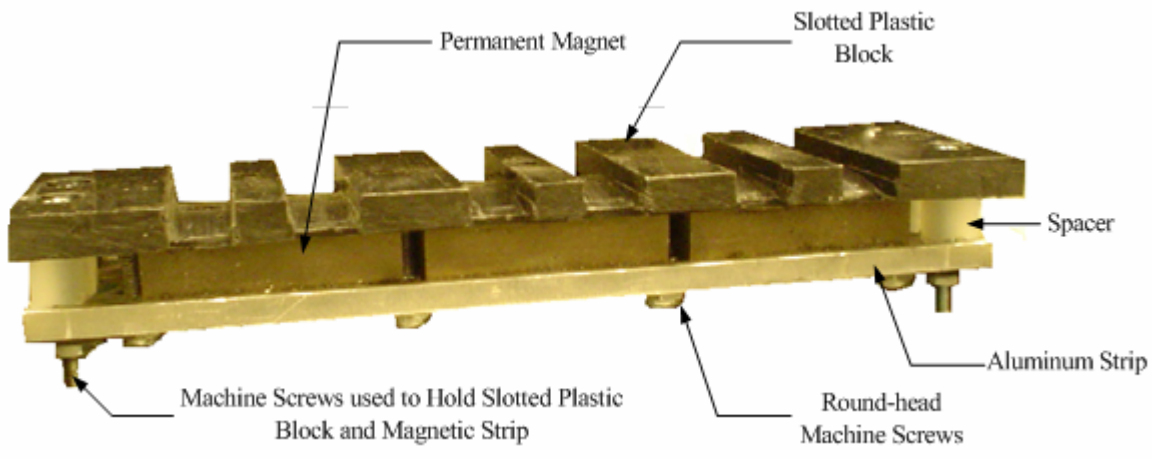

Fig. 3.6 Assembly of Slotted Plastic Block and the Magnetic Aluminum Strip

Elimination of sliding silverware pieces (Hashimoto's design, 1995) by employing this plastic block eliminated the jittery silverware vibrations that were produced in the previous version of the system designed by Nagaraj (2003) and Yeri (2003). Because of the absence of relative motion between the silverware and the plastic slotted block, this new design eliminated silverware vibrations. This facilitated formation of distortion free images by the camera.

3.3 Optical Sensors

Optical sensors (Photo Electric Switch from 'Omron', Model Number E3S-1L E21), are placed on the frame on either side parallel to the chain drive, as shown in Fig.3.1. They are placed at such a height that any magnet that passes across them on the

chain drive is detected, and the feedback is sent to a DAQ board in the computer that controls the overall operation. The input voltage supplied to these sensors is 12V. They are connected in such a way that during normal operation, when no magnet passes through them, 0 V is recorded as output. But when any magnet passes through them, 12V are recorded. To send the feedback to DAQ board, the 12 V output had to be converted to 5 V using a voltage regulator (LMV 7805). Pin DIO 6 of the Digital IO Port is the input port for this signal. The circuit diagram is shown in the Fig. 3.7.

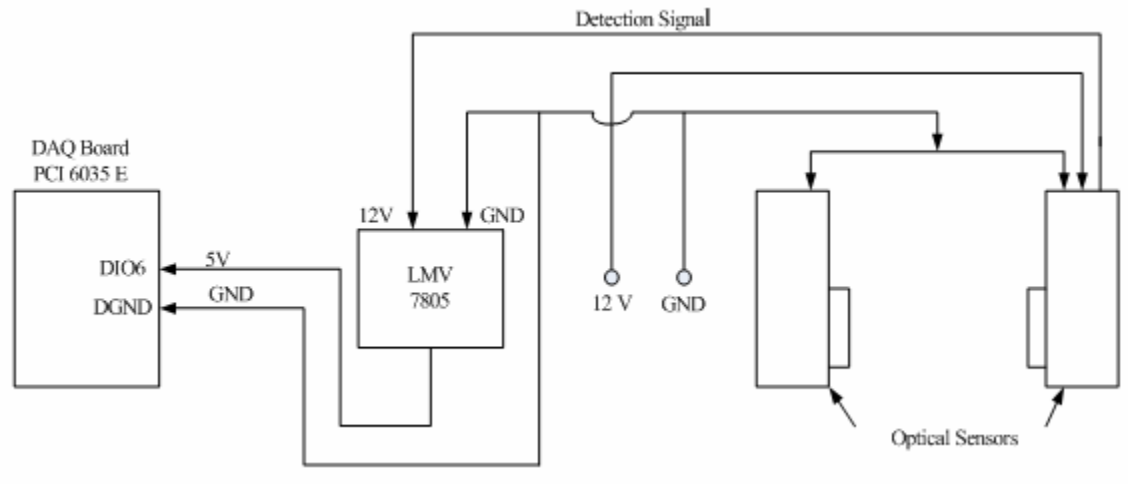

Fig. 3.7 Circuit Diagram for Optical Sensors

3.4 Lifting System for Identified, and Clean and Unclean Silverware

The lifting mechanism consists of a shaft and a hinged metal plate with fingers that mesh with the slots of the plastic block in Fig. 3.4 – 3.6. The lifter plate, shown in Fig. 3.8 (b), is fixed to a rotating shaft (Fig. 3.8 (a)), using 2 screws. The shaft is supported by the wall of the structure through holes on each side. Shaft collars are placed on the outer sides of each wall of the structure to prevent lateral motion, as shown in Fig. 3.8 (a).

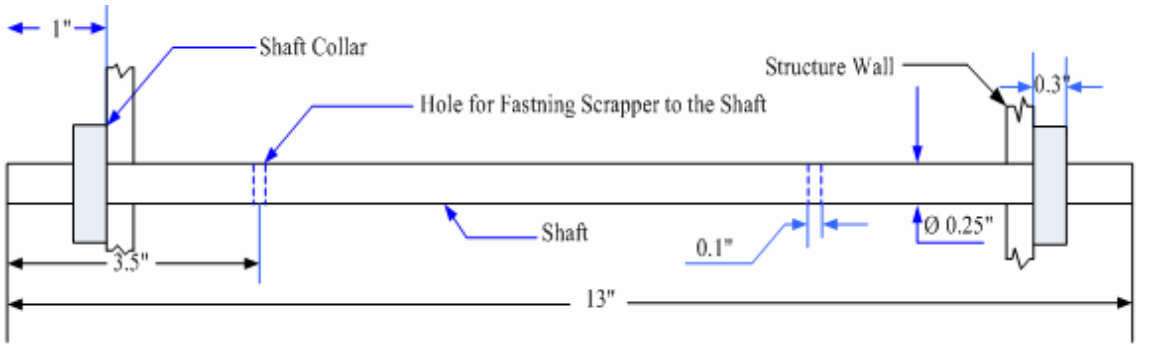

Fig. 3.8 (a) Lifter Shaft for Lifting the Identified and Clean Silverware

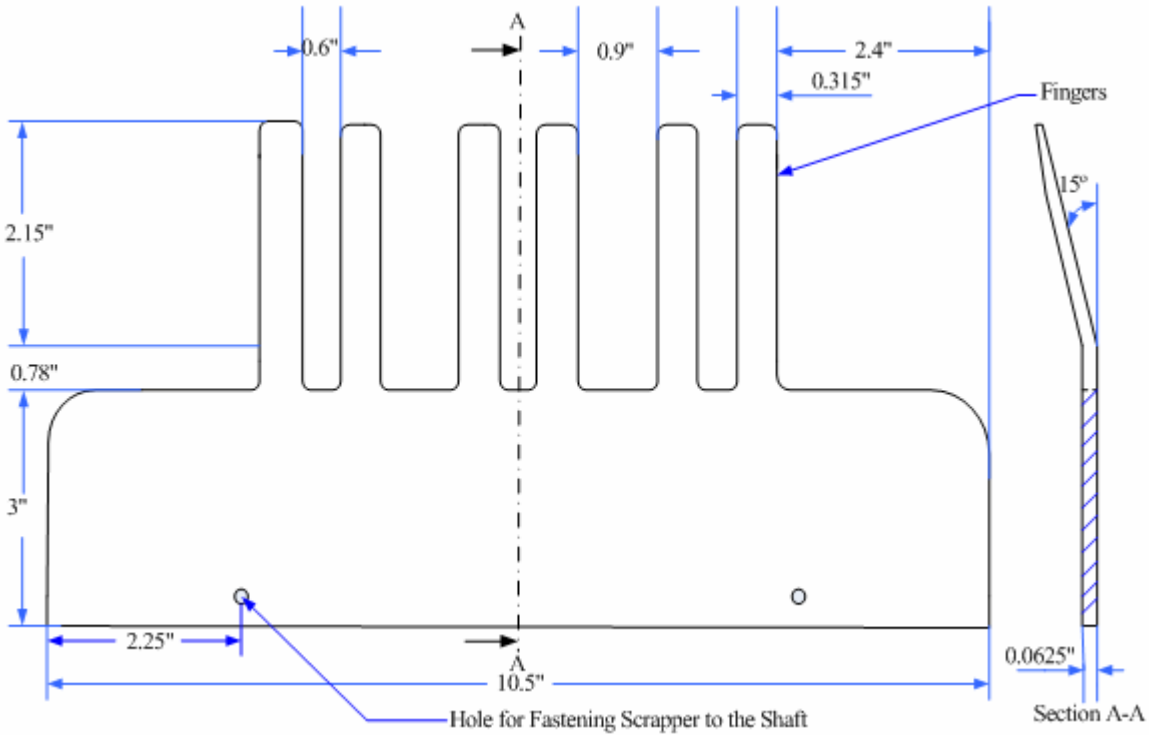

Fig. 3.8 (b) Lifter for Lifting the Identified and Clean Silverware

The lifters are actuated by solenoids, as shown in Fig. 3.9, the activated solenoid pulls a plunger into the solenoid body. The movement of the plunger is guided by a support, as shown in Fig. 3.9. The plunger pulls arm mechanism that causes the lifter shaft to rotate, which rotates the fingered lifter plate (Fig. 3.8 (b)) into lifting position.

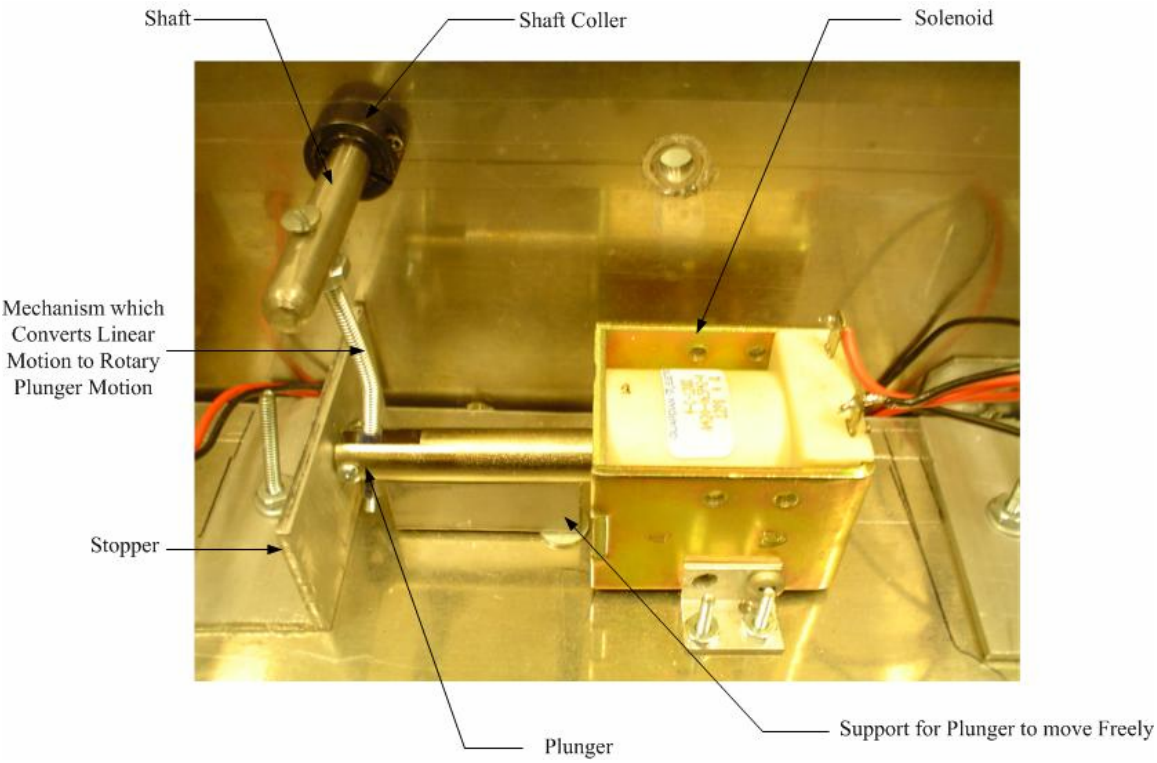

Fig. 3.9 Mechanism to Convert Linear Motion to Rotator Motion

A plunger stopper restricts the motion of the plunger. A lifter stopper, shown in Fig. 3.10, assures the lifter reaches the correct height. Since frequent striking occurs of the lifter stopper by the lifter, damper pads are used on the front side of the lifter, as shown in Fig. 3.10, which cushion the lifter each time it hits the lifter stopper. The fingers of the lifter are inclined at an angle of 10° to the incoming slotted plastic blocks holding the silverware pieces. This results in the fingers sliding along the slots of the plastic block, which causes silverware to be lifted off and directed to their respective orientation systems. When the solenoid is deactivated, the weight of the lifter under gravity moves it and its solenoid plunger back to their rest positions. Fig. 3.10 shows one of five lifting systems for identified, clean and unclean silverware pieces. Motion is towards the viewer.

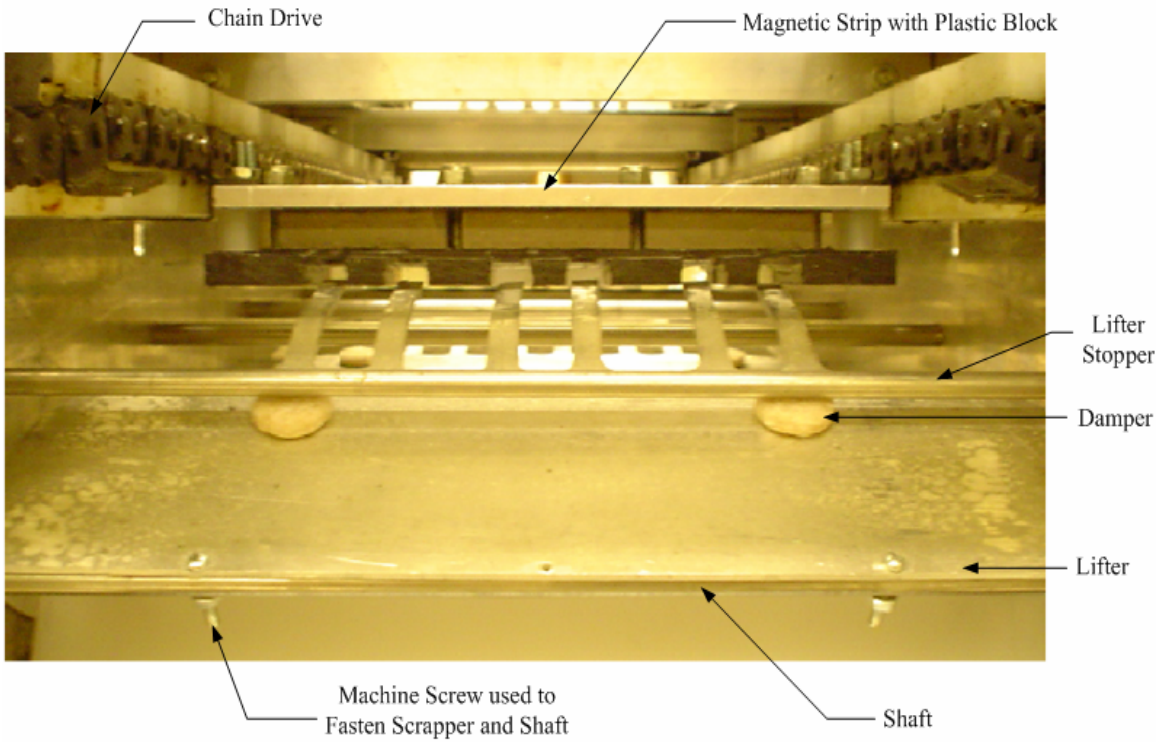

Fig. 3.10 Detailed Lifting System

When silverware riding on the plastic block passes under the camera, a photo optic sensor is triggered and the camera takes images of the silverware. This image is transmitted to the computer, which uses the software designed by Lolla (2005) to determine whether that specimen is clean. If the piece detected is unclean, the computer uses the DAQ PCI 6035 E board to signal activation of a lifter solenoid. This solenoid rotates the fingered lifter (Fig. 3.8 (b)) into the slots of the plastic block (Fig. 3.6) carrying that piece. This lifts the identified unclean piece off the plastic block, such that it falls into the collection bin (Fig 3.11). When the next trigger occurs for the silverware to be processed, the program sends a signal to deactivate, and gravity rotates the lifter to back its rest position. The overall lifting system for unclean silverware is shown in Fig. 3.11, arrows indicating the direction of motion.

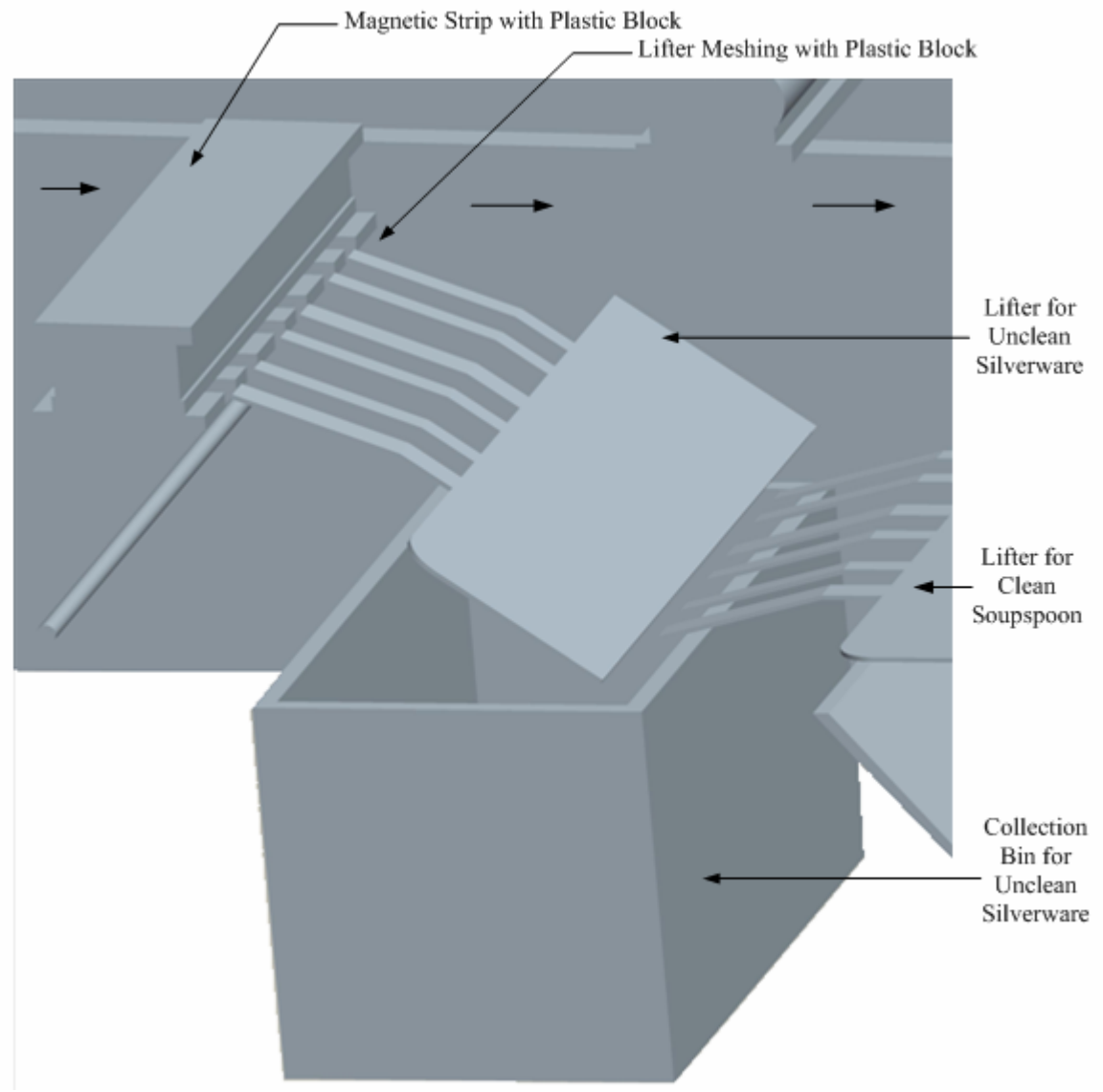

Fig. 3.11 Detailed Lifting System for Unclean Pieces

The lifter solenoid is from 'McMaster-Carr' (Part Number: 70155K46, Catalog Page Number: 894, 2005) with the following specifications: 24V DC, pull type, continues duty, '∞' ON time, 1″ stroke length and 27.5 Ω coil resistances. Since the solenoid operates with '∞' ON time in our application, this type of solenoid was selected. It has sufficient stroke length to raise the lifter high enough to allow the lifter to mesh with the plastic block.

The program controlling the lifting solenoid is coded such that Pin DIO5 of digital IO Port in the DAQ board remains low, causing the relay to give an output of 0 V when unclean silverware is not present. But when silverware passing through is detected as unclean, Pin DIO5 of digital IO Port in the DAQ board is made high, causing the relay to output 24 V. This 24 V input to the solenoid provides 0.8 A, causing the solenoid plunger to retract (Fig. 3.10), rotating the lifter up, and allowing silverware to be lifted off, causing the unclean silverware to fall into a collection bin. The solenoid circuit diagram is shown in Fig. 3.12.

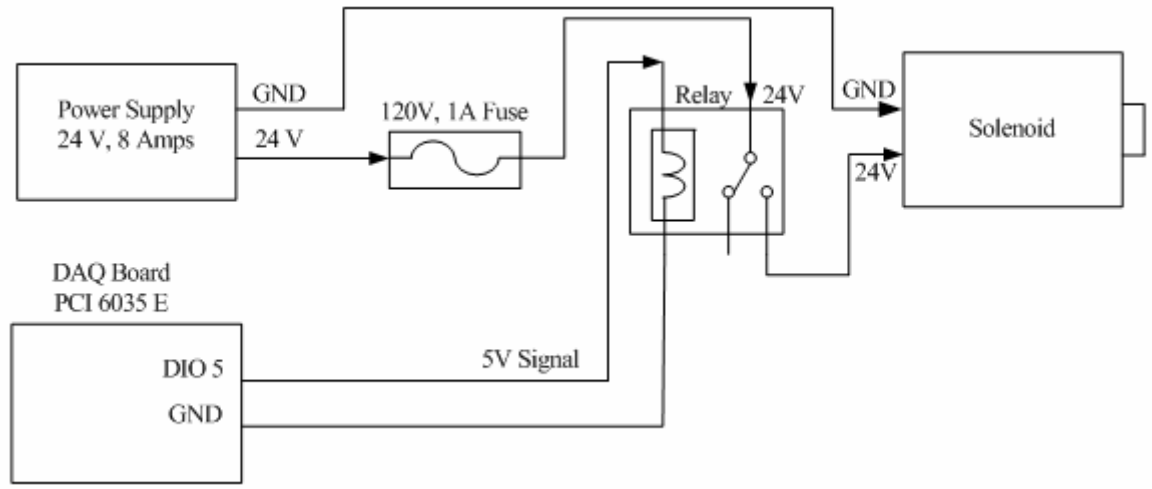

Fig. 3.12 Circuit Diagram of Lifting System for Unclean Pieces

Silverware detected as clean and identified as to type (knife, fork, spoon, or soupspoon) will cause the solenoid connected to the lifter designed for that piece to be activated, which rotates the fingered lifter (Fig. 3.11) into the slots of the plastic block (Fig. 3.6) carrying that piece. This lifts the identified clean piece off the plastic block, such that it falls into the orienting system, and into its respective collection bin. The program is coded in such a manner that once the optical sensor is triggered by a slotted plastic block, and silverware is clean and identified, depending on the type of silverware,

the command is sent from the data acquisition board (DAQ) to the appropriate relay, causing the relay to output 12 V and 0.75 A to actuate the corresponding solenoid. Solenoid activation rotates the lifter into the slots of the plastic block, as illustrated in Fig 3.10. Gravity returns the lifter to its designated, rest position once the program sends the signal to deactivate the solenoid attached to the lifter, as the next trigger occurs. Fig. 3.13 presents a circuit diagram for the four (knife, fork, spoon, soupspoon) lifter solenoids.

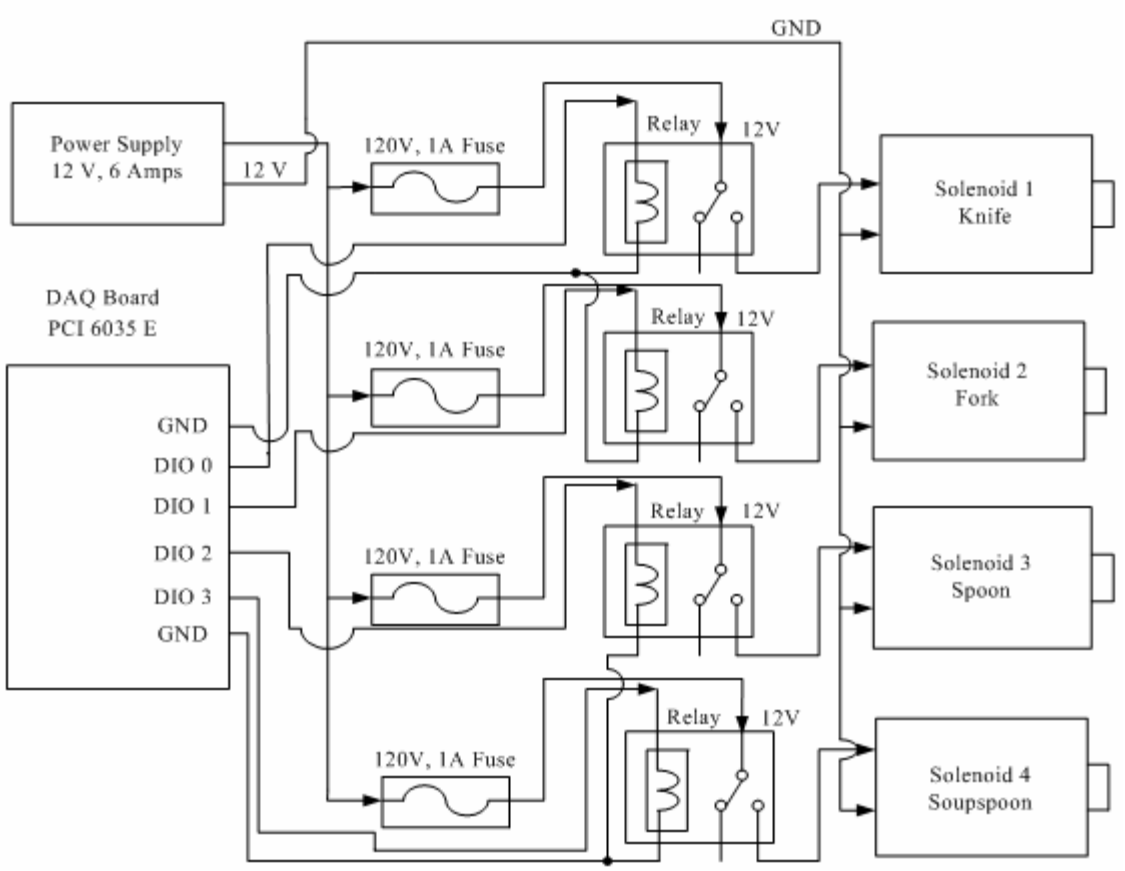

Fig. 3.13 Circuit Diagram of Lifting System for Identified and Clean Silverware

3.5 Lifting System for Unidentified Silverware

Silverware not identified by the vision system continues on its plastic block until it reaches a last stationary lifter, which lifts off all the pieces that reach it. Silverware could be unidentified for a number of reasons, including poor alignment along the plastic block, multiple silverware pieces on one block, or a failure of the vision system to identify a piece on a plastic block. This lifting system is static and fixed to the structure, as shown in Fig. 3.14. It is mounted such that the angle at which it is inclined to the moving blocks causes all the silverware pieces to be lifted from the blocks, reintroducing them into the singulating system for reprocessing. The design of the fingered lifting plate is similar to that in Fig. 3.9 but modified for static mounting. Fig. 3.15 presents a drawing of this lifting plate.

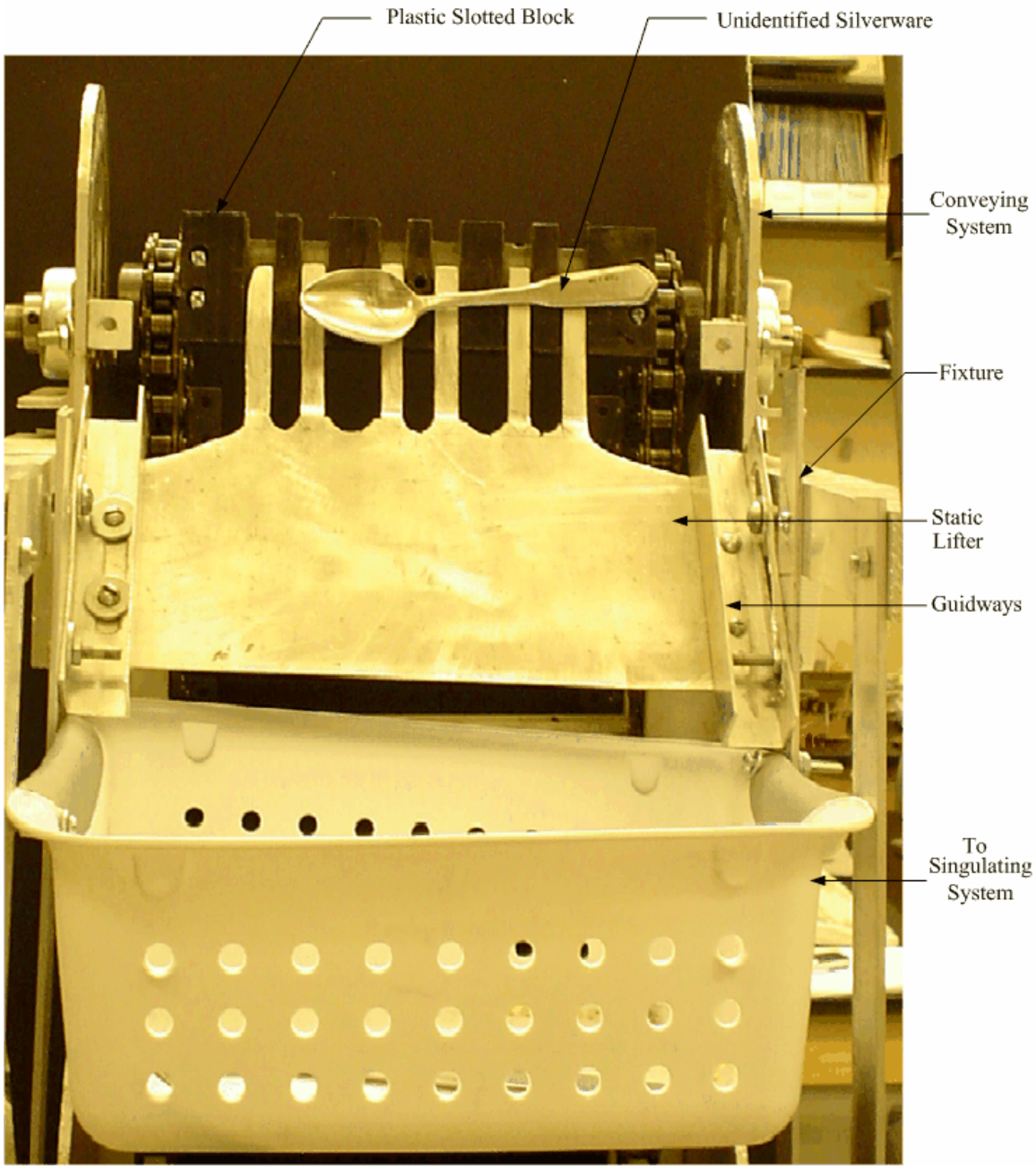

Fig. 3.14 Lifting System for Unidentified Silverware

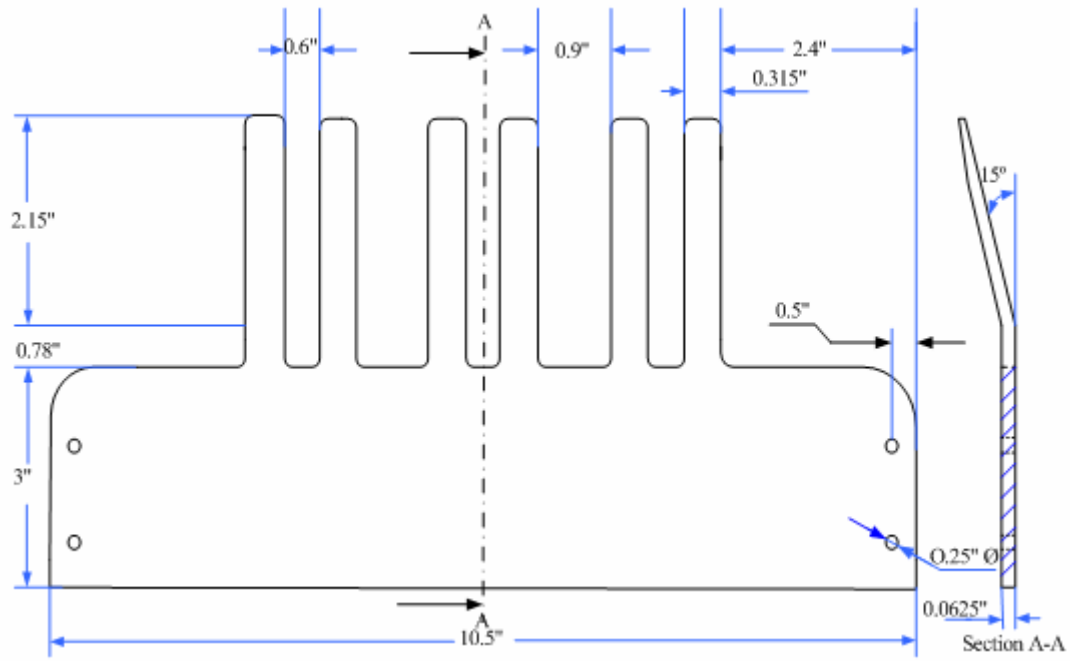

Fig. 3.15 Lifter to Remove Unidentified Silverware from the Slotted Plastic Block

3.6 Power Supply

The power supply for the actuated lifting system was constructed with the help of Brett Riegel at the Electronics shop in the Department of Mechanical and Aerospace Engineering, OSU. Two power sources were built, one of 24 V, 2 Amps, and the other of 12 V, 8 Amps. Table 3.1 gives the specifications of the power supply used for various components in this system.

Number	Components	Specifications	Brand Name
1	Solenoid	24 V, 0.8 Amps	Lambda Company # CA 0A021586
4	Solenoid	12 V, 0.8 Amps	Astec Company # ATX 202-3515
1	Optical Sensor	12 V, 0.8 Amps	Astec Company # ATX 202-3515

Table 3.1 Specifications for the Power Supply and Various Components

The power supply and other circuitry are housed in a box with an appropriate front panel having several outlets, through which the devices can be connected to the power supply. There is also a provision to collect the input signals from external devices through the front panel. The box is connected to connector blocks for the DAQ Board PCI 6035E using a DB 9 connector cable. A cooling fan is also incorporated to prevent overheating of components.

CHAPTER 4

SILVERWARE ORIENTATION MECHANISM AND SOFTWARE

4.1 Silverware Orientation System

Clean silverware exiting the silverware sorting system into a collection bin should be oriented with all handles in the same direction in that bin. This is to facilitate further handling of clean, sorted silverware. The desirable characteristics in this process are:

- High efficiency
- Low cost
- High working speed
- High Reliability
- Repeatability
- Minimum Space

4.2 Initial Experiments

Taking into consideration the dimensions of the silverware, and the desirable characteristics involved in this process, a variety of experiments were conducted, leading to an orienting system that requires no moving parts or actuation. The structural properties of the silverware, together with gravity, are the keys. This orienting mechanism is incorporated into the overall sorting system, shown in Fig. 4.1, at the entrance of each of the four clean silverware collection bins (not shown). No orientation

is needed for unclean pieces. A clean silverware piece removed by a lifter falls by gravity into one of the four orientation bins. It then falls through an orientation slot at the bottom of the bin, which orients it as explained below, and falls into its collection bin in the proper orientation.

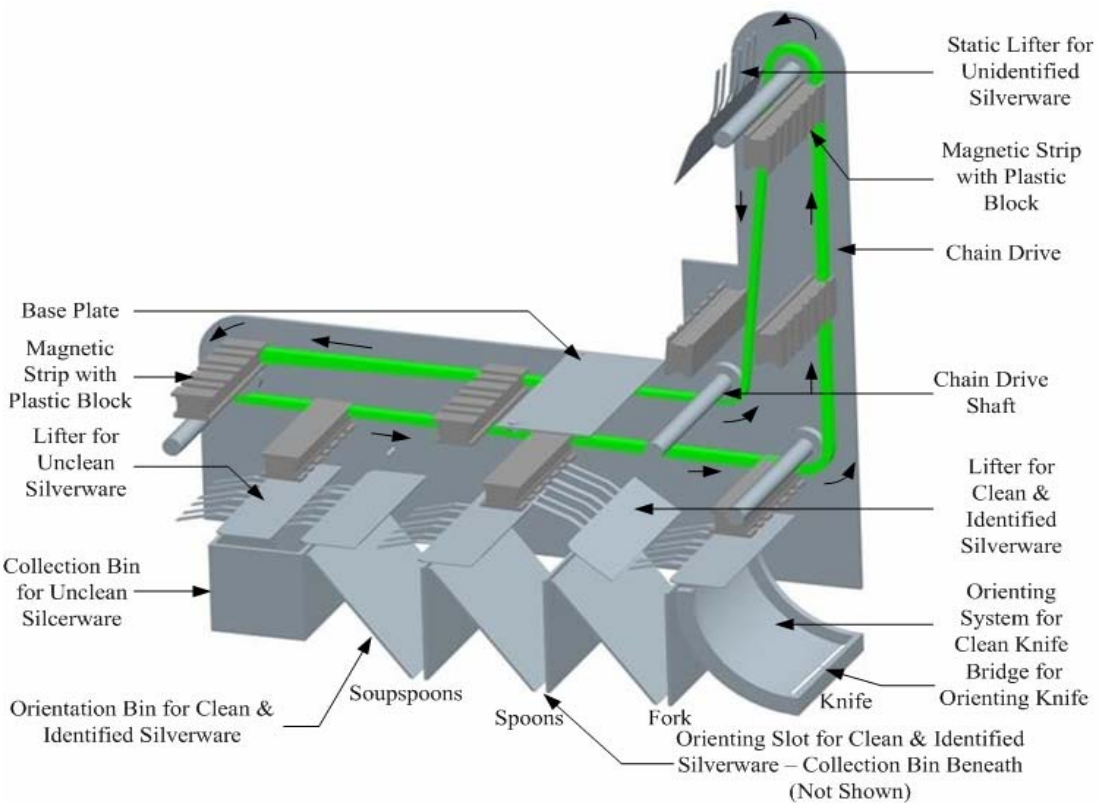

Fig. 4.1 Sorting and Orienting System

The dimensions of the silverware used in the design for silverware orienting are shown in Table 1.1. It was noted that the spoon, soupspoon and fork have more width near their heads (away from the handle). The knife is characterized by having more weight in the handle than the head. These differing properties were employed in orientation, as described below.

4.2.1 Orienting the Fork, Spoon and Soupspoon

The dimensional constraints that govern the system are as follows:

- The system height (6.5” in Fig. 4.2) is equal to the maximum length of the silverware. Greater height consumes more vertical space and provides more opportunity for undesired rotation of silverware. If the height of the orientation system is less then the maximum length of the silverware, then the silverware coming from the lifter may fall vertically, causing interference with the lifters of the sorting system.
- The length of the system (6.3” in Fig. 4.2) should be equal to the distance between two lifters of sorting system.
- The right hand (downstream) panel should be vertical to inhibit falling silverware from proceeding past the plane of the bottom opening.

By trial and error, the configuration shown in Fig 4.2 was derived. The panels are bolted to the steel structure of the overall structure for support and rigidity.

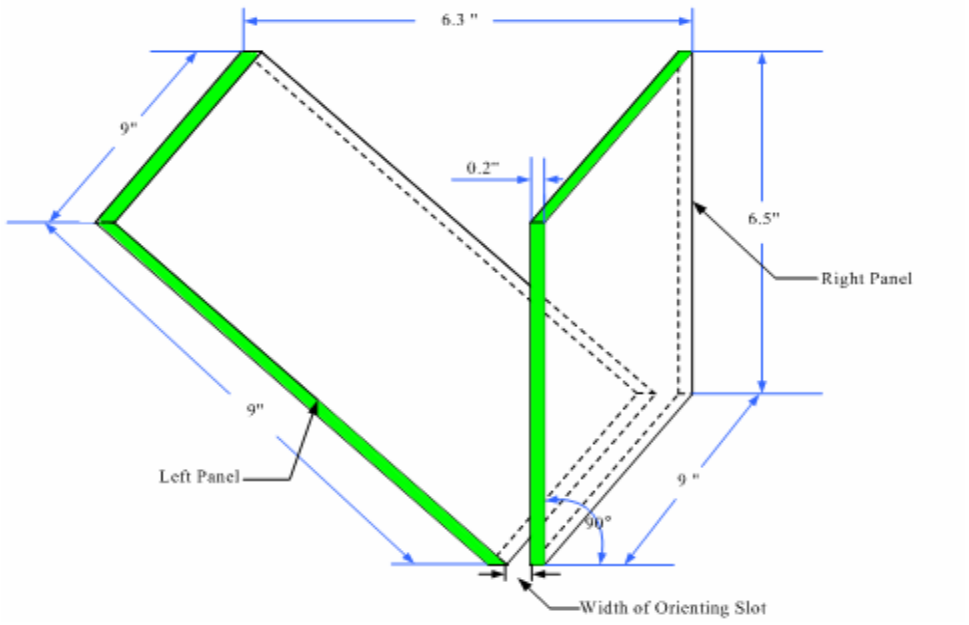

Fig. 4.2 Orientation Bin

Referring to Fig. 4.3, the width of the orienting slot is less than the total height of the silverware but more than the thickness of the head. Table 4.1 gives the dimensions of the 3 silverware pieces as well as the width of the corresponding orienting slot.

Silverware	Total Height of the Silverware (inches)	Width of the Head (inches)	Thickness of the Head (inches)	Width of the Orienting Slot (inches)
Fork	0.56	1.00	0.32	0.40
Spoon	0.54	1.29	0.27	0.35
Soupspoon	0.63	1.65	0.34	0.50

Table 4.1 Structural Details of the Silverware

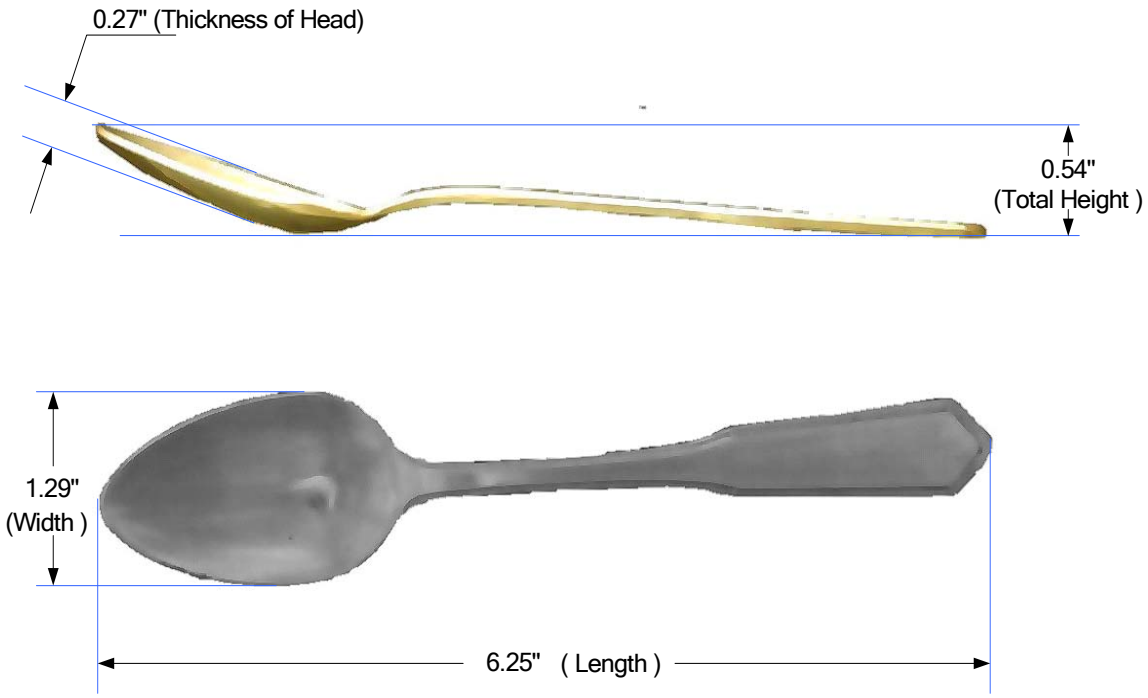

Fig. 4.3 Spoon with Dimensions

As shown in Fig. 4.4, once the silverware falls into the orientation bin, the converging panels obstruct the head of the silverware, as the width of the head is greater than the opening width. But the handle passes through the opening, as the width of the opening is greater than the width of the handle of the silverware, allowing it to fall from

the orientation system, handle oriented ‘down’, into the collection bin placed below (not shown).

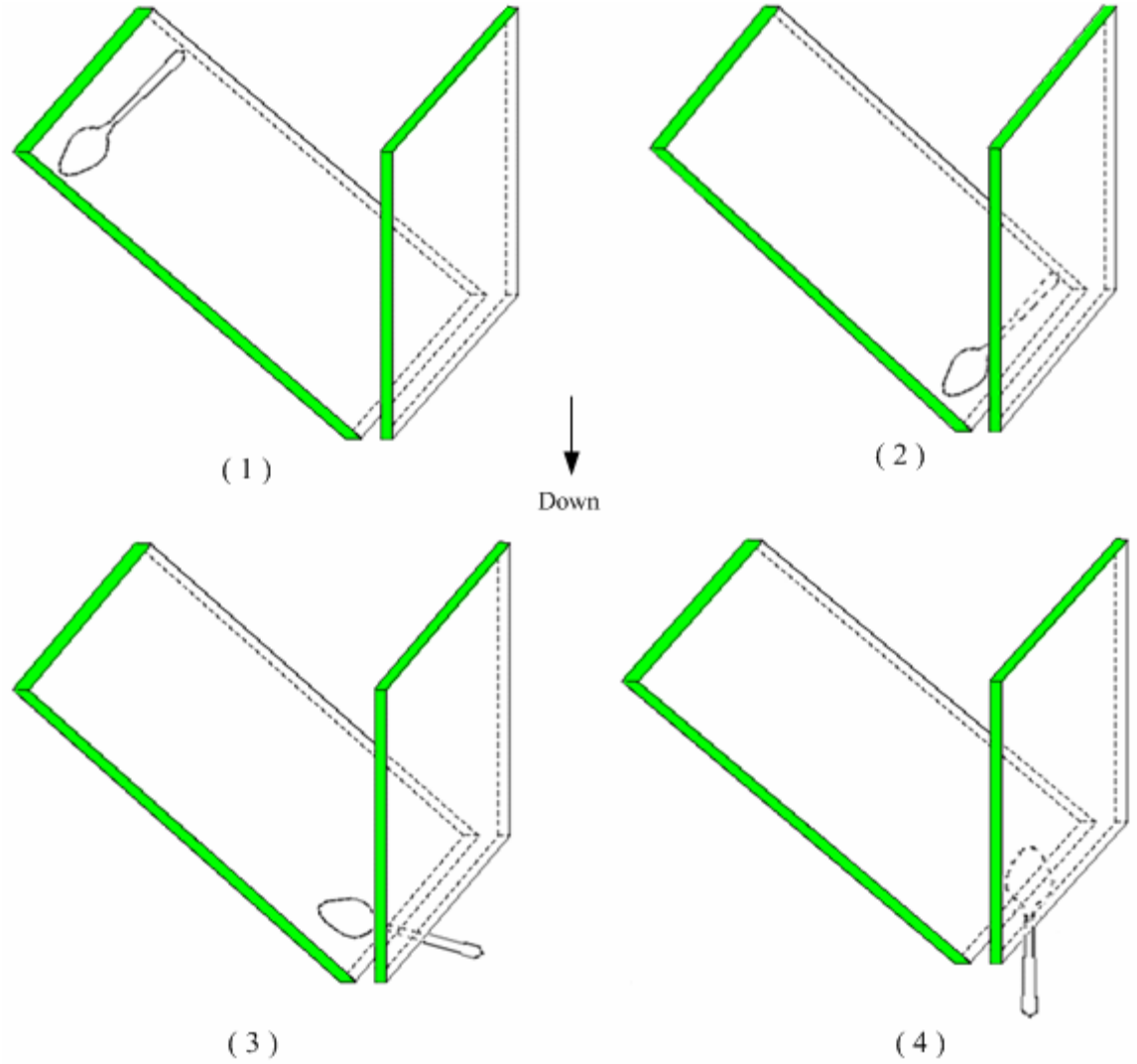

Fig. 4.4 A Schematic Representation of Silverware Orientation

4.2.2 Orienting the Knife

Since the width and thickness of the handle and the blade of a knife are not sufficiently different, it was decided to use differences in weight of these two components for orientation. Once a knife has been lifted off its slotted plastic block, it falls into a

knife orientation path, and slides toward a slot at the end, shown in Fig. 4.5. A pair of brackets is used to fix the knife orientation path to the sorting machine.

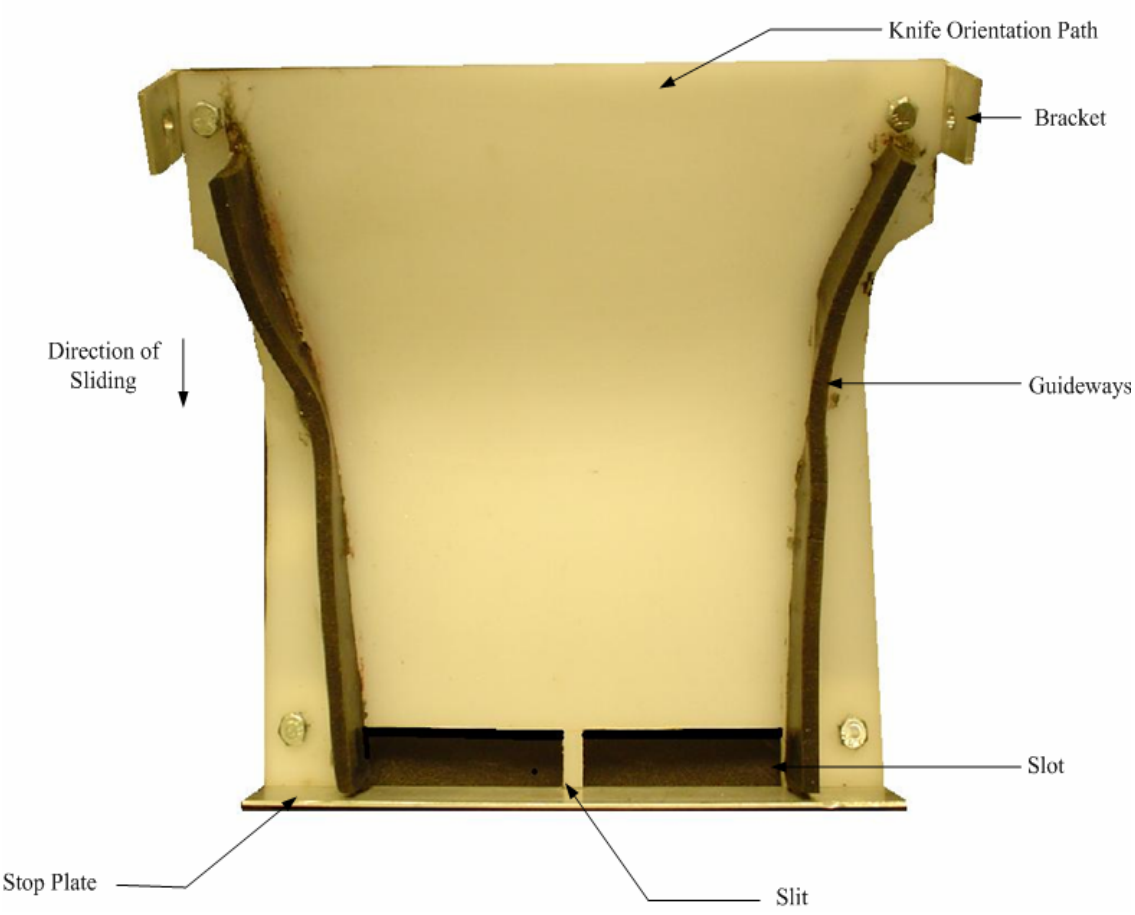

Fig. 4.5 Knife Orientation System

As shown in Fig. 4.6, the knife slides by gravitational force along the path bordered by guideways. At the end of the knife orientation path, a slot is provided for knifes to be oriented. This slot was designed with width and length 1/8th of an inch longer than the maximum width and length of the knife, respectively. A bridge is provided through the middle of the slot, which enables the heavier handle of the knife to fall through first, providing consistent "handle down" orientation, into a collection bin below (not shown).

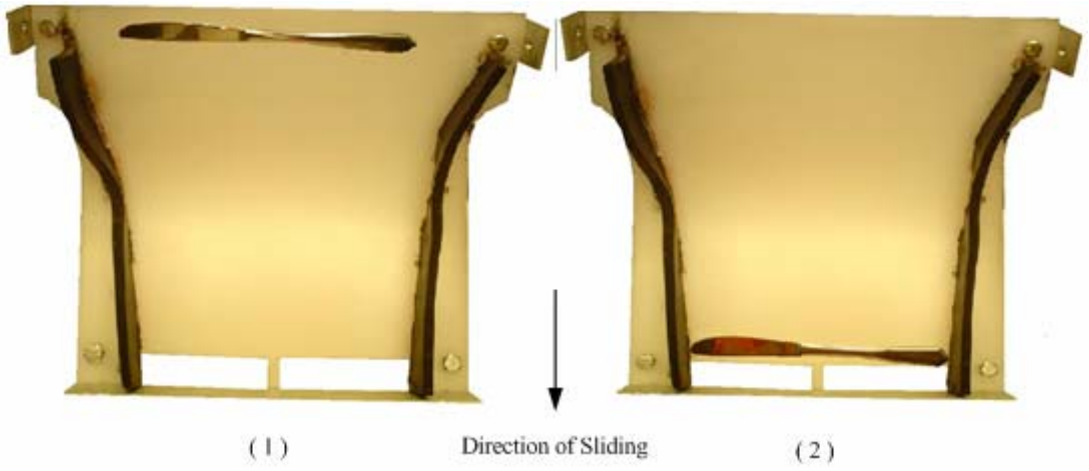

Fig. 4.6 Knife Orientation Process

A variety of tests were conducted with this apparatus, from which we concluded that the efficiency of the system was atleast 98.0% in most of the cases, but sometimes silverware jammed in the orienting slot. This happened when a silverware piece falling into the orientation bin rotated during sliding, as shown in Fig 4.7. The head then became stuck in the orienting slot. As a result, silverware jammed at the panel opening, such that all succeeding pieces jammed as well.

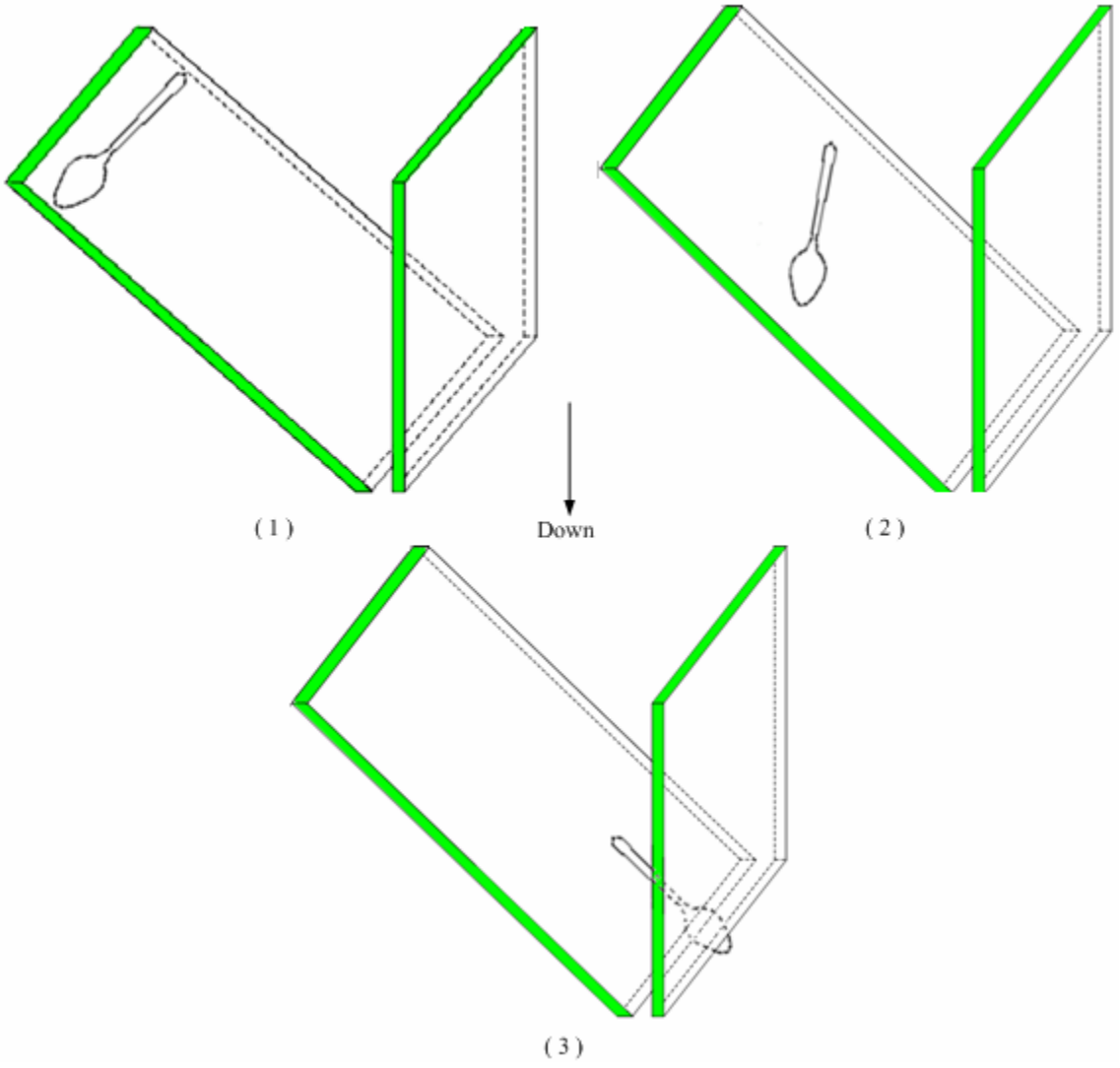

Fig. 4.7 Results in Silverware Orienting System

Increasing the width of the orienting slot to avoid jamming caused silverware to just pass through without being oriented, since the width of the head was then not greater than the opening width of converging panels. After a large number of tests, it was decided to discard this approach and search for a better, more robust alternative that could orient any type of silverware regardless of its shape.

4.3 New Orienting System

The basic idea of the new orienting system is to place differently oriented silverware in different bins, as illustrated in Fig. 4.8.

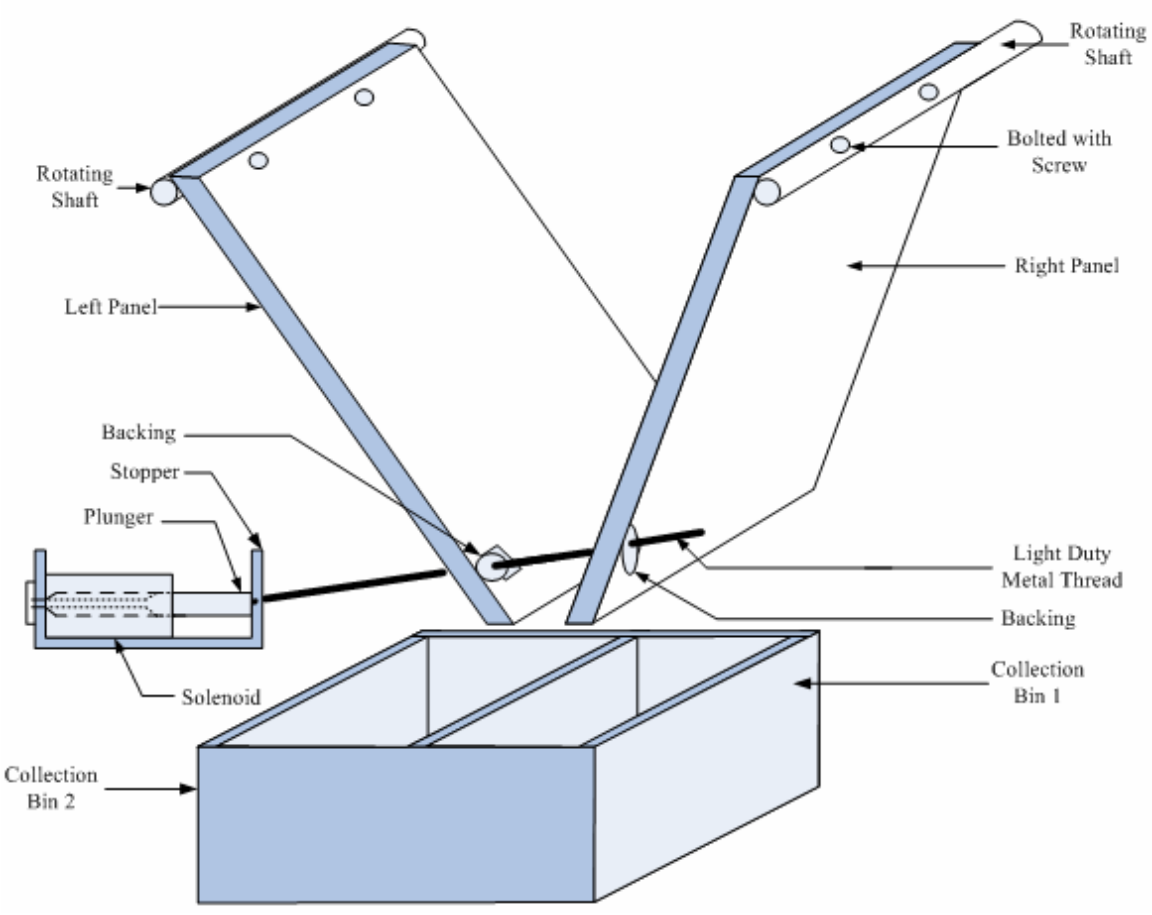

Fig. 4.8 New Orienting System

As an example, consider a spoon lifted by the sorting system. The new orienting panels place all the spoons oriented left in one collection bin and all the spoons oriented right in an adjacent collection bin. This means that there are now two collection bins for each kind of silverware.

The orienting mechanism for each type of silverware piece consists of a shaft and converging hinged wooden panels. The panels are located at the base of the machine at the discharge of the silverware from the sorting system. They are made of 1/8" thick plywood bolted to the rotating shafts, illustrated in Figs. 4.8 and 4.9. Panel dimensions are given in Fig. 4.10. The panels, shown in Fig. 4.10 (a) and (b) are fixed to the rotating shafts (Fig. 4.9), using two screws. The shafts are supported by the wall of the structure through holes on each side. Shaft collars are placed on the outer sides of the wall of the structure to prevent lateral motion.

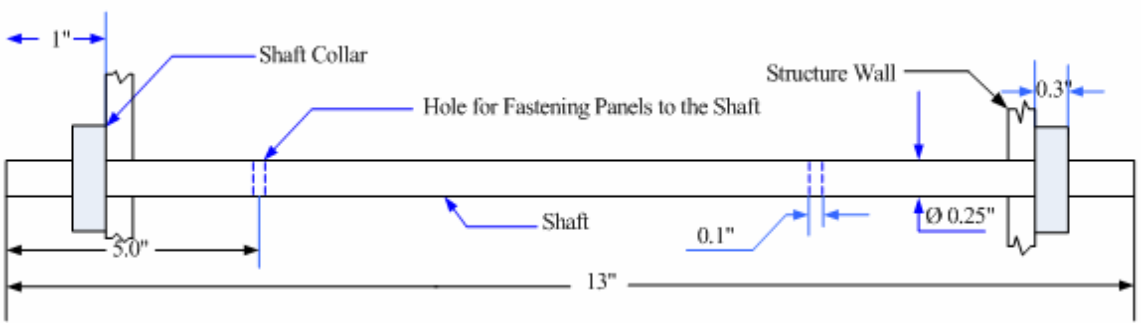

Fig. 4.9 Shaft for Orienting Identified and Clean Silverware

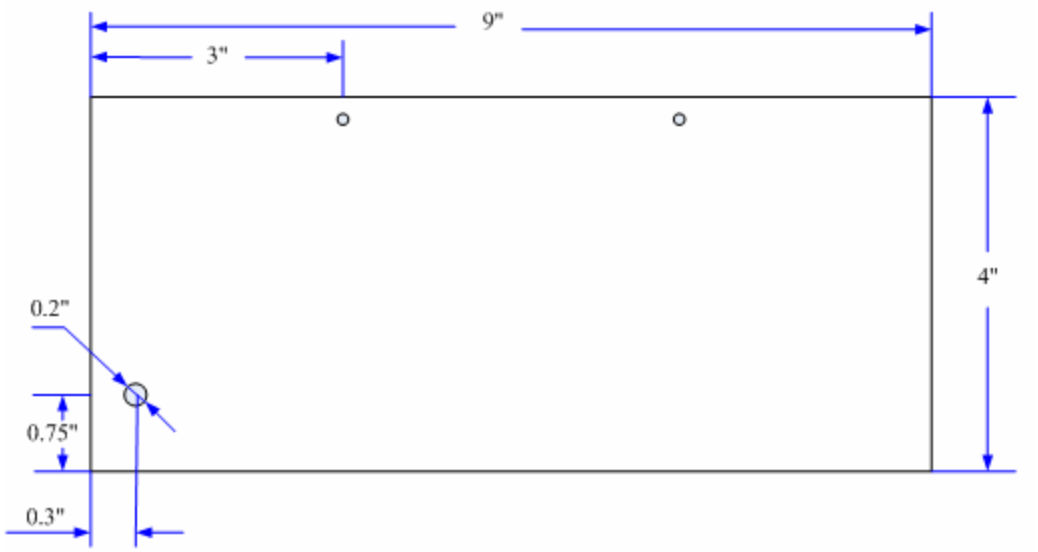

Fig. 4.10 (a) Left Panel

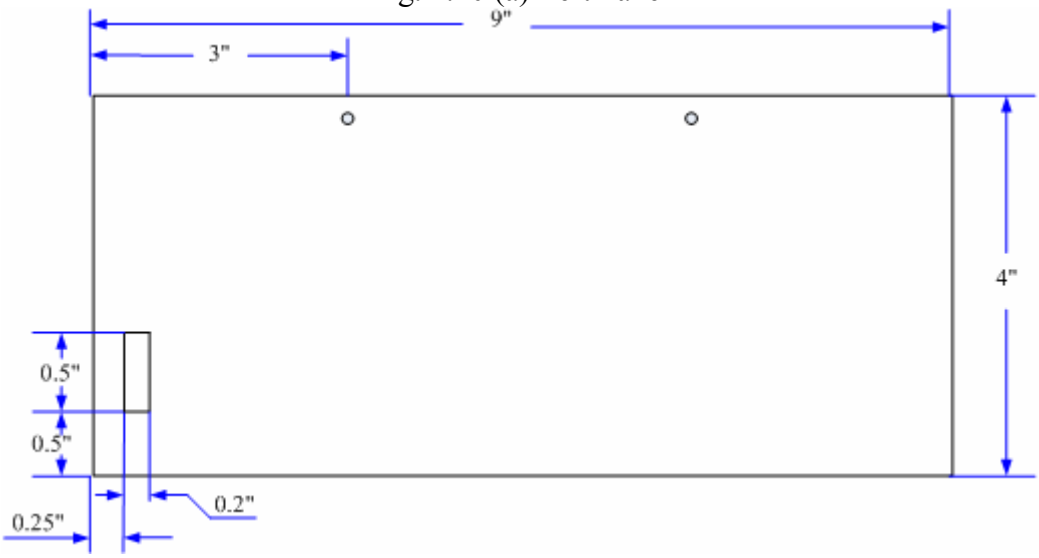

Fig. 4.10 (b) Right Panel

Fig. 4.10 Left and Right Panels

The left and the right panels are bolted to the shafts at the top and they converge toward the bottom. These panels are tied near the bottom left edge as shown in Fig. 4.8 using a light duty metal thread with a backing washer on each plate. The thread is fastened to a push type solenoid plunger. When the solenoid is de-activated, the panel opening aligns with Collection Bin 1, but when an appropriate signal is sent, the solenoid plunger retracts, pulling the wire, which rotates both panels such that the panel opening

aligns with Collection Bin 2. When the solenoid is de-activated, gravity rotates the panels back to align their slot with Collection Bin1. A plunger stopper restricts the motion of the plunger, assuring the panel opening aligns with Collection Bin 1.

The orienting solenoid is from 'Magnetic Sensor Systems' (Part Number: S25–125-H) with the following specifications: 12V DC, pull type, continues duty, '∞' ON time, 1″ stroke length and 16.6 Ω coil resistances. Since the solenoid operates with '∞' ON time in our application, this type of solenoid was selected. It has sufficient stroke length to move the panels enough to allow them to align with the correct collection bins.

Before solenoid activation, the converging panels of the orienting system converge to a Collection Bin 1 as shown in Fig. 4.11. When the silverware riding on the plastic block passes under the camera, a photo optic sensor is triggered and the camera takes the image of the silverware. This image is transmitted to the computer, which uses the software designed by Lolla (2005) to determine whether that specimen is clean, and its type and orientation if it's clean. Silverware detected as clean and identified as to orientation (left, right) and, type (knife, fork, spoon , soupspoon) will cause the solenoid connected to the lifter designed for that piece to be activated, which rotates the fingered lifter, into the slots of the plastic block carrying that piece. This lifts the identified clean piece off the plastic block such that it slides into the orienting system. If the silverware is oriented left as determined by software designed by Lolla (2005), the orienting solenoid will not actuate, allowing the silverware to reach Collection Bin 1 as shown in Fig. 4.11 (a). If the silverware orientation is detected as oriented right, then the orienting solenoid will actuate, the converging panels will now converge to Collection Bin 2 as shown in Fig. 4.11 (b), allowing the silverware to reach Bin 2. When the next trigger occurs for the

silverware to be processed, the program sends a signal to deactivate, and gravity rotates the converging panels to back its initial position (Fig. 4.11 (a)).

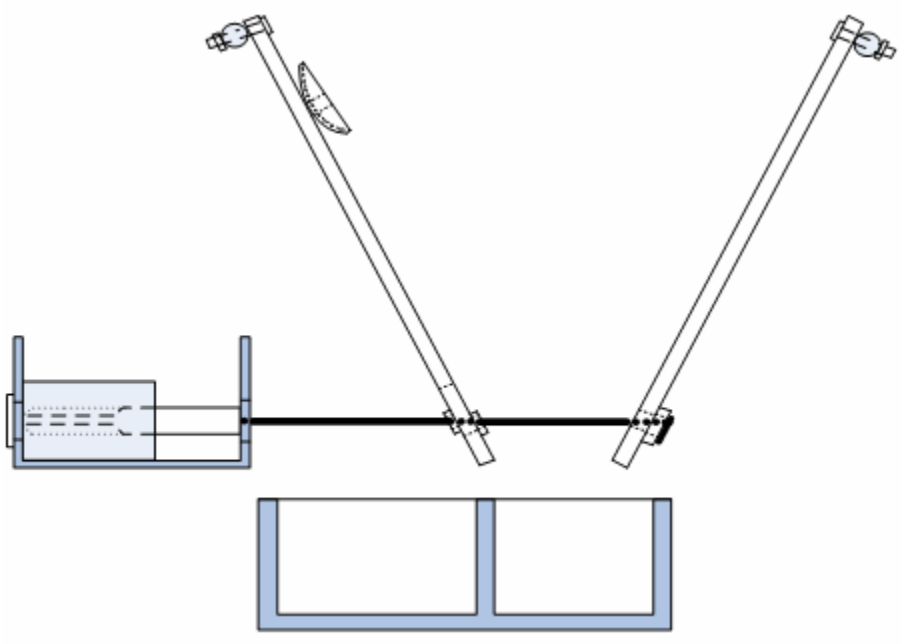

Fig. 4.11(a) Orienting System when Orienting Solenoid at Initial Position

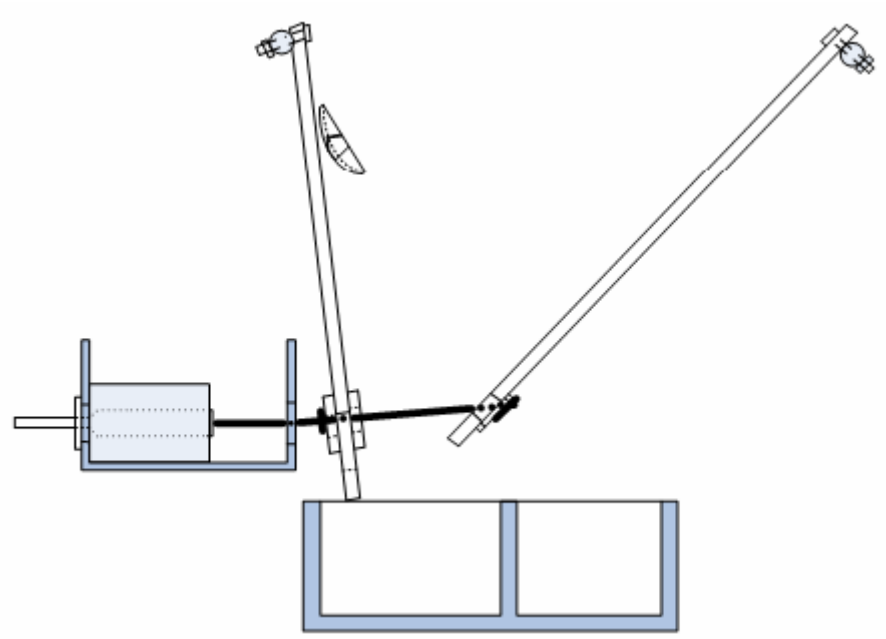

Fig. 4.11(b) Orienting System when Orienting Solenoid is Actuated

Fig. 4.11 Working of Orienting System

The program is coded in such a manner that once the optical sensor is triggered by a slotted plastic block, and silverware is clean and identified, depending on the orientation and the type of silverware, the command is sent from the data acquisition board (DAQ) PCI 6503 to the appropriate relay, causing the relay to output 12 V and 0.75 A to actuate the corresponding solenoid, with a delay of 0.25 times the total time between the triggers. Solenoid activation pulls the orienting panels to align with the Collection Bin 2, as illustrated in Fig. 4.11. Gravity returns the lifter to its designated, rest position (align with Collection Bin 1, Fig. 4.11 (a)) once the program sends the signal to deactivate the solenoid attached to the lifter, as the next trigger occurs. Fig. 4.12 presents a circuit diagram for the four (knife, fork, spoon, soupspoon) orienting solenoids.

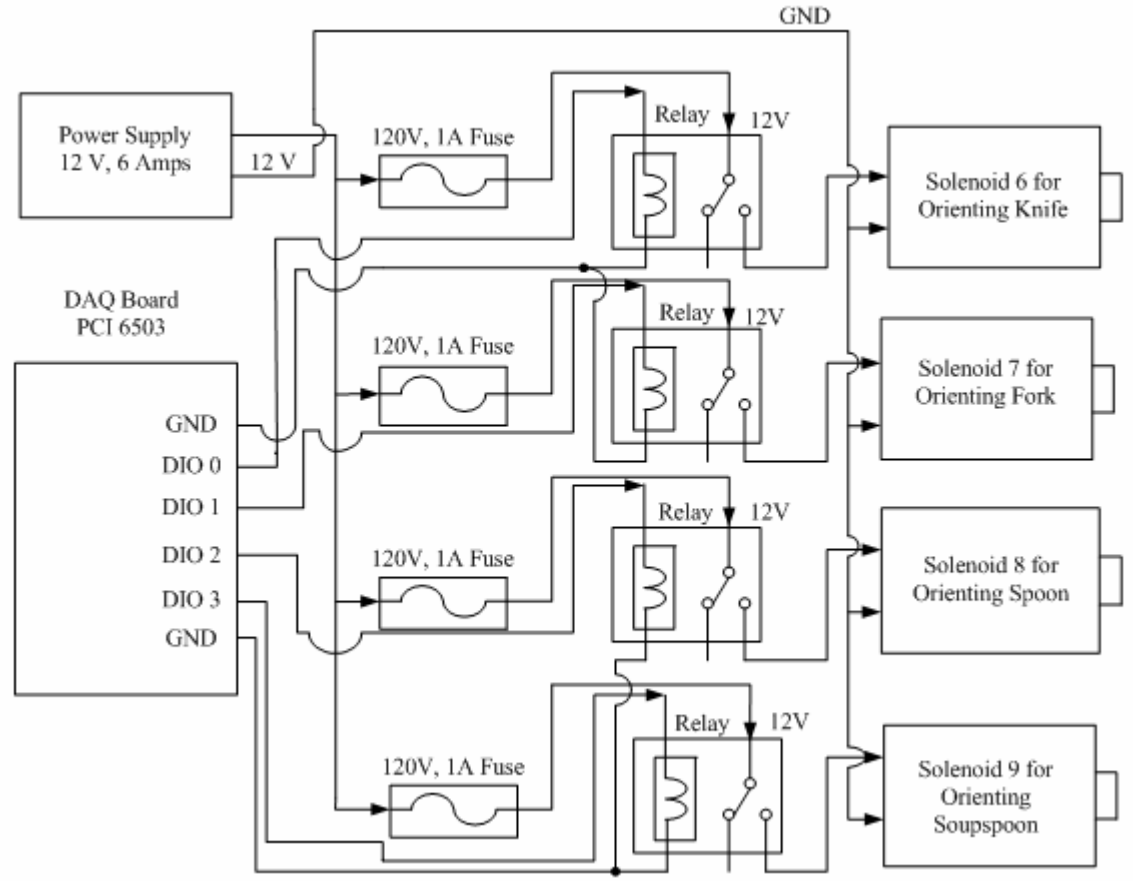

Fig. 4.12 Circuit Diagram of Orienting System for Identified and Clean Silverware

4.4 Power Supply

The power supply for the actuated orienting system was constructed with the help of Brett Riegel at the Electronics shop in the Department of Mechanical and Aerospace Engineering, OSU. One power source of 12 V, 8 Amps (Astec Company, # ATX 202-3515) was built for actuating the orienting solenoids. The power supply and other circuitry are housed in a box with an appropriate front panel having several outlets, through which the devices can be connected to the power supply. The box is connected to connector blocks for the DAQ Board PCI 6503 using a DB 9 connector cable.

4.5 Software

After the required hardware was constructed, the focus was on software development. An application-programming software package called NI DAQ from National Instruments, which accompanies the NIDAQ Board (Nagaraj, 2003) was used. This software acts as an interface with the DAQ application and DAQ boards, and provides functions pertaining to all the features available, such as Digital I/O, Analog I/O and timers (NIDAQ for PC compatibles, 2001). We used Measurement Automation Explorer (MAX), a graphic user interface (GUI) that enables easy DAQ application to all National Instruments devices. The main features of MAX are

- Configure all NI hardware and software.
- Add new channels, interfaces and virtual instruments
- Execute system diagnostics
- View devices and instruments connected to the system.
- Schedule updates to NI software.

4.5.1 Program Description

The major challenge was to develop a system that could work independent of conveyor belt speed. Relevant dimensions are given in Table 4.2 and 4.3. We define Magnetic Distance (MD) as a unit less quantity obtained by dividing an actual distance by the distance between two adjacent magnetic strips (12.6 inches).

Components	Distances (Inches)	Magnetic Distance (MD Units)
Distance Between Leading Edges of Two Adjacent Magnets	12.6	1.0
Distance Between Leading Edges of Two Adjacent Silverware Lifting Systems	6.3	0.5

Table 4.2 Distances Between Adjacent Components

COMPONENTS	Actual Distance from the Entrance of the Vision System (Inches)	Magnetic Distance (MD Units)
Distance to Leading Edge of Lifting System for Unclean Pieces	18.9	1.5
Distance to Leading Edge of Lifting System for Soupspoon	25.2	2
Distance to Leading Edge of Lifting System for Spoon	31.5	2.5
Distance to Leading Edge of Lifting System for Fork	37.8	3
Distance to Leading Edge of Lifting System for Knife	44.1	3.5

Table 4.3 Distances to Components from Vision System Entrance

The distance between two adjacent lifting systems is 6.3", which is 0.5 MD (Table 4.2). The distance from the entrance of the vision system to the lifting system for unclean pieces is 18.9", which is 1.5 MD (Table 4.3). Referring to Fig. 4.1 and Table 4.3, we can infer that if a slotted plastic block is at the entrance of the vision system, the next downstream slotted plastic block will be near the lifting system for unclean silverware which is 1.5 MD (Table 4.3). Similarly, the second downstream block will be past the lifting system for unclean silverware and near the lifting system for soupspoons, which is at 2 MD (Table 4.3); the third downstream block will be past the lifting system for soupspoons and near the lifting system for forks, which is at 3 MD (Table 4.3); and the forth downstream block will have just passed the lifting system for knifes. Hence for every trigger, one of the following actions will occur:

- An unclean piece is lifted at the next trigger.
- A spoon or soupspoon is lifted after the second trigger.
- A knife or fork is lifted after the third trigger.
- An unidentified silverware is lifted off by the static lifter.

It was noticed that the spacing between one pair of magnetic strips is 14.11", which is different form all the others, which causes, once each cycle of the conveying chain, an incorrect timing of the signal to the lifters. When the odd pair of the magnets triggers the optical sensor, and the silverware piece to be lifted is either a soupspoon or a fork, the signal will actuate the lifters with an incorrect time lag, causing the lifters to actuate just after the plastic block passes the lifter, such that the soupspoon or fork will not be lifted. This problem could be fixed by remaking the chain drive such that all magnetic blocks are equally spaced. The maximum lifting error was calculated as 12 % because there are seven equal spaces and one unequal space between magnets for one complete chain revolution. If suppose there was either a fork or a soupspoon on the magnet following the unequal space for all chain revolutions, then 12 pieces would not be lifted for every 100 pieces of silverware.

The program was written so as to sort the pieces independent of belt speed. Initially Pins DIO 0 to DIO 4 of the 8 bit Digital I/O Port of PCI 6035 E are configured as outputs, and Pin DIO 5 is configured as input (Fig. 4.13). Pins 6 and 7 are not used. For the other DAQ board PCI 6503, Pins PB0 to PB3 of the 8 bit Digital I/O Port are configured as outputs, and Pins PB4 to PB7 are not used.

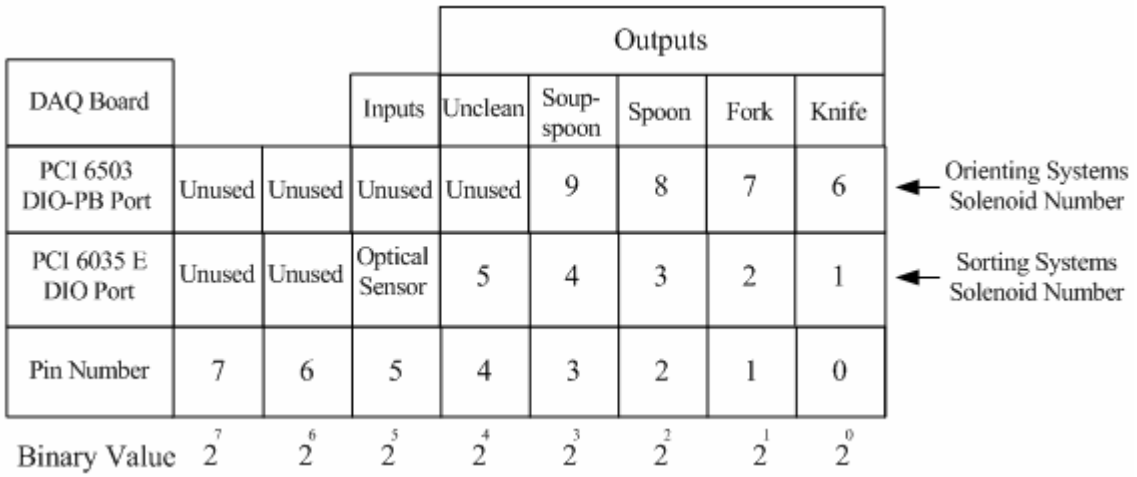

Fig. 4.13 Digital I/O Port of DAQ PCI 6035 E, and DAQ PCI 6503

Pin DIO 0 of the Digital I/O Port (PCI 6035 E) signals the lifting system for a knife (Solenoid 1, Table 4.4), i.e. if Pin DIO 0 is high then the bit value 1 which corresponds to the binary value 00000001 (Fig. 4.16, Table 4.4), is sent to the DAQ board, PCI 6035 E, Solenoid 1 connected to the lifter designed for the knife is activated, causing the knife to lift off the plastic block. Similarly for forks, spoons, soupspoons and unclean silverware. As an example, suppose the DAQ board (PCI 6035 E) receives the binary value 0001000. Then from Fig. 4.16 and Table 4.4, only Pin No. 3 would be "high", such that only Solenoid No. 4 would be activated, and only the soupspoon lifter would lift. On the other hand, suppose the DAQ board receives the binary value 0000110. Then form Fig. 4.16 and Table 4.4, both Pins 2 and 1 would be "high", such that both Solenoids 3 and 2 would be activated, and both the spoon and fork lifters would lift.

COMPONENTS	Solenoid Number	Bit Value for the Matrix	Binary Value (PCI 6035 E and PCI 6503)
Lifting System for Unclean Pieces	5	16	00010000
Lifting System for Soupspoon	4	8	00001000
Lifting System for Spoon	3	4	00000100
Lifting System for Fork	2	2	00000010
Lifting System for Knife	1	1	00000001
Orienting System for Soupspoon Oriented Right	9	8	00001000
Orienting System for Spoon	8	4	00000100
Orienting System for Fork Oriented Right	7	2	00000010
Orienting System for Knife Oriented Right	6	1	00000001

Table 4.4 Solenoids and Their Corresponding Bit and Binary values

Similarly, Pin PB0 of the Digital I/O Port signals the orienting system for a knife oriented right (Solenoid 6, Table 4.4), i.e. if Pin PB 0 is high then the bit value 1 which corresponds to the binary value 00000001 (Fig. 4.16, Table 4.4), is sent to the DAQ board, PCI 6503, Solenoid 6 connected to the orienting panels designed for the knife oriented right is activated, causing the orienting panels to align with the Collection Bin 2 for knives, and collect the knife oriented right. Similarly for forks, spoons, and soupspoons. Table 4.4 shows the orienting systems and their corresponding bit and binary values. As an example, suppose the DAQ board (PCI 6503) receives the binary value 0001000. Then from Fig. 4.16 and Table 4.4, only Pin PB3 would be “high”, such that only Solenoid No. 9 would be activated, and only the soupspoon orienting panels would move to Collection Bin 2. On the other hand, suppose the DAQ board receives the binary value 0000110. Then form Fig. 4.13 and Table 4.4, both Pins PB2 and PB1 would be

“high”, such that both Solenoids 7 and 8 would be activated, and both the spoon and fork orienting panels would move to Collection Bin 2.

Initially an array A[i], and B[i], with index i = 0 … 3, is declared and initialized at A[i] =0, and B[i] =0, for all ‘i’ as shown in Fig. 4.14. The magnet-aluminum-plastic block driven by the chain drive triggers the optical sensor at the entrance to the vision system, which causes the Pin DIO5 of the Digital IO Port of PCI 6035 E to become high, and at that instant the program outputs A[0] as signal to the DAQ board (PCI 6035E), and the respective solenoids are activated causing the appropriate silverware piece to be lifted off. The program outputs B[0] as signal to the DAQ board (PCI 6503) after 0.25 times the total time between triggers, and the respective solenoids are activated depending upon the orientation, causing the appropriate silverware piece to orient. A[0], and B[0] are the only elements in the arrays that provide a signal to the DAQ boards (PCI 6035 E and PCI 6503 E) respectively. All the other values for A[i], and B[i], i=1…3, are used to calculate A[0] and B[0] respectively, as determined from Table 4.5 and illustrated in Figs. 4.14 – 4.19.

SYSTEMS	CALCULATION New value=Old value+ Bit value
Lifting System for Unclean Pieces	A[0]=A[0]+16
Lifting System for Soupspoon	A[1]=A[1]+8
Lifting System for Spoon	A[1]=A[1]+4
Lifting System for Fork	A[2]=A[2]+2
Lifting System for Knife	A[2]=A[2]+1
Orienting System for Soupspoon Oriented Right	B[1]=B[1]+8
Orienting System for Spoon Oriented Right	B[1]=B[1]+4
Orienting System for Fork Oriented Right	B[2]=B[2]+2
Orienting System for Knife Oriented Right	B[2]=B[2]+1

Table 4.5 Systems and Corresponding Calculations

The program then waits until the next trigger signal is received, allowing the machine vision system to receive an image form the camera, identify and inspect the image using software designed by Lolla (2005), and transmit appropriate information (A[0], B[0]) to a solenoid activating program (Appendix). If the incoming piece is clean and is a spoon or soupspoon, then A[1] is incremented by the bit value 4 or 8, (Table 4.5) respectively; for a knife or fork, A[2] is incremented by the bit value 1 or 2 (Table 4.5) respectively. If the incoming piece is clean, is a spoon or soupspoon, and is oriented right then B[1] is incremented by the bit value 4 or 8, (Table 4.5) respectively; for a knife or fork oriented right, B[2] is incremented by the bit value 1 or 2 (Table 4.5) respectively, indicating solenoid actuation at the respective triggers. Then, the array A[i], and B[i] are decremented by index one, which means that the value of A[i] and B[i] are replaced by the value of A[i+1] and B[i+1], except for A[3] and B[3], which are replaced by 0. If the

silverware piece detected is dirty, the bit value 16 (Table 4.5) is added to array A[0] after decrementing the array, which indicates that Solenoid 5, which is used for lifting dirty pieces, is actuated next.

As an example to illustrate this process, assume the order of incoming pieces is as shown Left to Right in Table 4.6.

Silverware Pieces	Knife	Fork	Spoon	Soupspoon	Unclean	Unidentified
Orientation of Silverware	Right	Left	Right	Left		

Table 4.6 Order of Incoming Pieces (Example)

The initial step, as shown in the flow chat in Fig. 4.20, is to initialize array A[i], and B[i] to zeros (Fig. 4.14).

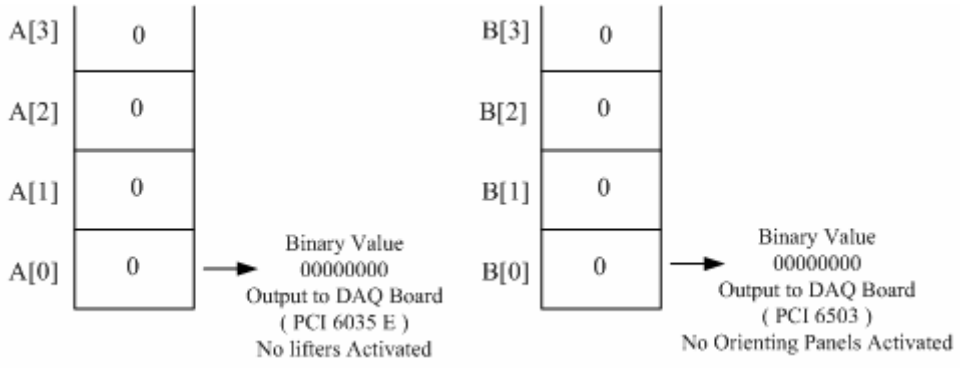

Fig. 4.14 Initializing the Array "A[i]", and "B[i]"

When the first trigger occurs by the slotted plastic block passing the photo optic sensor at the vision system entrance, the program takes the control to Process1 (Fig. 4.21), where the value of A[0] = 0 and B[0] = 0 is passed to the respective DAQ boards. Since A[0] = 0, and B[0] = 0, corresponding to the binary values 00000000 (none of the input pins are high, Fig. 4.13), the DAQ outputs will be zero, such that no lifter solenoid and orienting panel solenoid will be actuated. The program waits for one MD to be traversed by the

plastic block- chain drive system. Then, at the next trigger, the incoming piece is to be identified by the software developed by Lolla (2005). When the silverware is identified as a clean knife oriented right, the control goes to Process 2, as shown in the Process Flow Chart (Fig. 4.22), where the bit value 1 (Table 4.4) is added to A[2] and B[2] (Table 4.5) and both the arrays are decremented once, as shown in the Process Flow Chart 2 (Fig.4.22) and Fig. 4.15.

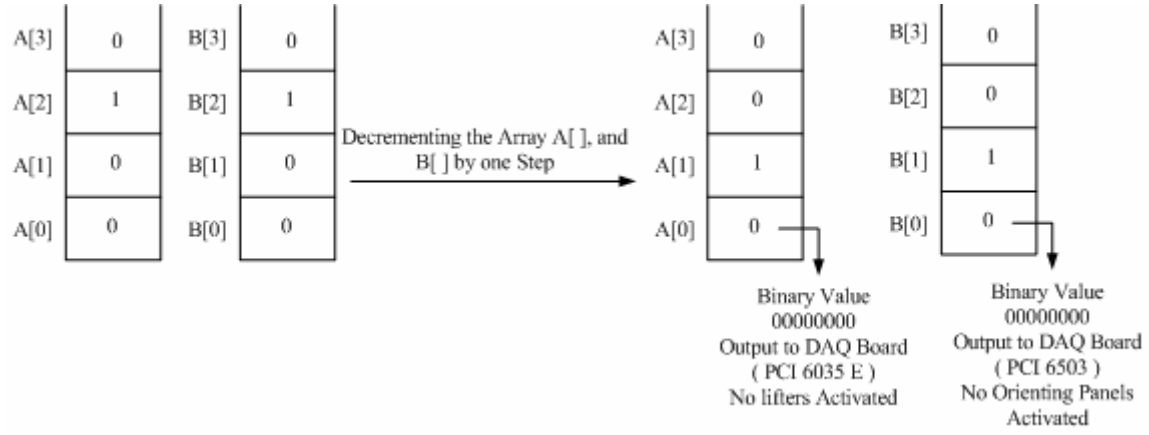

Fig. 4.15 Step if Clean Knife Oriented Right is Identified

Similarly, after another MD is traversed, the second trigger occurs, arrays A[0], B[0] are 0, whose binary values '00000000' are sent to the DAQ boards (PCI 6035E and PCI 6503). Since none of the pins is "high", (i.e. '1'), no lifter solenoids and orienting panel solenoids are activated (Fig 4.15). If the incoming piece is identified as a fork oriented left by the software, the value 2 (Table 4.5) is added to A[2], but no operation is done on array B[i], since the orientation was identified as left, and the orienting panels remain at to Collection Bin 1 (initial position), where forks oriented left are collected. Both arrays A[i], and B[i] are then decremented once as shown in Figs. 4.16 and 4.22.

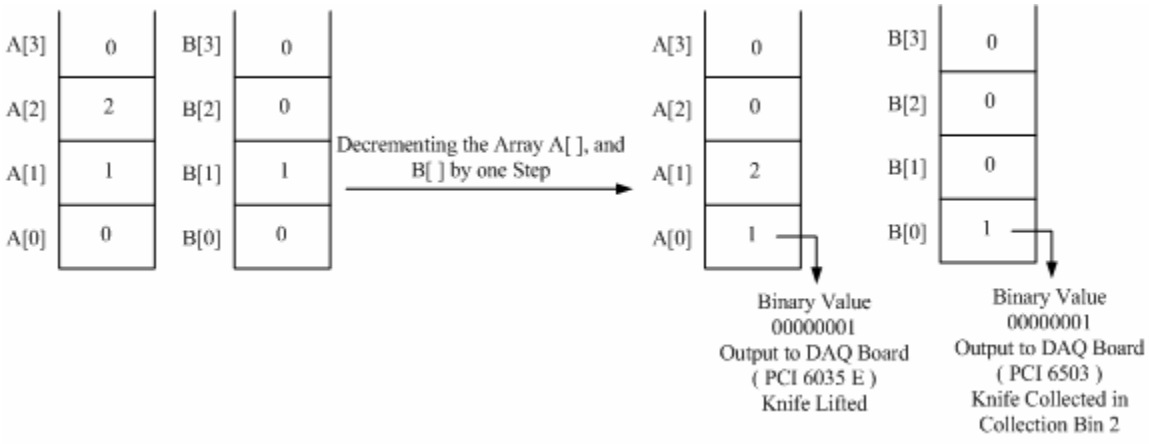

Fig. 4.16 Step if Clean Fork Oriented Left is Identified

As the third trigger occurs after another MD is traversed, the value of A[0] = 1, is sent to the DAQ, PCI 6035 E (Fig 4.21), and B[0] =1 is sent to the DAQ, PCI 6503. The binary value of A[0] is "00000001", Pin 0 of the DIO port (PCI 6035 E) is "high", (i.e. '1'), which causes the Solenoid 1 (Fig. 4.13) to activate and lift the knife off the slotted-plastic block and after 0.25 times the total time between triggers, the binary value of B[0] is "00000001", Pin PB0 of the DIO port (PCI 6503) is "high", (i.e. '1'), which causes the Solenoid 6 (Fig. 4.13) to activate, and align the orienting panels with Collection bin 2 of knifes so as to collect the right oriented knife in Collection bin 2. If the incoming piece is identified as a clean spoon oriented right, the value 4 is added to both A[1] and B[1] (Table 4.5), and both the arrays are decremented once as shown in the Process Flow Chart 2 (Fig. 4.22) and Fig. 4.17.

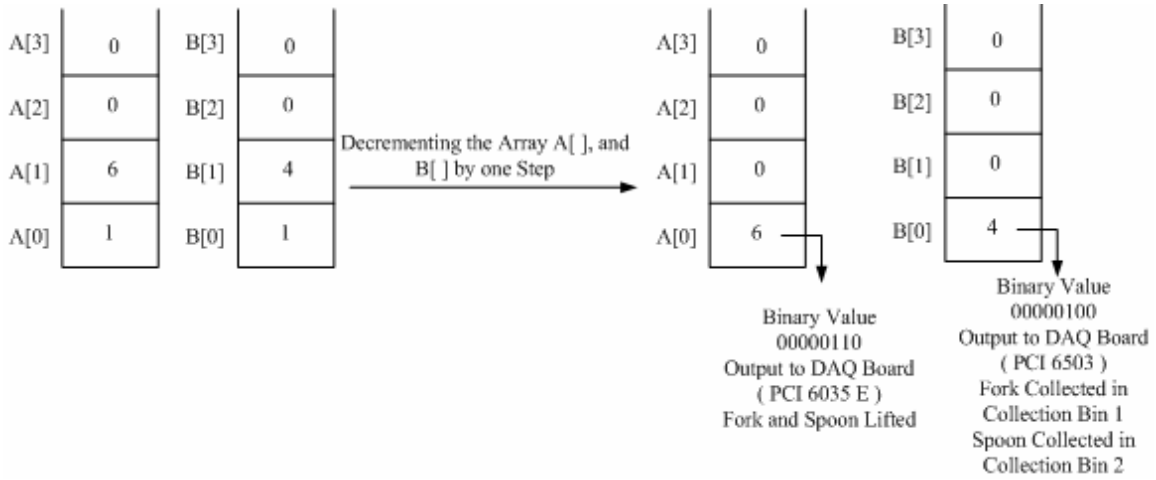

Fig. 4.17 Step if Clean Spoon Oriented Right is Identified

As the fourth trigger occurs after another MD is traversed, the program sends A[0] = 6 (binary value 00000110) to the DAQ board (PCI 6035 E), the Pins 1 and 2 go “high”, causing the Solenoids 2 and 3 to activate (Fig 4.13) the lifters for lifting both the fork and spoon off the plastic block into their respective orientation systems block; after 0.25 times the total time between triggers, the binary value of B[0] is “00000100”, Pin PB2 of the DIO port (PCI 6503) is “high”, (i.e. ‘1’), causes the Solenoid 8 (Fig. 4.13) to activate, and align the orienting panels with Collection bin 2 for Spoon

s, so as to collect the right oriented spoon in Collection bin 2. Likewise, Pin PB1 of the DIO port (PCI 6503) is “low”, (i.e. ‘0’), causing Solenoid 8 (Fig. 4.13) not to actuate, since the orientation was identified as left, and the orienting panels align with Collection Bin 1; the Fork oriented left is collected in Bin 1. Parallel processing is accomplished. If the incoming piece is identified as a soupspoon oriented left, the value 8 is added to A[1] (Table 4.5), but no operation is done on array B[ ], since the orientation was identified as left; the orienting panels align with Collection Bin 1, where soupspoons oriented left are collected. Both arrays A[i], and B[i] are then decremented, once as shown in the Figs. 4.18 and 4.22.

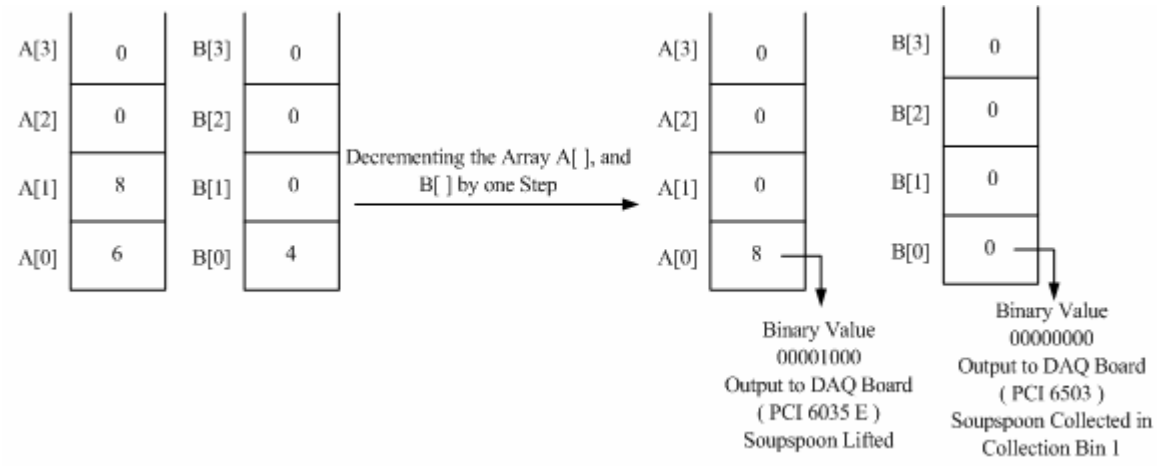

Fig. 4.18 Step if Clean Soupspoon Oriented Left is Identified

As the fifth trigger occurs, array A[0] = 8, (binary value 00001000) causes the Pin DIO 3 of DAQ board (PCI 6035 E) to go high, the Solenoid 4 activates, and the lifter lifts the soupspoon off the plastic block; after 0.25 times the total time between triggers, the value of B[0] = 0 is passed to the DAQ board (PCI 6503). Since B[0] = 0, corresponding to the binary value 00000000 (none of the input pins are high, Fig. 4.13), the DAQ board (PCI 6503) output will be zero, such that no orienting panel solenoid will be actuated, since the orientation was identified as left, and the orienting panels align with Collection Bin 1 and the soupspoon oriented left is Collected in Bin 1. If the incoming piece is identified as unclean, then both the arrays A[i], and B[i] are decremented once, the bit value 16 (Table 4.5) is added to A[0], and no operation is done on array B[0], as shown in the Figs. 4.19 and 4.22.

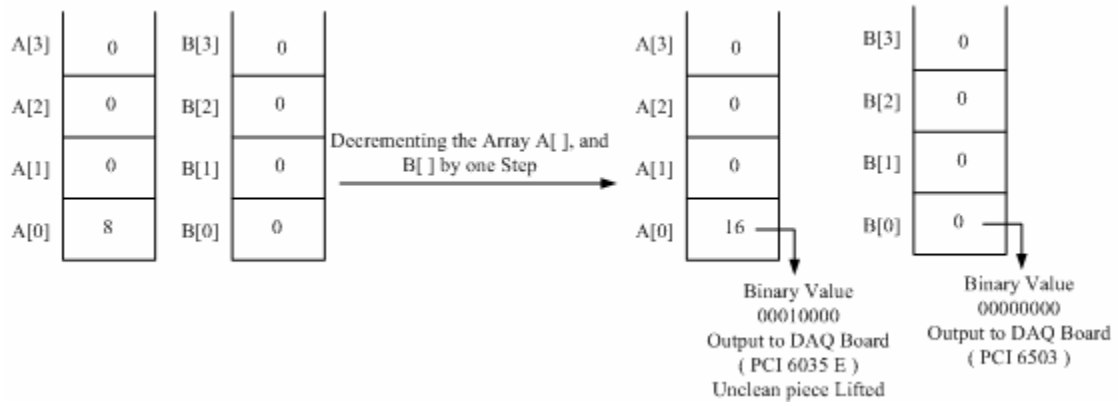

Fig. 4.19 Step if Silverware is Identified as Unclean

At the sixth trigger, array A[0] = 16 (binary value 0010000), the program sends signals to the solenoid using DAQ PCI 6035 E to activate the lifter for unclean silverware off the plastic block, since the Pin DIO 4 is high (Table 4.5). After the next image is captured by the vision system, the value of B[0] = 0 is passed to the DAQ board (PCI 6503). Since B[0] = 0, corresponding to the binary value 00000000 (none of the input pins are high, Fig. 4.13), the DAQ output will be zero, such that no orienting panel solenoid will be actuated. If the incoming piece is unidentified by the vision system, both the arrays A[i], and B[i] are simply decremented by index one, such that none of the solenoids activate. Thus, this unidentified piece is lifted off by the static lifter for unidentified silverware, reintroducing the silverware into the vibrating hopper (Hashimoto, 1995).

The program continues to run until the user stops the process. Figs. 4.20 – 4.22 present a flow chart of the software code, showing all the processes. The actual software code for this project has been included in the Appendix. The next chapter presents test results to evaluate the concept and operation described in this chapter.

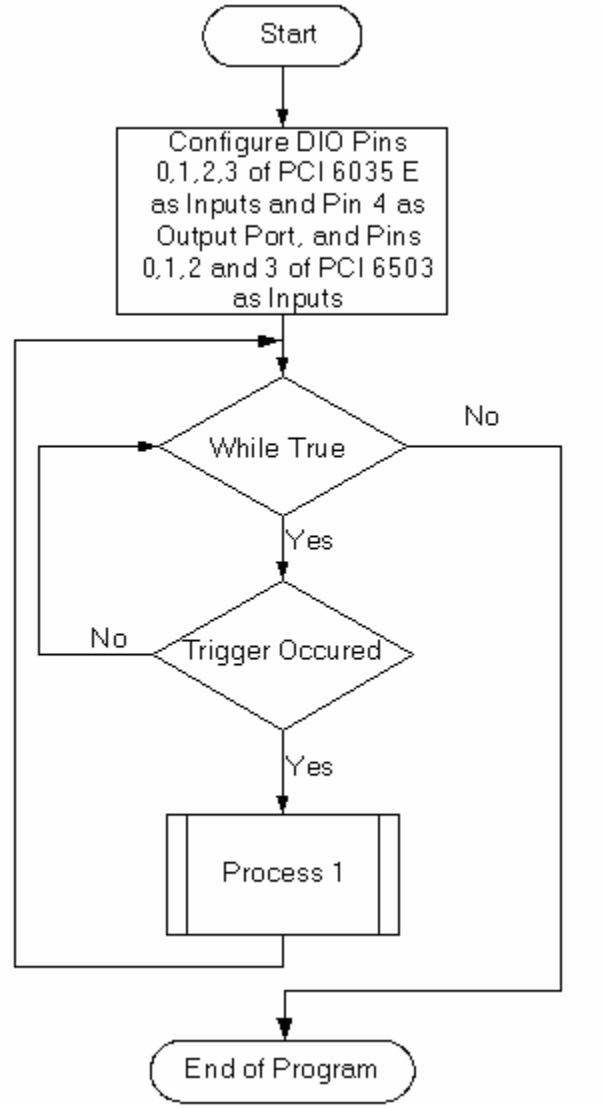

Fig. 4.20 Flow Chart

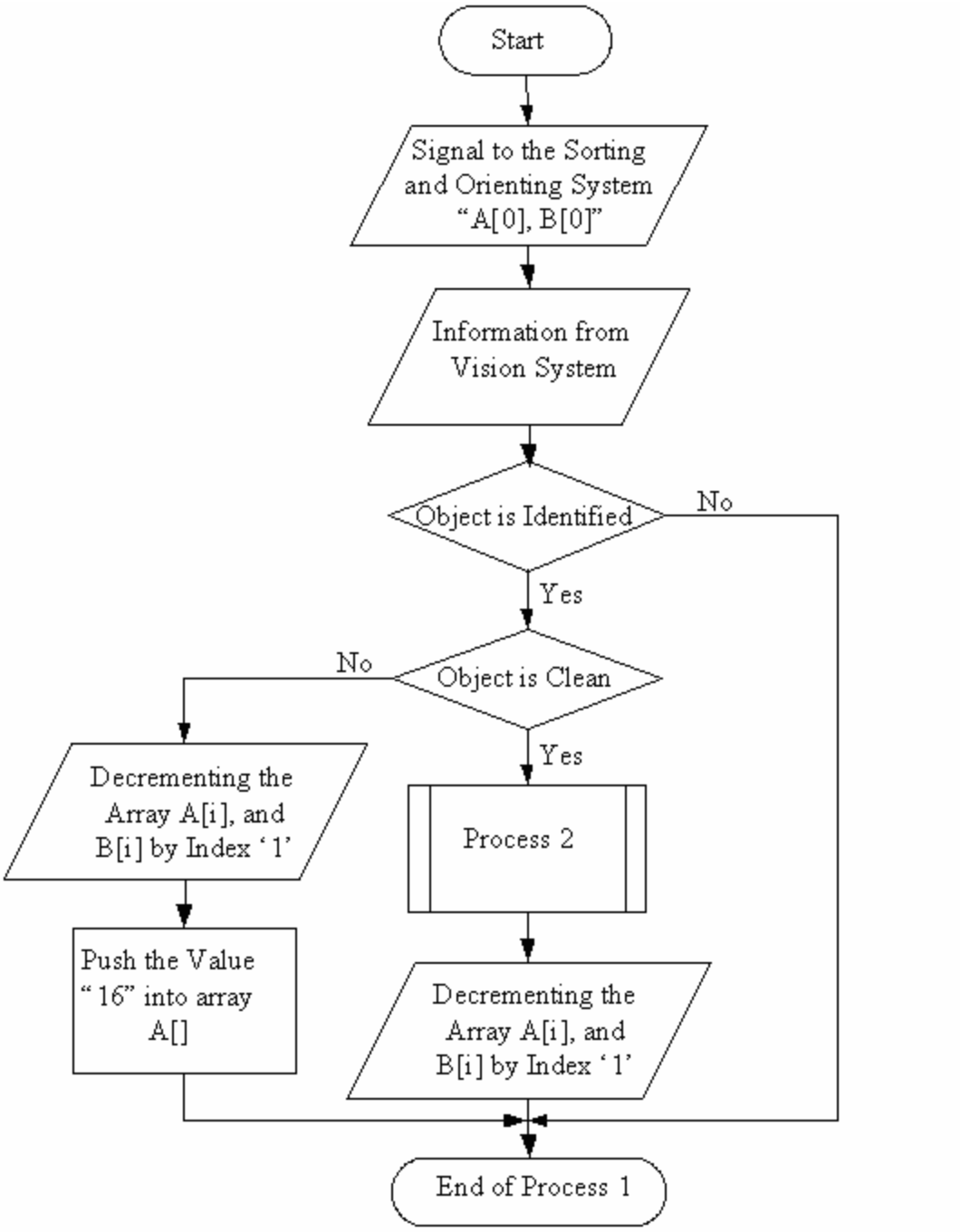

Fig. 4.21 Process Flow Chart 1

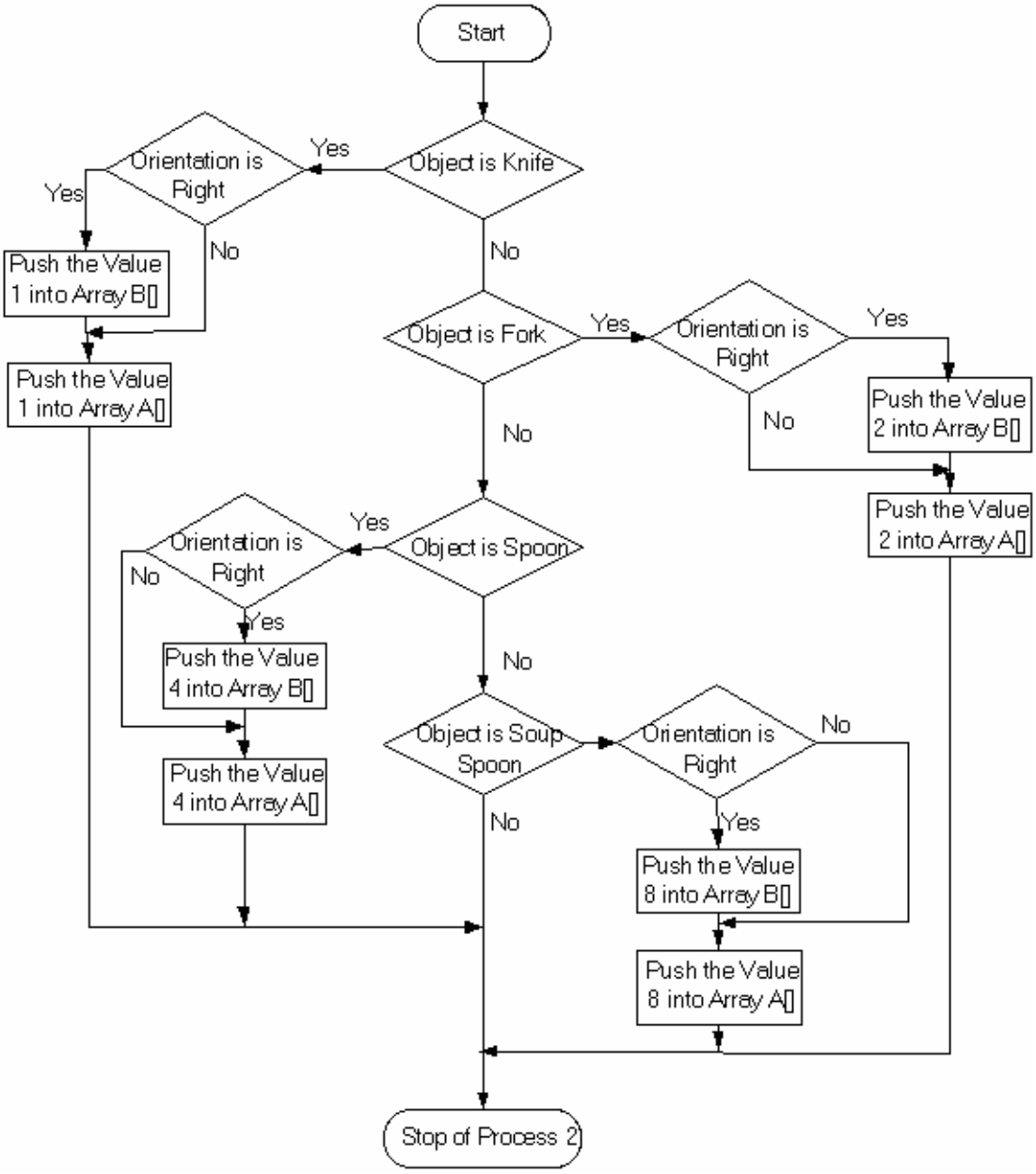

Fig. 4.22 Process Flow Chat 2

CHAPTER 5

RESULTS, CONCLUSIONS AND RECOMMENDATIONS

5.1 Criteria for Experimentation

After implementing the design and software described in the previous chapters, the Silverware Sorting and Orienting Machine (SSOM) was ready for evaluation. The criteria selected to evaluate the performance of the SSOM were as follows:

- The accuracy with which the silverware slides along the short base plate to the top of a slotted plastic block
- The accuracy with which the lifter operates, causing the silverware to lift off the slotted plastic block.
- The accuracy with which silverware pieces are oriented and directed to their respective collection bins.
- Repeatability
- Rate of processing – number of silverware pieces sorted and oriented correctly per unit time.
- Overall Efficiency of SSOM

5.2 Evaluation Independent of Machine Vision Identification

The purpose of this study was to investigate means to effectively sort and orient mixed silverware, piece by piece, in order to test the silverware sorting machine independent of the machine vision based silverware identification system (Fig. 5.1). To

do this, the silverware was manually fed at the entrance of the vision system in a pre-selected sequence and orientation. The information regarding the type of silverware, its orientation, and its position in the sequence was keyed into a special sorting test computer program, which replaced the vision system function. This "sorting" program sent signals to the SSOM system, which then processed silverware accordingly. In other words, after a photo-optic sensor was triggered, information about the type and orientation of the specific silverware piece came from this sorting test program, rather than vision system.

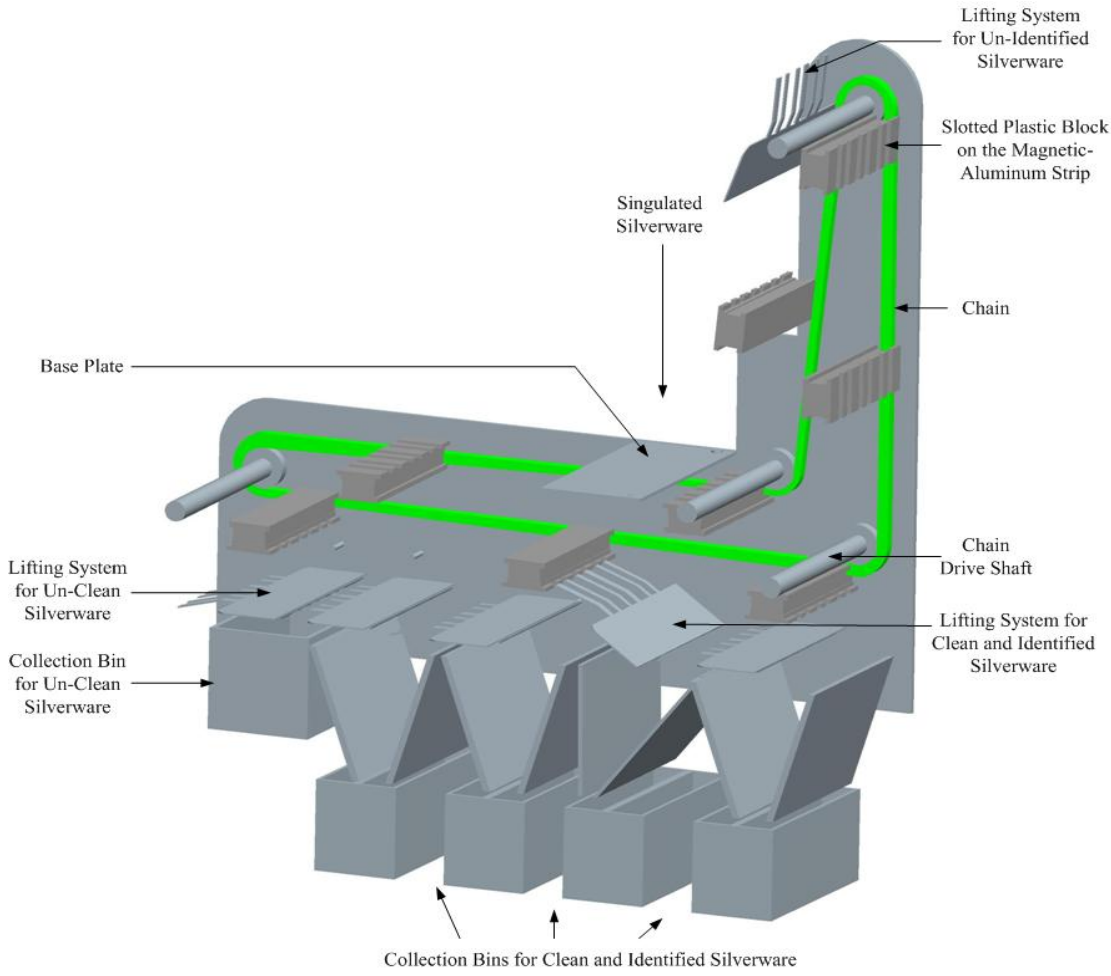

Fig. 5.1 Sorting and Orienting System without Vision System

For testing and evaluation purposes a batch consisting of 25 randomly mixed silverware pieces consisted of 5 each of clean knives, forks, spoons, and soupspoons, plus 3 unclean, and 2 unidentified pieces was used. The sequences chosen (Sequence 1, and Sequence 2) is given in the Appendix. Sequences 1 and 2 were each implemented 10 times, giving a total of 500 entities processed. The performance of the lifter and the orientation system powered by solenoids was observed and recorded at several different belt speeds. Belt speeds are recorded in pieces/min, assuming every magnet contained a silverware piece.

5.2.1 Performance at 40 pieces/minute Processing Rate

A batch of 25 pieces of silverware consisted of 5 each of clean forks, knives, spoons, and soupspoons plus 3 unclean, and 2 unidentified pieces with Sequence 1 and Sequence 2 (Appendix) was implemented 10 times for each sequence, giving 250 entities processed for each sequence. The performance of the lifters and the orientation system powered by solenoids was observed and recorded at a belt speed of 40 pieces/ min, with results given in Table 5.1 and Table 5.2.

Trial	**Correctly Processed 25 Pieces of Silverware**	**Incorrectly Processed**	
		Sorting System	**Orienting System**
1	25	0	0
2	24	1	0
3	25	0	0
4	24	1	0
5	24	1	0
6	25	0	0
7	25	0	0
8	25	0	0
9	24	1	0
10	25	0	0
Total	246	4	0

Table 5.1 Performance of SSOM Components for Sequence 1, 40 pieces/min

Trial	Correctly Processed 25 Pieces of Silverware	Incorrectly Processed	
		Sorting System	Orienting System
1	24	1	0
2	25	0	0
3	25	0	0
4	25	0	0
5	24	1	0
6	25	0	0
7	24	1	0
8	25	0	0
9	24	1	0
10	25	0	0
Total	246	4	0

Table 5.2 Performance of SSOM Components for Sequence 2, 40 pieces/min

It can be seen from Tables 5.1 and 5.2 that the accuracy of sorting was 98.40%, and the accuracy of orientation was 100.0%. Further analysis shows that the errors (1.60%) in sorting were caused by the unequal spacing between one pair of magnetic strips, as expected (discussed in Chapter 4), which is within the maximum error rate of 12.00%. This occurred once for each revolution of the chain holding the magnetic blocks, such that the lifter did not actuate at the correct time. This problem could be fixed my remaking the chain drive such that all magnetic blocks are equally spaced. We conclude that the SSOM performs consistently and, has a high rate of repeatability and accuracy at 40 pieces/min processing rate.

5.2.2 Performance at 55 pieces/minute Processing Rate

The performance of the lifters and the orientation system powered by solenoid was observed and recorded at a belt speed of 55 pieces/ min, with the results for Sequences 1 and 2 given in Tables 5.3 and 5.4.

Trial	**Correctly Processed 25 Pieces of Silverware**	**Incorrectly Processed**	
		Sorting System	**Orienting System**
1	25	1	0
2	24	1	0
3	24	1	0
4	25	0	0
5	24	1	0
6	25	0	0
7	24	1	0
8	25	0	0
9	24	1	0
10	25	0	0
Total	245	5	0

Table 5.3 Performance of SSOM Components for Sequence 1, 55 pieces/min

Trial	Correctly Processed 25 Pieces of Silverware	Incorrectly Processed	
		Sorting System	Orienting System
1	25	0	0
2	25	0	0
3	25	0	0
4	24	1	0
5	25	0	0
6	25	0	0
7	24	1	0
8	24	1	0
9	25	0	0
10	24	1	0
Total	246	4	0

Table 5.4 Performance of SSOM Components for Sequence 2, 55 pieces/min

Table 5.3 shows that accuracy of sorting was 98.00%, and Table 5.4 shows that accuracy of sorting was 98.4%, an average of 98.2% accuracy in sorting, only slightly less than for the 40 pieces/min trial. Accuracy of orientation was 100% for both sequences. As before, sorting errors were caused solely by one pair of magnetic blocks having spacing different from the others. We concluded that the SSOM has a high rate of repeatability and accuracy at 55 pieces/minute.

5.2.3 Performance at 60 pieces/minute Processing Rate

The performance of the lifters and the orientation system powered by solenoid was observed and recorded at a belt speed of 60 pieces/ min, with the results for Sequences 1 and 2 given in Tables 5.5 and 5.6.

Trial	Correctly Processed 25 Pieces of Silverware	Incorrectly Processed	
		Sorting System	Orienting System
1	24	1	0
2	24	1	0
3	24	0	1
4	25	1	0
5	23	2	0
6	24	1	0
7	24	1	0
8	25	0	0
9	25	0	0
10	24	1	0
Total	242	8	1

Table 5.5 Performance of SSOM Components for Sequence 1, 60 pieces/min

Trial	Correctly Processed 25 Pieces of Silverware	Incorrectly Processed	
		Sorting System	Orienting System
1	22	2	1
2	24	1	0
3	25	0	0
4	23	2	0
5	24	0	1
6	25	0	0
7	24	1	0
8	24	1	0
9	25	0	0
10	25	0	0
Total	241	7	2

Table 5.6 Performance of SSOM Components for Sequence 2, 60 pieces/min

From Table 5.5, the solenoid efficiency was 96.80% and the accuracy of orientation was 99.59%, Table 5.6 shows that accuracy of sorting was 97.20% and the accuracy of orientation was 99.20%, and an average of 97.00% accuracy in sorting and 99.39% in orientation. Further analysis shows that errors in sorting and orientation were caused by:

1. Some sorting errors were caused by one pair of magnetic blocks having spacing different than the others, as discussed in Chapter 4.

2. In a number of cases, silverware pieces were not lifted off the slotted plastic block because solenoid action was insufficiently fast, causing the block carrying the silverware to pass before lifter actuation.
3. Silverware pieces were not diverted to Collection Bin 2 because solenoid action was insufficiently fast, causing the silverware to collect in Collection Bin 1.

Assuming we desire atleast 98% overall accuracy, at 60 pieces/min, the overall sorting accuracy is low for acceptable operation. However, the accuracy could be increased by using fast actuating solenoids for both sorting and orienting systems.

5.3 Evaluation in Cooperation with Machine Vision Identification System

After testing the SSOM by itself, we conducted experiments to evaluate the performance of the SSOM together with the vision system used for identification and inspection of silverware (Lolla, 2005). Silverware pieces were manually fed at the entrance of the vision system in random sequence and orientation. Each silverware piece triggered a photo-optic sensor, queuing the camera to acquire an image of the silverware (Fig. 5.2). This image was transmitted to the computer, which used the software designed by Lolla (2005) to determine whether that specimen is clean. The information regarding the type of silverware, its orientation, and its position was sent to sorting and orienting test computer program. This “sorting and orienting” program sent signals to the SSOM system, which then processed silverware accordingly.

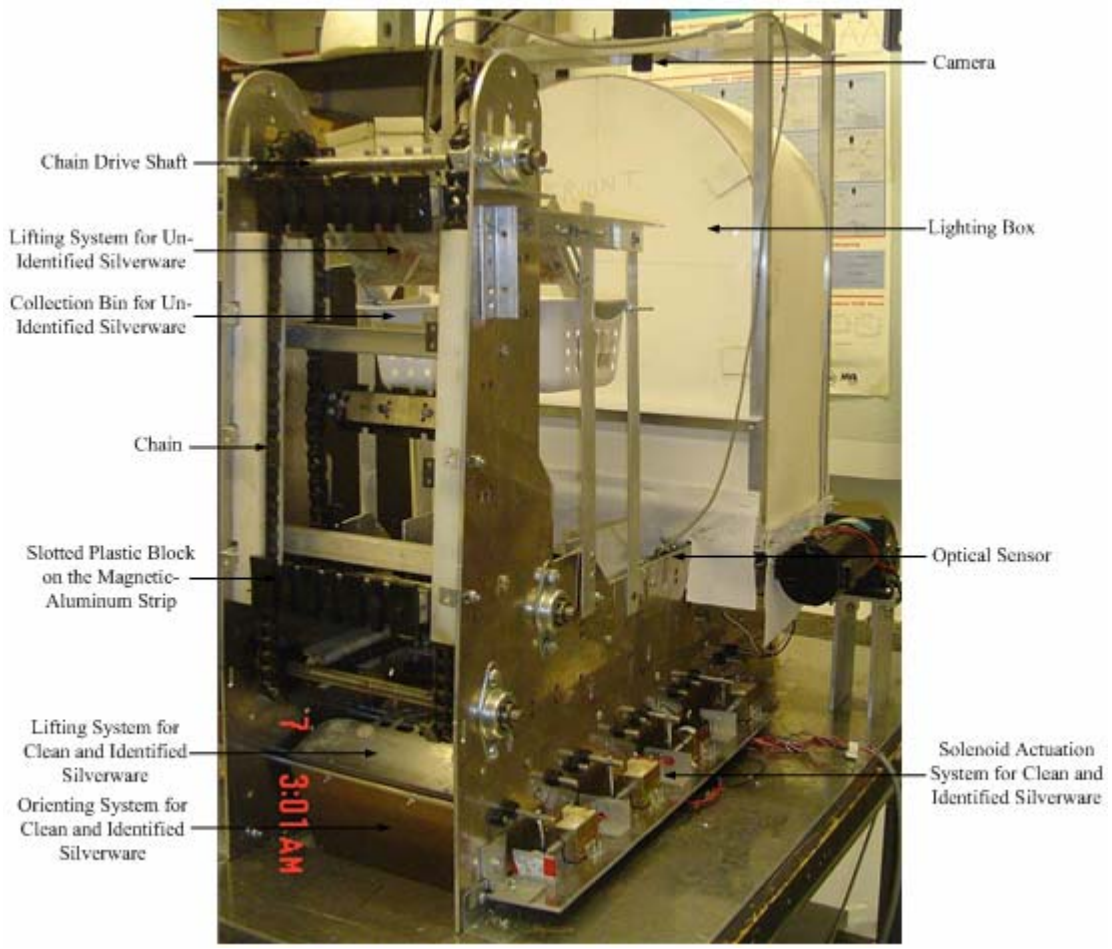

Fig. 5.2 Sorting and Orienting System with Vision System

The speed of the magnetic conveyor belt was set to trigger every 1.3 seconds, yielding a processing rate of 45 pieces/min, which was 40% of the maximum conveyor speed. This trigger time was the sum of the following component times:

1. Time for a slotted plastic block to travel from the photo optic sensor to the line scan camera (0.30 sec);
2. The time taken for the image to be captured by the vision system (0.30 sec); and
3. The maximum time taken for identification and inspection (0.70 sec, Lolla, 2005), which totals 1.30 sec.

Table 5.6 gives the performance of the SSOM coupled to the vision system. Ten trials, in random order at a belt speed of 45 pieces/min were carried out with 25 pieces of silverware in each trial.

Trial	**Correctly Processed 25 Pieces of Silverware**	**Incorrectly Processed**	
		Sorting System	**Orienting System**
1	25	0	0
2	25	0	0
3	25	0	0
4	24	1	0
5	24	1	0
6	24	1	0
7	24	1	0
8	25	0	0
9	24	1	0
10	25	0	0
Total	245	5	0

Table 5.7 Performance of SSOM Components with Vision System.

We observe from Table 5.7 that the accuracy of sorting using the vision system was 98.00%, comparable with the results for the 40 pieces/min trial. Accuracy of orientation was 100%. As before, sorting errors were caused by one pair of magnetic blocks having spacing different than the others. We conclude that the SSOM has a high rate of repeatability and accuracy at 45 pieces/minute.

5.4 Conclusions

In this research we have focused on the design, development, implementation, and evaluation of a silverware sorting and orientation machine. The system is capable of handling both clean and dirty, identified and unidentified, silverware, by sorting, orienting and collecting them in their respective collection bins. The major contributions of this research are:

- Designed, developed and tested a vibration free conveying system.
- Developed, constructed, and evaluated a novel lifting system, replacing the former slow sorting machine that involved many motors and sensors.
- Modified the lifting flap mechanism, making it more reliable and efficient.
- Designed and constructed solenoid-mounting fixtures, along with selecting suitable solenoids for actuating lifters.
- Identified, designed, implemented, and evaluated a method for orienting the silverware.
- Utilized suitable data acquisition boards (DAQ) to implement PC - based control for all components of the Silverware Sorting Machine.
- Eliminated motors and sensors to increase the processing time over previous models.
- Reduced the overall size of the sorting and orienting system.
- Designed, developed, and implemented software code to control all elements of the sorting apparatus, and hence automated the silverware sorting and orienting operations.

- Produced an integrated silverware sorting and orienting system capable of processing silverware at a process rate of 55 pieces/min, with an accuracy of more than 98.00%.
- Synchronized the operation of the Machine Vision System with that of the Silverware Sorting Machine, and processed at the belt speed of 45 pieces/min, with an accuracy of 98.00% in sorting, and 100% in orientation.

5.5 Recommendations

The following recommendations are directed towards improving the Silverware Sorting Machine into a more compact, durable and efficient system.

- To force the solenoid to return more quickly to its rest position after de-magnetization, a small weight should be placed on the underside of the outer edge of the lifter. However, this weight should be sized such that the solenoid has sufficient power to raise the flap when energized.
- Increase the number of magnetic-aluminum strips that are attached to the conveying system to decrease the operation speed of the motor for driving the conveying system and increase the processing rate.
- Reconstruct the magnetic strip and chain drive system such that all magnets are equally spaced.
- Replace existing solenoids with fast actuating solenoids to decrease the actuating time.
- Develop a more efficient silverware singulating system than that described by Hashimoto (1995) to feed the silverware sorting and orienting system.

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APPENDIX A

COPIES OF PATENTS REVIEWED

US005655663A

United States Patent [19]

Spradlin

[11] Patent Number: 5,655,663

[45] Date of Patent: Aug. 12, 1997

[54] **SELF-SEPARATING FLATWARE AND METHOD FOR SORTING SAME**

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[21] Appl. No.: **498,680**

[22] Filed: **Jul. 3, 1995**

[51] **Int. Cl.**[6] **B03D 1/00**; A47J 43/28

[52] **U.S. Cl.** **209/172.5**; 209/173; 209/926; 30/147; 30/340

[58] **Field of Search** 209/155, 172, 209/172.5, 173, 208, 926; 30/142, 147, 322–328, 340, 342

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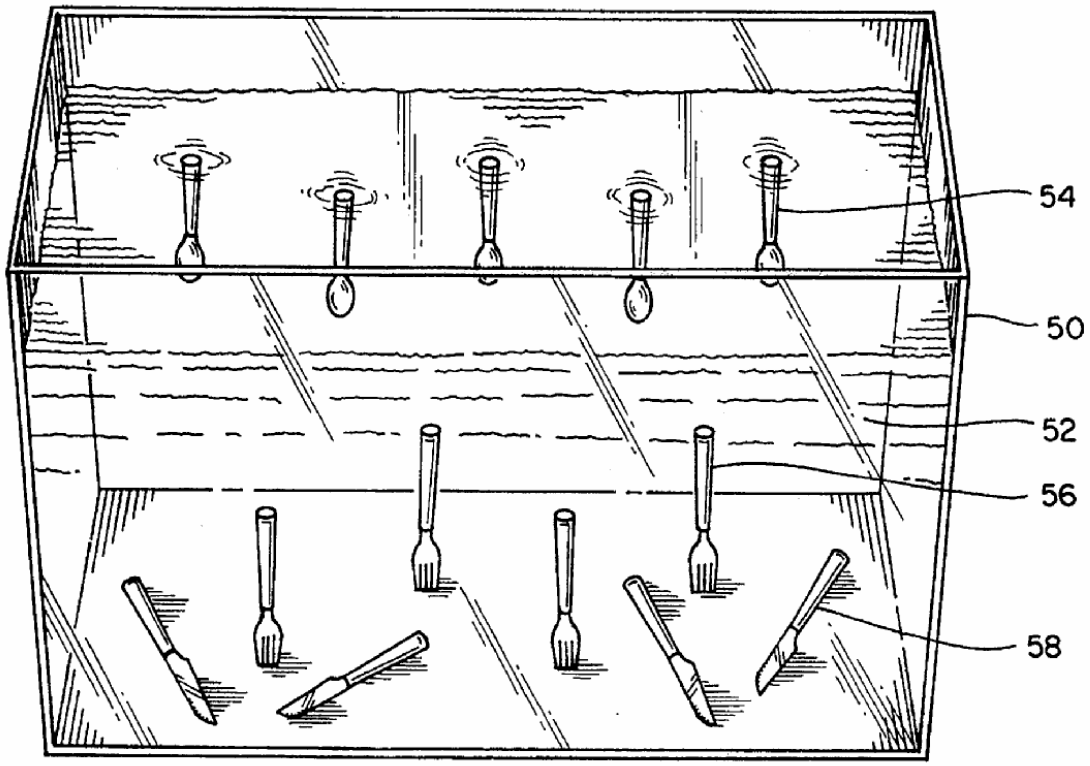
Primary Examiner—William E. Terrell
Assistant Examiner—Tuan Nguyen
Attorney, Agent, or Firm—Charles F. Meroni, Jr.

[57] **ABSTRACT**

Flatware that can be quickly and easily sorted when placed in a liquid solution, the flatware includes spoons, forks and knives. The spoons have a generally uniform buoyancy so as to float at a first level in the liquid solution, the forks have a generally uniform buoyancy so as to float at a second level in the liquid solution, and the knives have a generally uniform buoyancy so as to float at a third level in the liquid solution. The flatware floats at different levels in the liquid solution which provides the separation of the spoons, forks and knives in the liquid solution and enables the retrieval of the separated flatware in a sorted fashion.

19 Claims, 2 Drawing Sheets



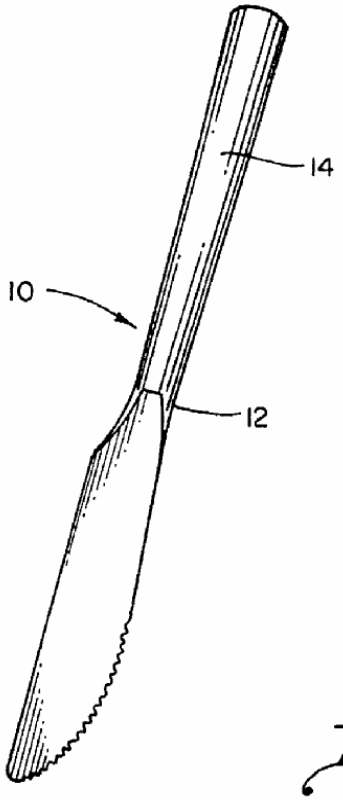


Fig. 1

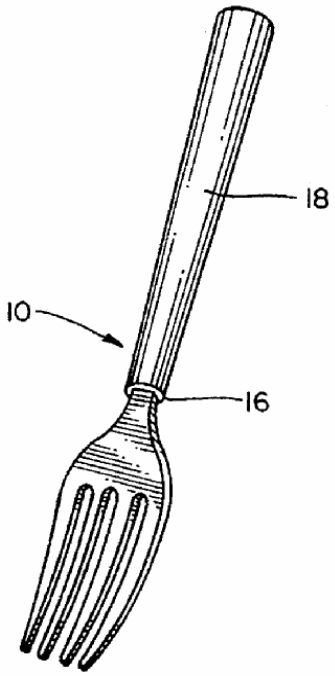


Fig. 2

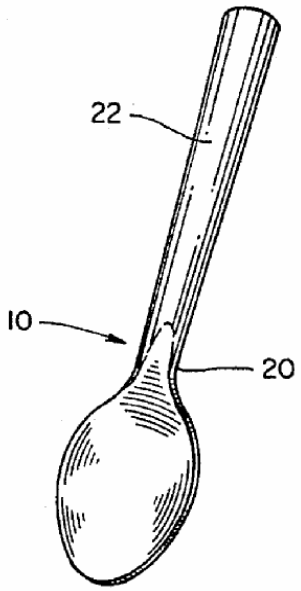


Fig. 3

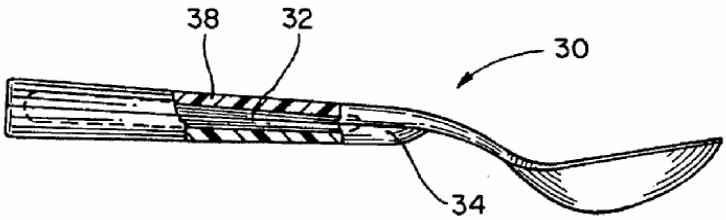


Fig. 4

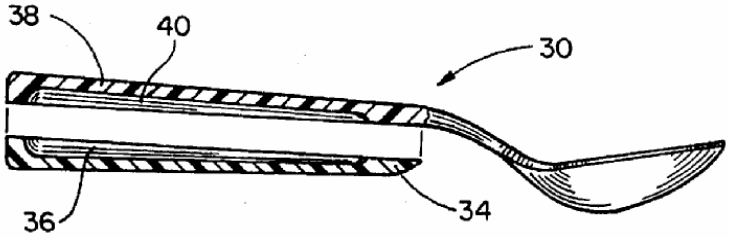


Fig. 5

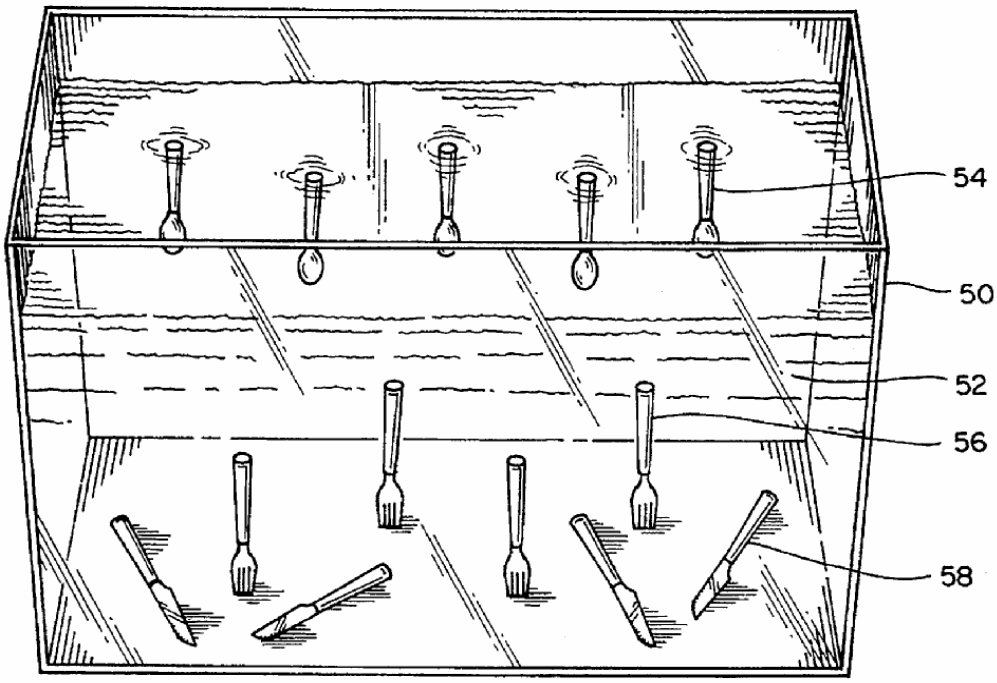


Fig. 6

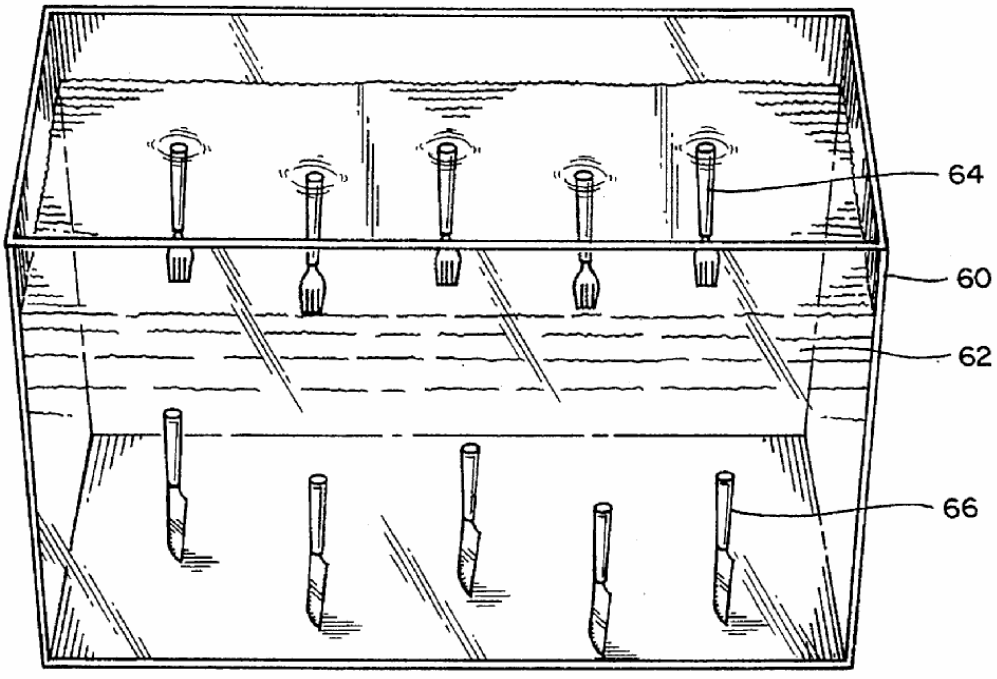


Fig. 7

SELF-SEPARATING FLATWARE AND METHOD FOR SORTING SAME

BACKGROUND OF THE INVENTION

The present invention relates generally to low cost buoyant flatware, such as spoons, forks and knives, that can be quickly and easily sorted without spending the time to manually sort the flatware by hand. Cafeterias in governmental institutions, mental hospitals, mental health schools, offices and the like typically provide flatware for use with the meals that are served. The flatware is typically reusable since it can be expensive to constantly provide disposable flatware. Prior to this invention, after the flatware is used, the flatware is then typically washed and then sorted into containers for re-use. The sorting of the flatware in governmental institutions now commonly includes the hand labor of separating the spoons, forks and knives into containers and also orienting the flatware in one uniform direction. In a cafeteria where numerous meals are served, the sorting of the flatware can be very time consuming, especially if hundreds or thousands of meals are served on a daily basis. Some cafeterias may have flatware sorting machines, however, these machines can be very costly and are not always very reliable.

Using the buoyant flatware of the present invention involves placing the flatware in a tank containing a liquid solution such as water or soapy water. The flatware will then separate in the liquid solution and can then be removed in a sorted fashion without having to separate the flatware by hand or to have an expensive machine to separate the flatware. The flatware of the present invention can improve or eliminate mechanical sorting and can greatly improve the time of manually sorting the flatware. The sorting of the flatware can take place before or after washing the flatware.

The flatware sorting techniques disclosed in the prior art do not offer the flexibility and inventive features of my floating and quick sorting flatware. As will be described in greater detail hereinafter, the floating flatware of the present invention differs from those previously proposed.

SUMMARY OF THE INVENTION

According to my present invention I have provided flatware that can be quickly and easily sorted when placed in a liquid solution, the flatware comprises three classes, each of said three classes comprises spoons, forks and knives, the spoons have a generally uniform buoyancy so as to float at a first level in the liquid solution, the forks have a generally uniform buoyancy so as to float at a second level in the liquid solution, and the knives have a generally uniform buoyancy so as to float at a third level in the liquid solution, which thereby provides separation of the spoons, forks and knives in three different levels in the liquid solution and enables the retrieval of the separated flatware in a sorted fashion.

Another feature of my invention relates to the flatware described above, wherein the flatware has handles that are buoyant and the flatware further floats in a vertical position in the liquid solution, which thereby enables the handles of the flatware to be sorted in one uniform direction.

Still another feature of my invention concerns the flatware described above, wherein one class of the flatware floats at a top surface portion in the liquid solution, a second class of the flatware floats at a bottom portion in the liquid solution in such a manner so that the second class of flatware stands on one end in a vertical position, and a third class of the flatware lies flat at a bottom portion in the liquid solution.

According to important features of my invention I have also provided floating flatware as described above, wherein

a prescribed amount of salt is mixed into liquid solution, the salt acts to change the specific gravity in the liquid solution, the prescribed mount of salt is sufficient to enable the second class of the flatware to float from a bottom portion in the liquid solution to a top surface portion in the liquid solution and also is sufficient to enable the third class of the flatware to stand on one end in a vertical position at a bottom portion in the liquid solution, which thereby enables the handles of the flatware to be sorted in one uniform direction.

Yet another feature of my invention I have provided a method of sorting flatware in a liquid solution, the flatware comprises three classes, each of the three classes comprises spoons, forks and knives, each of the three classes further have a varying buoyancy so as to float at three different levels in the liquid solution, the method comprising: placing the flatware in a liquid solution; removing a first class of the flatware at a first level in the liquid solution; removing a second class of the flatware at a second level in the liquid solution; and removing a third class of the flatware at a third level in the liquid solution.

Other objects, features and advantages of my invention will become more readily apparent upon reference to the following description when taken in conjunction with the accompanying drawings, which drawings illustrate several embodiments of my invention.

DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective view of a knife having a buoyant handle;

FIG. **2** is a perspective view of a fork having a buoyant handle;

FIG. **3** is a perspective view of a spoon having a buoyant handle;

FIG. **4** is a partial cross-sectional view of a spoon having a hollow handle embodying important features of my invention;

FIG. **5** is an exploded longitudinal view of a spoon embodying further features of my invention;

FIG. **6** is a perspective view of my buoyant flatware in a tank containing a liquid solution showing how my flatware is separated; and

FIG. **7** is a perspective view of my buoyant flatware in a tank containing a modified type of liquid solution showing how my flatware is further separated and oriented.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawings, FIGS. **1–3** show my new and improved pieces of flatware **10**. The flatware **10** consists of a knife **12** having a buoyant handle **14**; a fork **16** having a buoyant handle **18**; and a spoon **20** having a buoyant handle **22**. The flatware **10** is designed and constructed in such a manner so that each class of flatware will float or sink at different levels when placed in a liquid solution such as water. For example, the spoons **20** would be designed to float at an upper level in the water, the forks **16** would be designed to stand on end at a bottom level in the water and the knives **12** would be designed to sink to the bottom and lie flat at the bottom surface in the water.

FIGS. **4** & **5** illustrate one of many methods of constructing my separating flatware. The flatware **30** can be constructed by sealing an air pocket **32** within the handle. This can be accomplished by securing and sealing a handle cover **34** having an indented hollow portion **36** at one end thereof to the handle **38** of the flatware **30** with a waterproof

adhesive. The handle **38** of the flatware can additionally have an indented hollow portion **40** to provide additional buoyancy in the flatware. The handle cover **34** is secured to the handle **38** of the flatware in such a manner that the hollow portions **36**, **40** adjoin each other and are sealed inside the handle of the flatware, thereby creating a sealed air pocket **32**. Each class of flatware may require a larger or smaller air pocket. For example, if the spoons were designed to float at a top portion in the liquid solution, then the spoons would have the most buoyant handle. If the forks were designed to stand on end at a bottom portion in the liquid solution, then the forks would have a less buoyant handle than the spoons. If the knives were designed to lie flat at the bottom portion in the liquid solution, then the knives would be have the least buoyant or non-buoyant handle.

Excellent results can be obtained if the flatware is made of plastic and weighing in the range of 0.4 to 0.7 ounces, however other suitable materials could also be used such as synthetic plastics, wood and metal. The construction of the flatware may have to be modified to provide a more buoyant handle if metal flatware is used or less buoyant if a light plastic is used. It is contemplated that the use of plastic flatware can be used in institutions, correctional facilities, prisons and the like since metal flatware could be more easily used as a dangerous weapon.

FIG. **6** further illustrates how my flatware is separated in a container **50** of a liquid solution **52**, such as a sink filled with water. The spoons **54** are all designed to float in a vertical position at a top portion in the liquid solution with the handles pointed up. The forks **56** are designed to stand on end at a bottom portion in the liquid solution, and the knives **58** are designed to lay flat on the bottom of the container. The spoons **54** can then be easily removed at the same time without removing any forks **56** or knives **58**. After the spoons are removed, the forks can then be removed by grabbing their handles. The removal of the spoons **54** and forks **56** provides sorting of the flatware and orientation of the flatware in one uniform direction with the handles being oriented on one side. Excellent results are obtained when the flatware is designed to float in the manner described above, however, each class of flatware, such as the spoons, can be designed to float at any level in the liquid solution.

FIG. **7** illustrates how my flatware can be sorted in a modified way so that all three classes of flatware can be separated and sorted in one uniform direction so that the handles will be on one side. After the spoons are removed from the container **60** of liquid solution **62**, a prescribed amount of salt or a salt solution can be added to the liquid solution **62** thereby changing the specific gravity of the liquid solution and making the liquid solution more dense. Excellent results can be obtained by adding 10 to 30 grams of salt per each gallon of the liquid solution while using plastic flatware that weighs approximately 0.4 to 0.7 ounces. Since the addition of salt makes the liquid solution more dense, the best results are obtained when 30 grams of salt per gallon are added to the liquid solution. This would then enable the forks **64** to float at a top portion in the liquid solution and would then enable the knives **66** to stand on end. The forks could then be removed with the handles being oriented in one uniform direction without accidentally picking up any knives. After the forks are removed, the knives could also then be removed with the handles being oriented in one uniform direction.

The removal of the flatware from the liquid solution can be done manually or mechanically with a machine. It is contemplated that the flatware would be sorted and separated before washing since the salt solution may need to be washed off. However, depending on how the cafeteria is organized, the separating and sorting of the flatware may take place after washing.

As various possible embodiments may be made in the above invention for use for different purposes and as various changes might be made in the embodiments and method above set forth, it is understood that all of the above matters here set forth or shown in the accompanying drawings are to be interpreted as illustrative and not in a limiting sense.

I claim:

1. In combination, a container, said container having a liquid solution therein, and flatware, said flatware designed to be quickly and easily sorted when placed in the liquid solution, said flatware comprising three classes, each of said three classes comprising spoons, forks and knives, said spoons having a generally uniform buoyancy so said spoons float at a first level in the liquid solution, said forks having a generally uniform buoyancy so said forks float at a second level in the liquid solution, and said knives having a generally uniform buoyancy so said knives float at a third level in the liquid solution, thereby providing separation of the spoons, forks and knives in different levels in the liquid solution, wherein said flatware has handles that are buoyant and each of said flatware further floats in a common position in the liquid solution and enabling the retrieval of the separated flatware in a sorted fashion.

2. The combination of claim **1**, wherein said flatware is a material selected from the group consisting of: plastic, synthetic plastic, wood and metal.

3. The combination of claim **1**, wherein said liquid solution is a liquid selected from the group consisting of: water and soapy water.

4. The combination of claim **1**, wherein said flatware has handles that are buoyant and said flatware further floats in a vertical position in the liquid solution, thereby enabling the handles of the flatware to be sorted in one uniform direction.

5. The combination of claim **4**, wherein the buoyancy of the spoons, forks and knives is different thereby enabling the separation of the spoons, forks and knives at three different levels in the liquid solution.

6. The combination of claim **4**, wherein said flatware has air pockets sealed inside each handle defining a sealed hollow portion, thereby enabling the flatware to float in the liquid solution.

7. The combination of claim **4**, wherein said handles have a floatation attached thereto, thereby enabling the flatware to float in the liquid solution.

8. The combination of claim **1**, wherein one class of said flatware floats at a top surface portion in the liquid solution, a second class of said flatware floats at a bottom portion in the liquid solution in such a manner so that the second class of flatware stands on one end in a vertical position, and a third class of said flatware lies flat at a bottom portion in the liquid solution.

9. The combination of claim **8**, wherein a prescribed amount of salt is mixed into liquid solution, said salt acting to change the specific gravity in the liquid solution, said prescribed amount of salt being sufficient to enable said second class of said flatware to float from the bottom portion in the liquid solution to the top surface portion in the liquid solution and also being sufficient to enable said third class of said flatware to stand on one end in the vertical position at the bottom portion in the liquid solution.

10. The combination of claim **8**, wherein said first class of said flatware are spoons, said second class of said flatware are forks and said third class of said flatware are knives.

11. A method of sorting flatware in a liquid solution, said flatware comprising three classes, each of said three classes

comprising spoons, forks and knives, each of said three classes further having a varying buoyancy so as to float at three different levels in the liquid solution, wherein said flatware has handles that are buoyant and each of said flatware further floats in a common position in the liquid solution, the method comprising:

placing said flatware in the liquid solution;

removing the first class of said flatware at the first level in the liquid solution;

removing the second class of said flatware at the second level in the liquid solution; and

removing a third class of said flatware at a third level in the liquid solution.

12. The method of claim **11**, wherein said flatware is a material selected from the group consisting of: plastic, synthetic plastic, wood and metal.

13. The method of claim **11**, wherein said liquid solution is a liquid selected from the group consisting of: water and soapy water.

14. The method of claim **11**, wherein said flatware has handles that are buoyant and said flatware further floats in a vertical position in the liquid solution, thereby enabling the handles of the flatware to be sorted in one uniform direction.

15. The method of claim **14**, wherein the buoyancy of the spoons, forks and knives is different thereby enabling the separation of the spoons, forks and knives at three different levels in the liquid solution.

16. The method of claim **14**, wherein said flatware has air pockets sealed inside each handle defining a sealed hollow portion, thereby enabling the flatware to float in the liquid solution.

17. The method of claim **14**, wherein said handles have a floatation attached thereto, thereby enabling the flatware to float in the liquid solution.

18. The method of claim **11**, wherein one class of said flatware floats at a top surface portion in the liquid solution, a second class of said flatware floats at a bottom portion in the liquid solution in such a manner so that the second class of flatware stands on one end in a vertical position, and a third class of said flatware lies flat at a bottom portion in the liquid solution.

19. The method of claim **18**, wherein a prescribed amount of salt is mixed into liquid solution after said first class of flatware is removed from the liquid solution, said salt acting to change the specific gravity in the liquid solution, said prescribed amount of salt being sufficient to enable said second class of said flatware to float from the bottom portion in the liquid solution to the top surface portion in the liquid solution and also being sufficient to enable said third class of said flatware to stand on one end in the vertical position at the bottom portion in the liquid solution.

* * * * *

US005931307A

United States Patent [19]

Spradlin

[11] **Patent Number: 5,931,307**

[45] **Date of Patent: *Aug. 3, 1999**

[54] **SELF SEPARATING FLATWARE AND METHOD FOR SORTING SAME**

[76] Inventor: **Lyndon D. Spradlin**, 9N176 Rte. 59, Elgin, Ill. 60120

[*] Notice: This patent is subject to a terminal disclaimer.

[21] Appl. No.: **08/814,079**

[22] Filed: **Mar. 10, 1997**

Related U.S. Application Data

[63] Continuation-in-part of application No. 08/498,680, Jul. 3, 1995, Pat. No. 5,655,663.

[51] **Int. Cl.**[6] **B03D 1/00**; A47J 43/28

[52] **U.S. Cl.** **209/172.5**; 209/11; 209/173; 209/926; 30/147; 30/340

[58] **Field of Search** 209/155, 172, 209/172.5, 173, 208, 926, 11; 30/142, 147, 322–328, 340, 342

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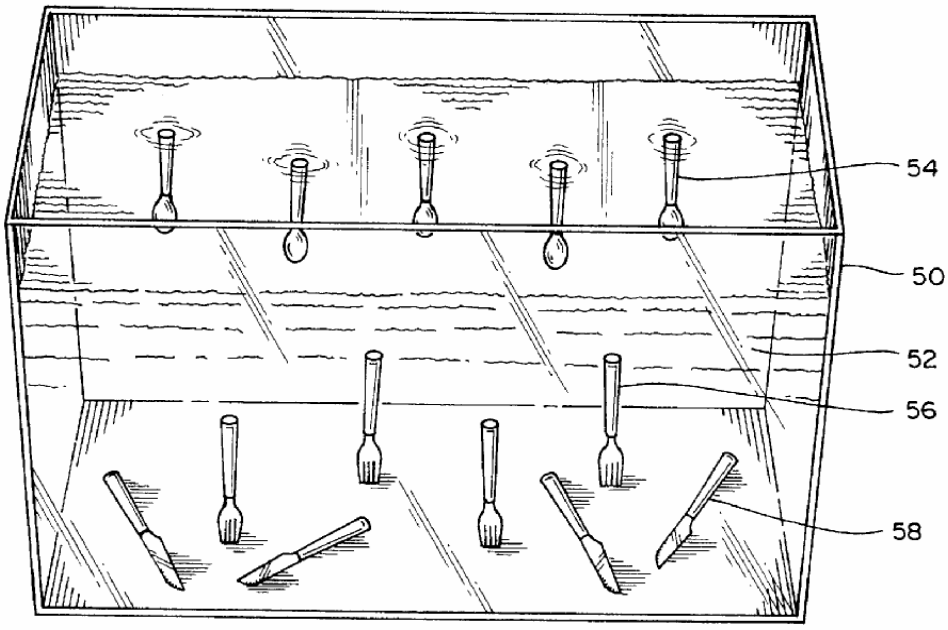
Primary Examiner—Tuan N. Nguyen
Attorney, Agent, or Firm—Meroni & Meroni

[57] **ABSTRACT**

Flatware that can be quickly and easily sorted when placed in a liquid solution, the flatware encompasses three classes, spoons, forks and knives. The spoons have a generally uniform buoyancy so as to float at a first level in the liquid solution, the forks have a generally uniform buoyancy so as to float at a second level in the liquid solution, and the knives have a generally uniform buoyancy so as to float at a third level in the liquid solution. The flatware floats at different levels in the liquid solution which provides the separation of the spoons, forks and knives in the liquid solution and enables the retrieval of the separated flatware in a sorted fashion. An additional method of sorting and removing the flatware from the liquid solution includes mixing in a prescribed amount of salt solution to the liquid solution and/or raising the temperature of the liquid solution a predetermined amount. The change in specific gravity of the liquid solution and/or the rise in temperature would enable one to make each class of flatware float to a top surface in the liquid solution at different intervals.

19 Claims, 3 Drawing Sheets



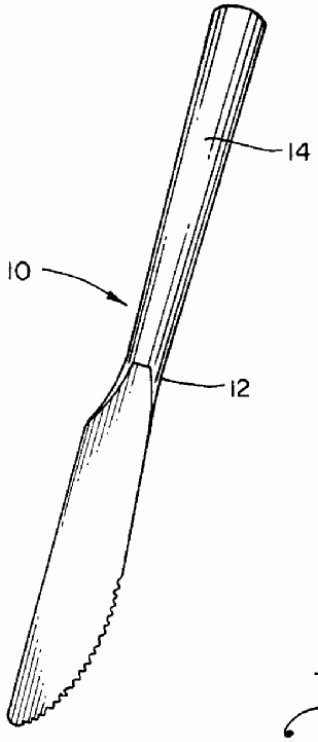


Fig. 1

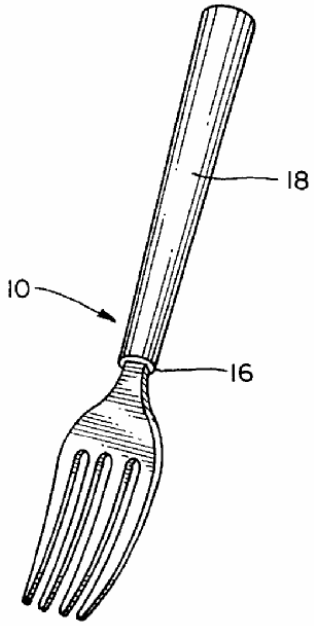


Fig. 2

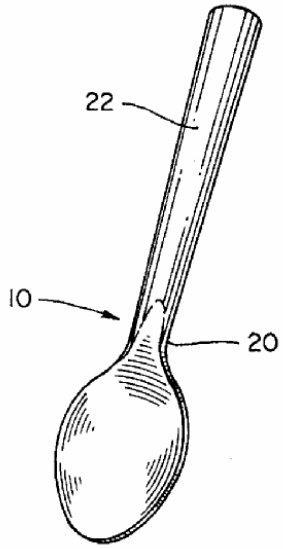


Fig. 3

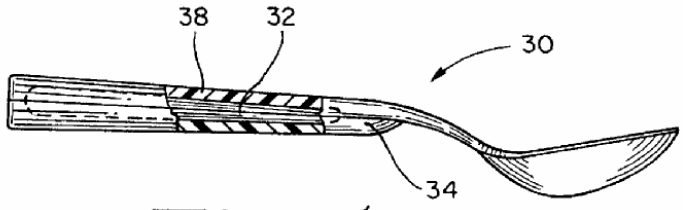


Fig. 4

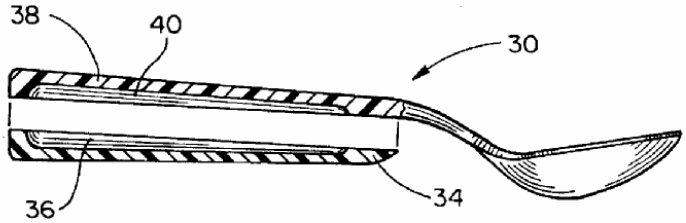


Fig. 5

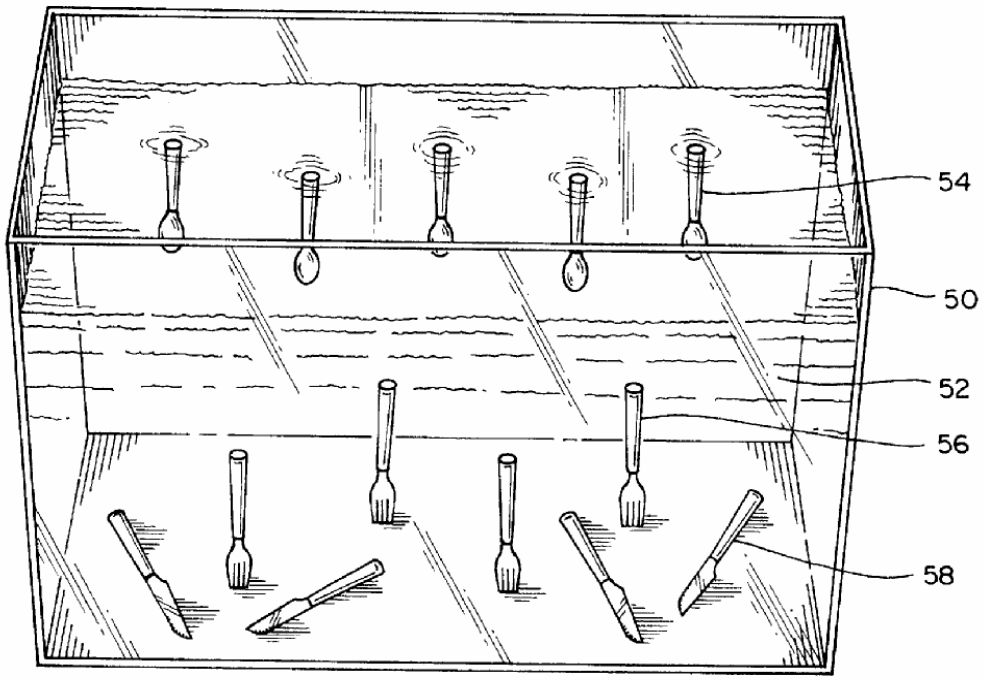


Fig. 6

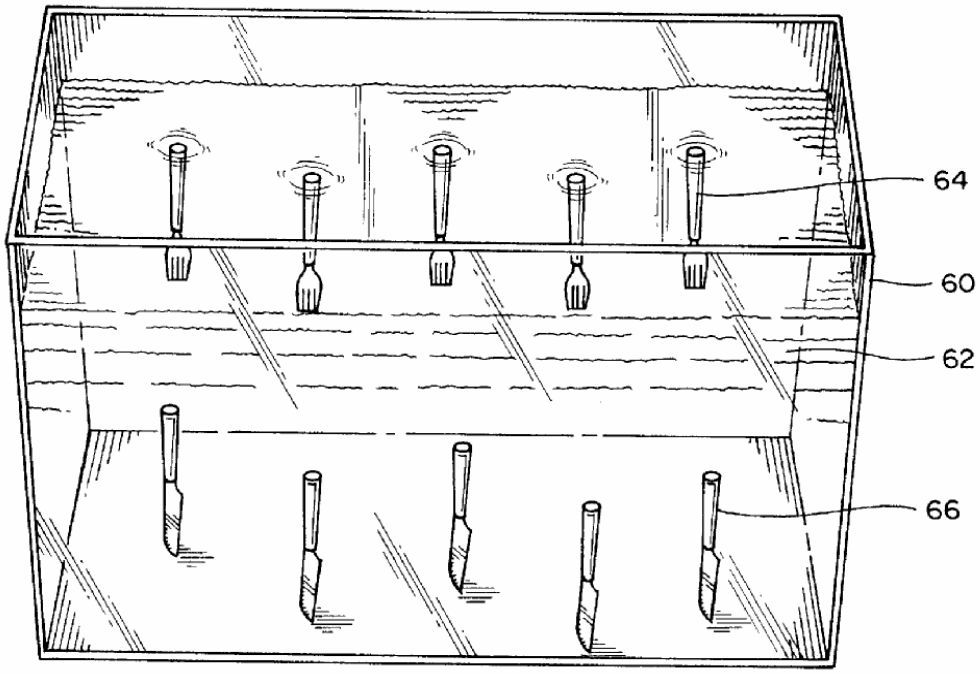


Fig. 7

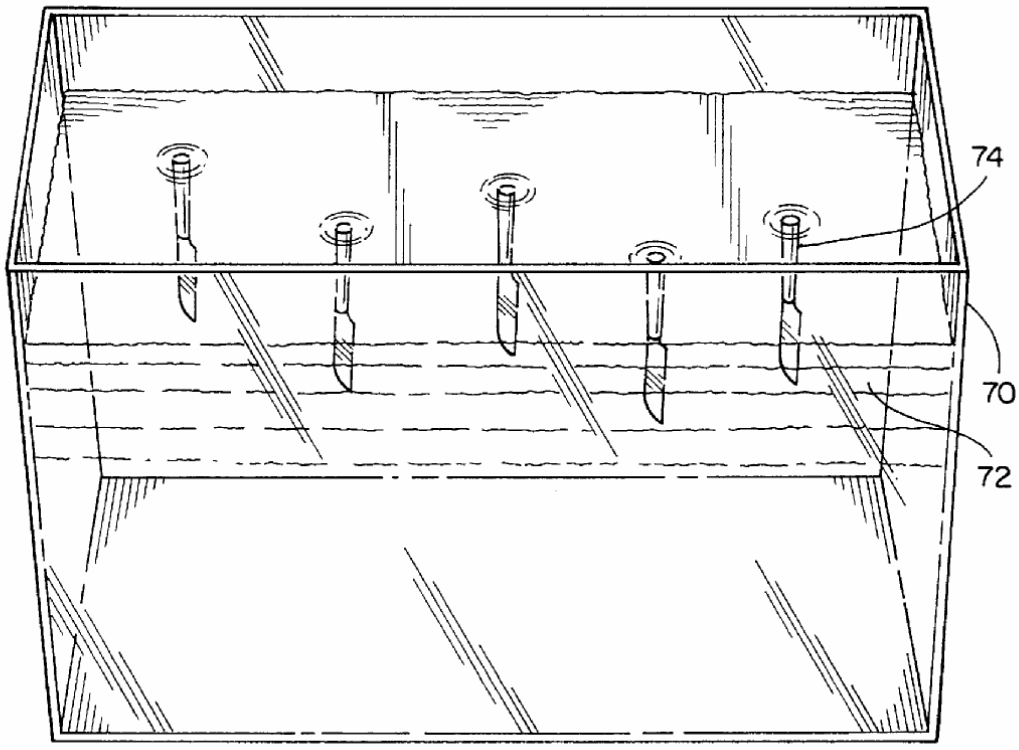


Fig. 8

SELF SEPARATING FLATWARE AND METHOD FOR SORTING SAME

This application is a Continuation-In-Part of my earlier filed U.S. application for patent entitled "Self Separating Flatware and Method For Sorting Same" filed on Jul. 3, 1995, and bearing U.S. Ser. No. 08/498,680, now U.S. Pat. No. 5,655,663.

BACKGROUND OF THE INVENTION

The present invention relates generally to low cost buoyant flatware, such as spoons, forks and knives, that can be quickly and easily sorted without spending the time to manually sort the flatware by hand. Cafeterias in governmental institutions, mental hospitals, mental health schools, offices and the like typically provide flatware for use with the meals that are served. The flatware is typically reusable since it can be expensive to constantly provide disposable flatware. Prior to this invention, after the flatware is used, the flatware is then typically washed and then sorted into containers for re-use. The sorting of the flatware in governmental institutions now commonly includes the hand labor of separating the spoons, forks and knives into containers and also orienting the flatware in one uniform direction. In a cafeteria where numerous meals are served, the sorting of the flatware can be very time consuming, especially if hundreds or thousands of meals are served on a daily basis. Some cafeterias may have flatware sorting machines, however, these machines can be very costly and are not always very reliable.

Using the buoyant flatware of the present invention involves placing the flatware in a tank containing a liquid solution such as water or soapy water. The flatware will then separate in the liquid solution and can then be removed in a sorted fashion without having to separate the flatware by hand or to have an expensive machine to separate the flatware. The flatware of the present invention can improve or eliminate mechanical sorting and can greatly improve the time of manually sorting the flatware. The sorting of the flatware can take place before or after washing the flatware.

The flatware sorting techniques disclosed in the prior art do not offer the flexibility and inventive features of my floating and quick sorting flatware. As will be described in greater detail hereinafter, the floating flatware of the present invention differs from those previously proposed.

SUMMARY OF THE INVENTION

According to my present invention I have provided flatware that can be quickly and easily sorted when placed in a liquid solution, the flatware comprises three classes, each of the three classes comprises spoons, forks and knives, each of the three classes having a generally uniform buoyancy, wherein the flatware has handles that are buoyant and each class of the flatware further floats in a common position in the liquid solution and enabling the retrieval of the separated flatware in a sorted fashion.

Another feature of my invention relates to the flatware described above, wherein one class of the flatware floats at a top surface portion in the liquid solution, a second class of flatware floats at a bottom portion in the liquid solution in such a manner so that the second class of flatware stands on one end in a vertical position, and a third class of said flatware lies flat at a bottom portion in the liquid solution.

Yet another feature of my invention relates to the flatware described above, wherein a prescribed amount of a salt solution is mixed into the liquid solution, the salt solution acting to change the specific gravity in the liquid solution, the prescribed amount of salt solution being sufficient to enable at least one of the three classes of flatware to rise from one level in the liquid solution to a second level in the liquid solution.

Still another feature of my invention relates to the flatware described above, wherein a temperature of the liquid solution is raised a predetermined amount, the rise in temperature being sufficient to enable at least one of the three classes of flatware to rise from one level in the liquid solution to a second level in the liquid solution.

According to important features of my invention I have also provided a method of sorting flatware in a liquid solution, the flatware comprising three classes, each of the three classes comprising spoons, forks and knives, each of the three classes further having a varying buoyancy so as to float at three different levels in the liquid solution, wherein the flatware has handles that are buoyant and each class of flatware further floats in a common position in the liquid solution the method comprising: placing the flatware in the liquid solution; removing the first class of flatware from the liquid solution; removing the second class of flatware from the liquid solution; and then removing the third class of flatware from the liquid solution.

Yet another feature of my invention concerns the method described above further including mixing a prescribed amount of salt solution into the liquid solution and/or raising the temperature of the liquid solution before the first class of flatware is removed from the liquid solution, the salt solution acting to change the specific gravity in the liquid solution, the prescribed amount of salt solution being sufficient to enable the first class of flatware to float to a top surface portion in the liquid solution.

Still another feature of my method described above includes mixing a prescribed amount of salt solution into the liquid solution and/or raising the temperature of the liquid solution after the first class of flatware is removed from the liquid solution, the salt solution acting to change the specific gravity in the liquid solution, the prescribed amount of salt solution being sufficient to enable the third class of flatware to stand on one end at a bottom portion in the liquid solution.

Other objects, features and advantages of my invention will become more readily apparent upon reference to the following description when taken in conjunction with the accompanying drawings, which drawings illustrate several embodiments of my invention.

DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective view of a knife having a buoyant handle;

FIG. **2** is a perspective view of a fork having a buoyant handle;

FIG. **3** is a perspective view of a spoon having a buoyant handle;

FIG. **4** is a partial cross-sectional view of a spoon having a hollow handle embodying important features of my invention;

FIG. **5** is an exploded longitudinal view of a spoon embodying further features of my invention;

FIG. **6** is a perspective view of my buoyant flatware in a tank containing a liquid solution showing how my flatware is separated;

FIG. **7** is a perspective view of my buoyant flatware in a tank containing a modified type of liquid solution showing how my flatware is further separated and oriented; and

FIG. **8** is a perspective view of my buoyant flatware in a tank containing a modified type of liquid solution showing how yet another class of my flatware is further separated and oriented.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawings, FIGS. **1–3** show my new and improved pieces of flatware **10**. The flatware **10** consists of a knife **12** having a buoyant handle **14**; a fork **16** having a buoyant handle **18**; and a spoon **20** having a buoyant handle **22**. The flatware **10** is designed and constructed in such a manner so that each class of flatware will float or sink at different levels or in a common position when placed in a liquid solution such as water. For example, the spoons **20** would be designed to float at an upper level in the water, the forks **16** would be designed to stand on end at a bottom level in the water and the knives **12** would be designed to sink to the bottom and lie flat at the bottom surface in the water.

FIGS. **4** & **5** illustrate one of many methods of constructing my separating flatware. The flatware **30** can be constructed by sealing an air pocket **32** within the handle. This can be accomplished by securing and sealing a handle cover **34** having an indented hollow portion **36** at one end thereof to the handle **38** of the flatware **30** with a waterproof adhesive. The handle **38** of the flatware can additionally have an indented hollow portion **40** to provide additional buoyancy in the flatware. The handle cover **34** is secured to the handle **38** of the flatware in such a manner that the hollow portions **36**, **40** adjoin each other and are sealed inside the handle of the flatware, thereby creating a sealed air pocket **32**. Each class of flatware may require a larger or smaller air pocket. For example, if the spoons were designed to float at a top portion in the liquid solution, then the spoons would have the most buoyant handle. If the forks were designed to stand on end at a bottom portion in the liquid solution, then the forks would have a less buoyant handle than the spoons. If the knives were designed to lie flat at the bottom portion in the liquid solution, then the knives would be have the least buoyant or non-buoyant handle.

Excellent results can be obtained if the flatware is made of plastic and weighing in the range of 0.4 to 0.7 ounces, however other suitable materials could also be used such as synthetic plastics, wood and metal. The construction of the flatware may have to be modified to provide a more buoyant handle if metal flatware is used or less buoyant if a light plastic is used. It is contemplated that the use of plastic flatware can be used in institutions, correctional facilities, prisons and the like since metal flatware could be more easily used as a dangerous weapon. However, if heavier flatware is used, such as metal, a buoyant device could possibly be attached to the handle of each piece of flatware (not shown). Various types of attachable floatation devices would include styrofoam, buoyant plastic, and other suitable materials that would be sufficient to make the flatware float. It is contemplated that the attached floatation devices could be permanently or temporarily affixed to each handle using a variety of different methods including, but not limited to: adhesive, clips, and elastic attachment. Furthermore, the attached floatation devices would not be too bulky so as to make it cumbersome for a user to utilize while eating with the flatware having the attached floatation device.

FIG. **6** further illustrates how my flatware is separated in a container **50** of a liquid solution **52**, such as a sink filled with water. The spoons **54** are all designed to float in a vertical position at a top portion in the liquid solution with the handles pointed up. The forks **56** are designed to stand on end at a bottom portion in the liquid solution, and the knives **58** are designed to lay flat on the bottom of the container. The spoons **54** can then be easily removed at the same time without removing any forks **56** or knives **58**. After the spoons are removed, the forks can then be removed by grabbing their handles. The removal of the spoons **54** and forks **56** provides sorting of the flatware and orientation of the flatware in one uniform direction with the handles being oriented on one side. Excellent results are obtained when the flatware is designed to float in the manner described above, however, each class of flatware, such as the spoons, can be designed to float at any level in the liquid solution.

FIG. **7** illustrates how my flatware can be sorted in a modified way so that all three classes of flatware can be separated and sorted in one uniform direction so that the handles will be on one side. After the spoons are removed from the container **60** of liquid solution **62**, a prescribed amount of salt or a salt solution can be added to the liquid solution **62** thereby changing the specific gravity of the liquid solution and making the liquid solution more dense. Excellent results can be obtained by adding 10 to 30 grams of salt per each gallon of the liquid solution while using plastic flatware that weighs approximately 0.4 to 0.7 ounces. Since the addition of salt makes the liquid solution more dense, the best results are obtained when 30 grams of salt per gallon are added to the liquid solution. This would then enable the forks **64** to float at a top portion in the liquid solution and would then enable the knives **66** to stand on end. The forks could then be removed with the handles being oriented in one uniform direction without accidentally picking up any knives. After the forks are removed from the container **70** (FIG. **8**), additional salt solution can be added to the liquid solution **72** to make the knives **74** float at a top surface, then the knives could then be removed with the handles being oriented in one uniform direction.

Another method of being able to make a class of flatware rise from a bottom portion in the liquid solution to a top portion would be to increase the temperature of the liquid solution. The increased temperature in the liquid solution would in turn increase the temperature of the flatware. The increased temperature in the flatware would cause the air pocket or air pockets in the handles of the flatware to heat and expand thereby causing the handles of the flatware to be more buoyant and effectively being able to make a class of flatware rise from a bottom portion in the liquid solution to a top portion. Excellent results can be obtained by designing each class of flatware to change its floatation effect in a liquid solution, such as water, in 10–20 degree increments. For example, the flatware could be designed as follows:

TABLE 1

Temperature of Liquid Solution	Characteristics of Flatware in a Liquid Solution (Water)
<70° F.	Knives lie flat on the bottom surface
	Spoons stand on end (handles up) on the bottom surface
	Forks stand on end (handles up) on the bottom surface
100° F.	Knives lie flat on the bottom surface
	Spoons float at the top surface (handles up)
	Forks stand on end (handles up) on the bottom surface
120° F.	Knives lie flat on the bottom surface
	Spoons float at the top surface (handles up)
	Forks float at the top surface (handles up)
130° F.	Knives stand on end (handles up) on the bottom surface
	Spoons float at the top surface (handles up)
	Forks float at the top surface (handles up)

TABLE 1-continued

Temperature of Liquid Solution	Characteristics of Flatware in a Liquid Solution (Water)
>150° F.	Knives float at the top surface (handles up) Spoons float at the top surface (handles up) Forks float at the top surface (handles up)

The removal of the flatware from the liquid solution can be done manually or mechanically with a machine. It is contemplated that the flatware would be sorted and separated before washing since the salt solution may need to be washed off. However, depending on how the cafeteria is organized, the separating and sorting of the flatware may take place after washing.

A further method of sorting the flatware would include combining the use of a salt solution and modifying the temperature of the liquid solution. The combined use of changing the specific gravity and increasing the temperature of the liquid solution could make it easier and more desirable for one to be able to sort and separate a group of flatware.

As various possible embodiments may be made in the above invention for use for different purposes and as various changes might be made in the embodiments and method above set forth, it is understood that all of the above matters here set forth or shown in the accompanying drawings are to be interpreted as illustrative and not in a limiting sense.

I claim:

1. In combination, a container, said container having a liquid solution therein, and flatware, said flatware designed to be quickly and easily sorted when placed in the liquid solution, said flatware comprising three classes, each of said three classes comprising spoons, forks and knives, each of said three classes having a generally uniform buoyancy, wherein said flatware has handles that are buoyant and each class of flatware further floats in a common position in the liquid solution and enabling the retrieval of the separated flatware in a sorted fashion.

2. The combination of claim **1**, wherein one class of said flatware floats at a top surface portion in the liquid solution, a second class of flatware floats at a bottom portion in the liquid solution in such a manner so that the second class of flatware stands on one end in a vertical position, and a third class of flatware lies flat at a bottom portion in the liquid solution.

3. The combination of claim **2**, wherein a prescribed amount of a salt solution is mixed into the liquid solution, said salt solution acting to change the specific gravity in the liquid solution, said prescribed amount of salt solution being sufficient to enable said second class of flatware to float from the bottom portion in the liquid solution to the top surface portion in the liquid solution.

4. The combination of claim **3**, wherein a second prescribed amount of the salt solution is mixed into the liquid solution, said salt solution acting to change the specific gravity in the liquid solution, said second prescribed amount of salt solution being sufficient to enable said third class of flatware to stand on one at the bottom portion in the liquid solution.

5. The combination of claim **4**, wherein a third prescribed amount of the salt solution is mixed into the liquid solution, said salt solution acting to change the specific gravity in the liquid solution, said third prescribed amount of salt solution being sufficient to enable said third class of flatware to float from the bottom portion in the liquid solution to the top surface portion in the liquid solution.

6. The combination of claim **1**, wherein a prescribed amount of a salt solution is mixed into the liquid solution, said salt solution acting to change the specific gravity in the liquid solution, said prescribed amount of salt solution being sufficient to enable at least one of said three classes of flatware to rise from one level in the liquid solution to a second level in the liquid solution.

7. The combination of claim **1**, wherein a temperature of the liquid solution is raised a predetermined amount, said rise in temperature being sufficient to enable at least one of said three classes of flatware to rise from one level in the liquid solution to a second level in the liquid solution.

8. The combination of claim **7**, wherein a prescribed amount of a salt solution is mixed into the liquid solution, said salt solution acting to change the specific gravity in the liquid solution, said prescribed amount of salt solution being sufficient to enable at least one of said three classes of flatware to rise from one level in the liquid solution to another level in the liquid solution.

9. A method of sorting flatware in a liquid solution, said flatware comprising three classes, each of said three classes comprising spoons, forks and knives, each of the three classes further having a varying buoyancy so as to float at three different levels in the liquid solution, wherein the flatware has handles that are buoyant and each class of the flatware further floats in a common position in the liquid solution the method comprising:

placing the flatware in the liquid solution;

removing the first class of flatware from the liquid solution;

removing the second class of flatware from the liquid solution; and then

removing the third class of flatware from the liquid solution.

10. The method of claim **9**, further including:

mixing a prescribed amount of salt solution into the liquid solution before the first class of flatware is removed from the liquid solution, the salt solution acting to change the specific gravity in the liquid solution, the prescribed amount of salt solution being sufficient to enable the first class of flatware to float to a top surface portion in the liquid solution.

11. The method of claim **9**, further including:

mixing a prescribed amount of salt solution into the liquid solution after the first class of flatware is removed from the liquid solution, the salt solution acting to change the specific gravity in the liquid solution, the prescribed amount of salt solution being sufficient to enable the second class of flatware to float to a top surface portion in the liquid solution.

12. The method of claim **9**, further including:

mixing a prescribed amount of salt solution into the liquid solution after the first class of flatware is removed from the liquid solution, the salt solution acting to change the specific gravity in the liquid solution, the prescribed amount of salt solution being sufficient to enable the third class of flatware to stand on one end at a bottom portion in the liquid solution.

13. The method of claim **9**, further including:

mixing a prescribed amount of salt solution into the liquid solution after the second class of flatware is removed from the liquid solution, the salt solution acting to change the specific gravity in the liquid solution, the prescribed amount of salt solution being sufficient to enable the third class of flatware to float to a top surface portion in the liquid solution.

14. The method of claim 9, further including:

raising the temperature of the liquid solution a predetermined amount before the first class of flatware is removed from the liquid solution, the rise in temperature being sufficient to enable the first class of flatware to float to a top surface portion in the liquid solution.

15. The method of claim 9, further including:

raising the temperature of the liquid solution a predetermined amount after the first class of flatware is removed from the liquid solution, the rise in temperature being sufficient to enable the second class of flatware to float to a top surface portion in the liquid solution.

16. The method of claim 9, further including:

raising the temperature of the liquid solution a predetermined amount after the first class of flatware is removed from the liquid solution, the rise in temperature being sufficient to enable the third class of flatware to stand on one end at a bottom portion in the liquid solution.

17. The method of claim 9, further including:

raising the temperature of the liquid solution a predetermined amount after the second class of flatware is removed from the liquid solution, the rise in temperature being sufficient to enable the third class of flatware to float to a top surface portion in the liquid solution.

18. The method of claim 9, further including:

mixing a prescribed amount of salt solution into the liquid solution and raising the temperature of the liquid solution before the first class of flatware is removed from the liquid solution, the salt solution acting to change the specific gravity in the liquid solution, the combination of the prescribed amount of salt solution and the rise in temperature being sufficient to enable the first class of flatware to float to a top surface portion in the liquid solution.

19. The method of claim 9, further including:

mixing a prescribed amount of salt solution into the liquid solution and raising the temperature of the liquid solution before the third class of flatware is removed from the liquid solution, the salt solution acting to change the specific gravity in the liquid solution, the combination of the prescribed amount of salt solution and the rise in temperature being sufficient to enable the third class of flatware to stand on one end at a bottom portion in the liquid solution.

* * * * *

US005996809A

United States Patent [19]

Chiasson

[11] Patent Number: 5,996,809

[45] Date of Patent: Dec. 7, 1999

[54] **FLATWARE SORTING MACHINE**

[76] Inventor: **Robert H. Chiasson**, c/o East Coast Industries, Inc. 2532 Main St., Concord, Mass. 01742

[21] Appl. No.: **08/852,088**

[22] Filed: **May 7, 1997**

[51] **Int. Cl.**[6] **B07C 5/344**; B65G 17/32

[52] **U.S. Cl.** **209/636**; 209/904; 209/919; 209/926; 198/443; 198/679; 198/681; 198/803.6

[58] **Field of Search** 209/636, 904, 209/907, 919, 926; 198/678.1, 679, 681, 690.1, 803.6, 443

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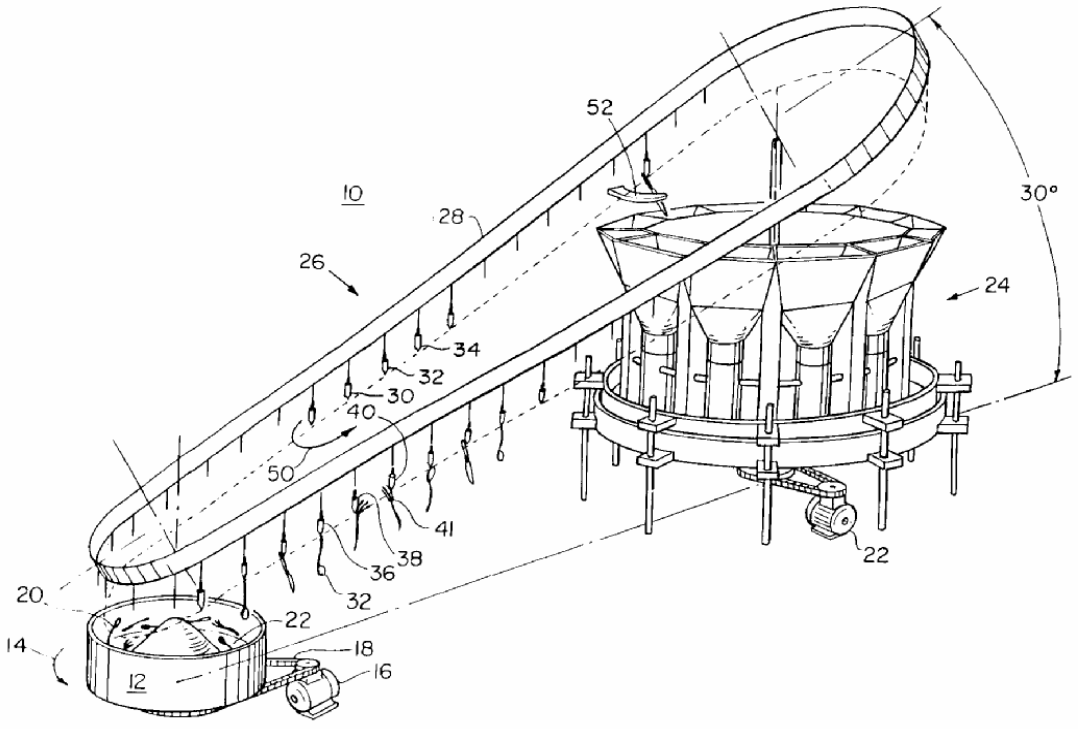
Primary Examiner—Tuan N. Nguyen
Attorney, Agent, or Firm—Iandiorio & Teska

[57] **ABSTRACT**

A flatware sorting machine including a feed bin for holding unsorted flatware, a sorting system for sorting the flatware, and a flatware pick-up and transport system for retrieving the flatware from the feed bin and transporting them to the sorting system.

16 Claims, 12 Drawing Sheets



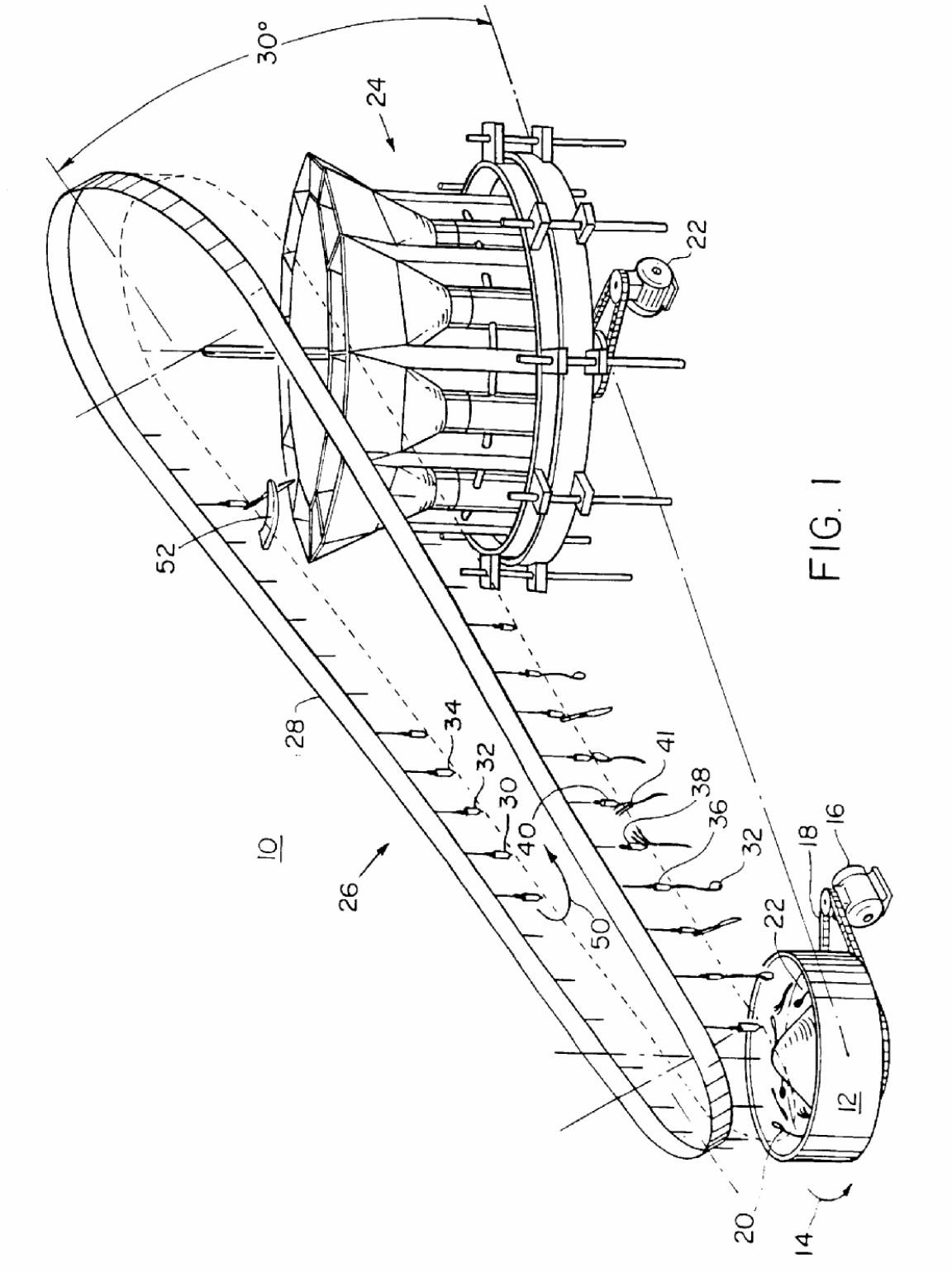


FIG. 1

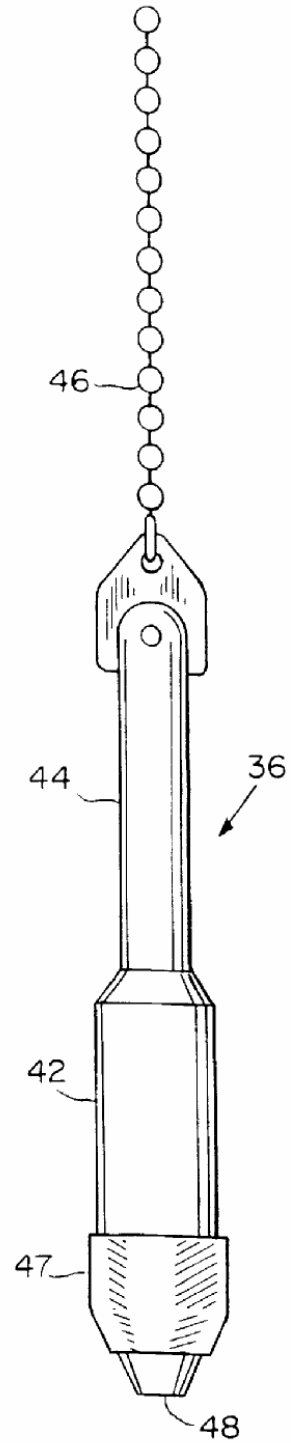


FIG. 2

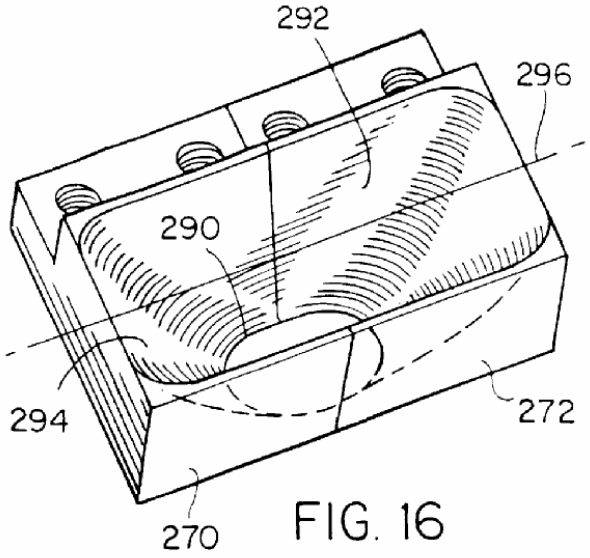


FIG. 16

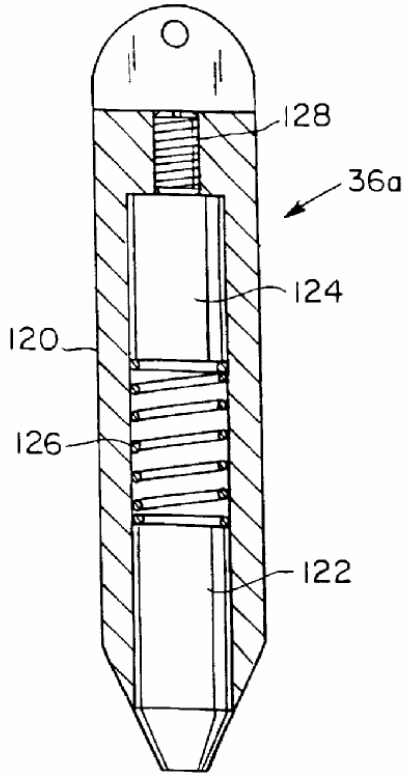


FIG. 7

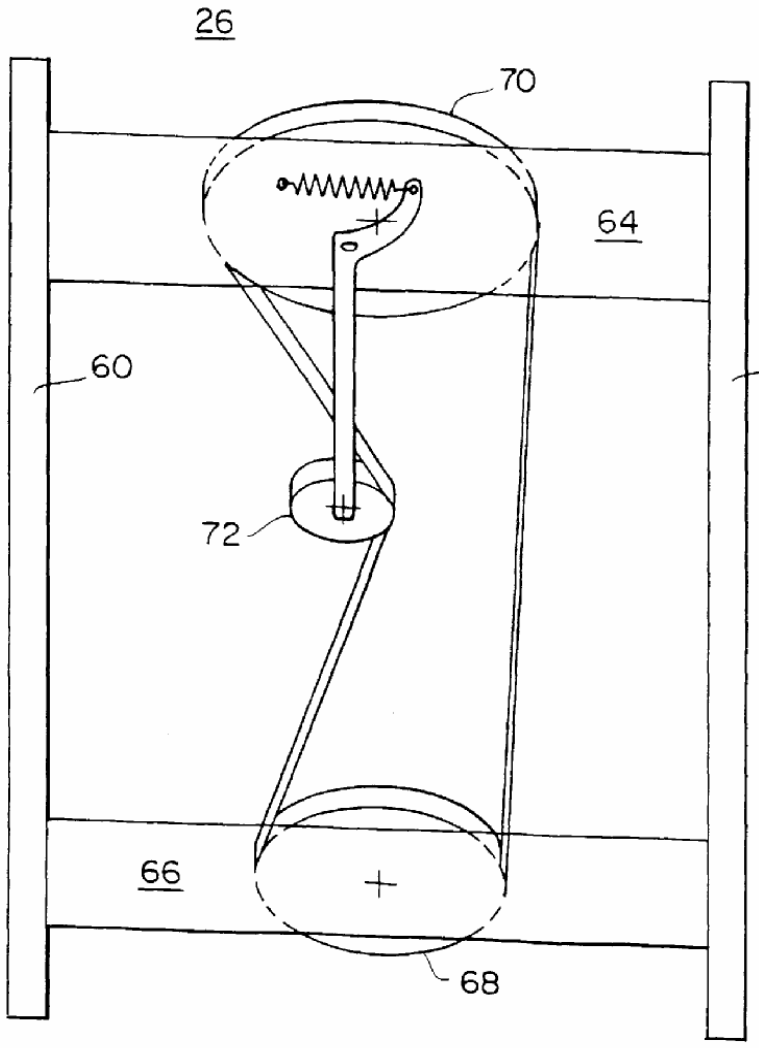


FIG. 3

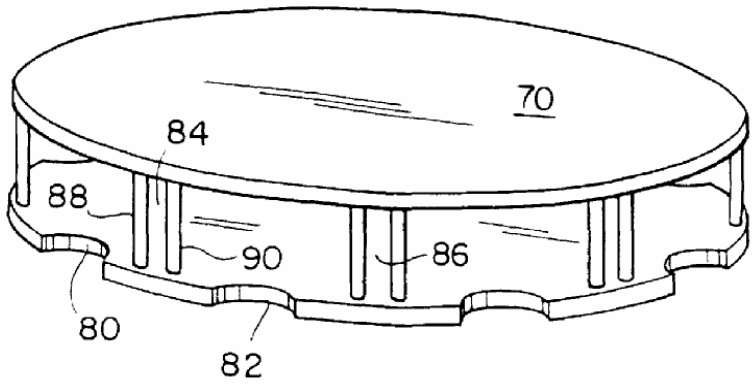


FIG. 4

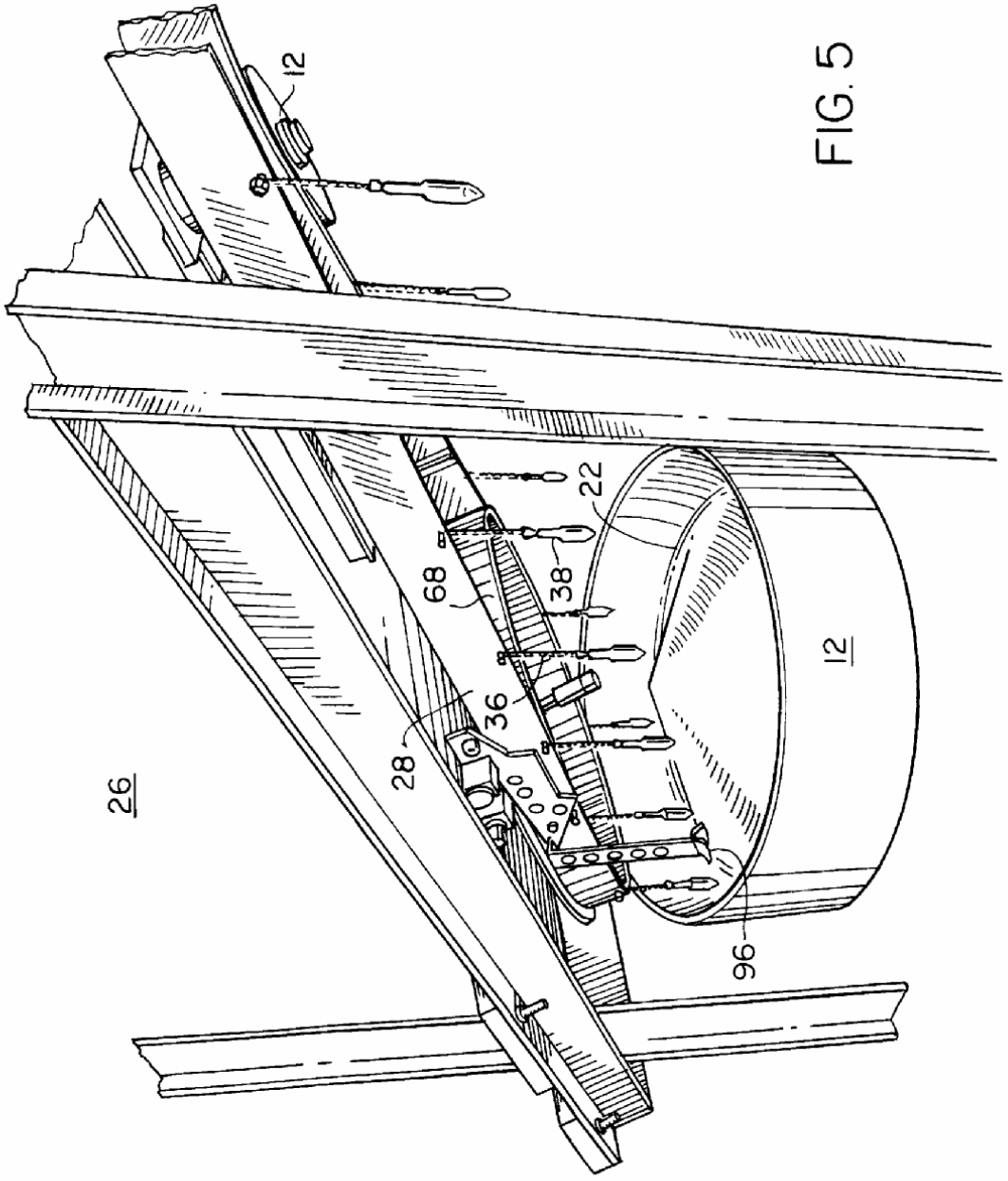


FIG. 5

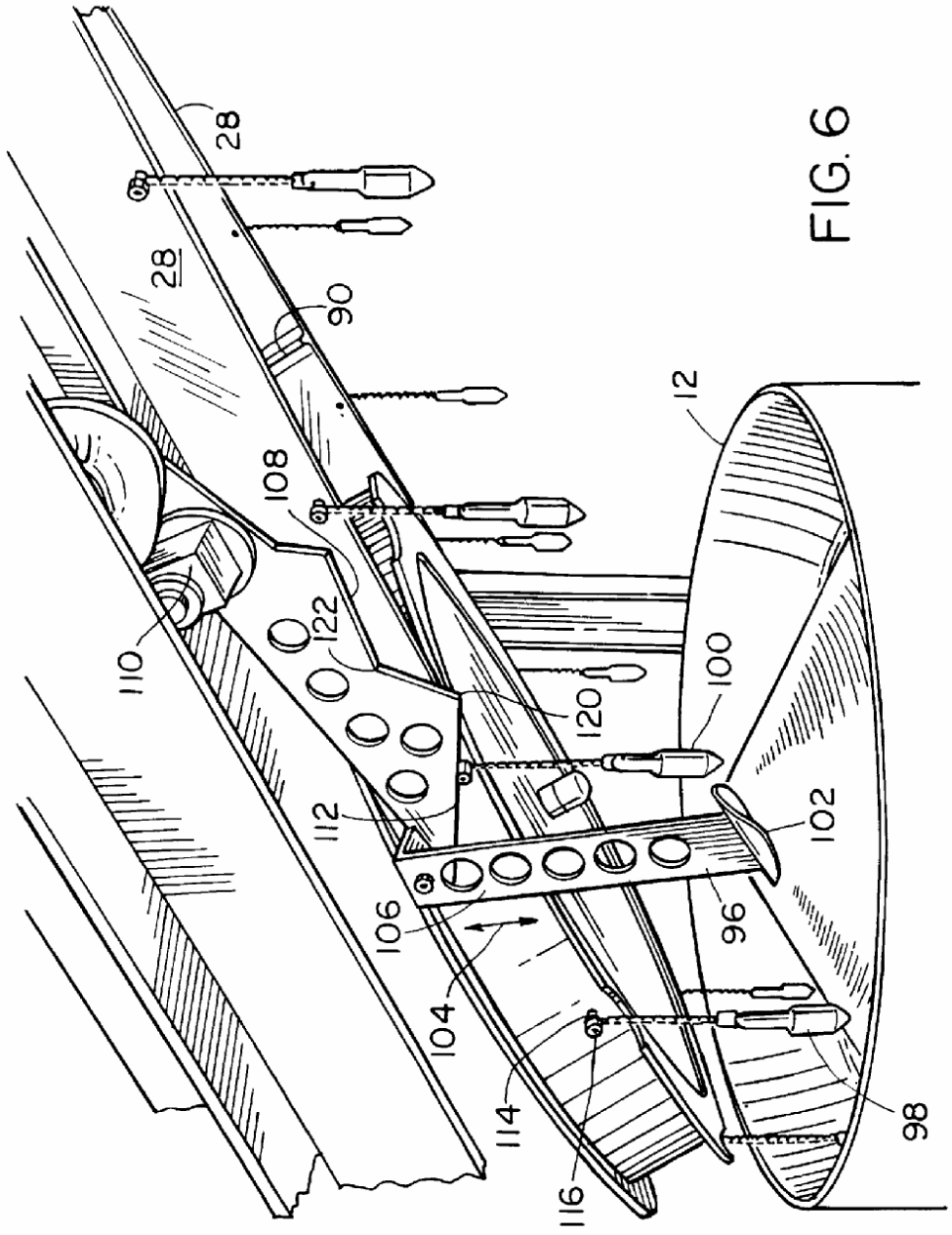


FIG. 6

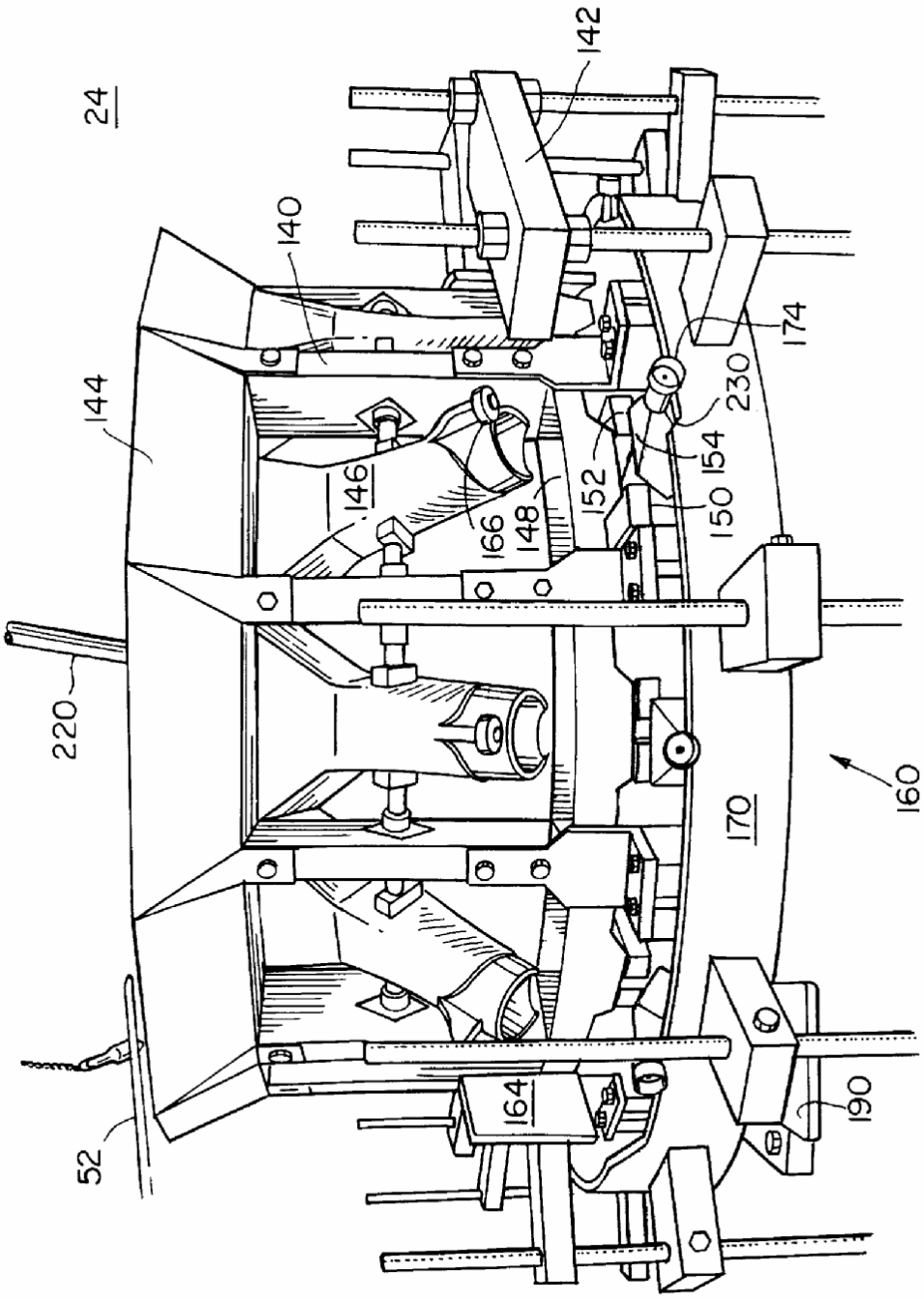

24
142
140
144
146
166
148
152
154
150
174
230
220
170
160
164
190
52

FIG. 8

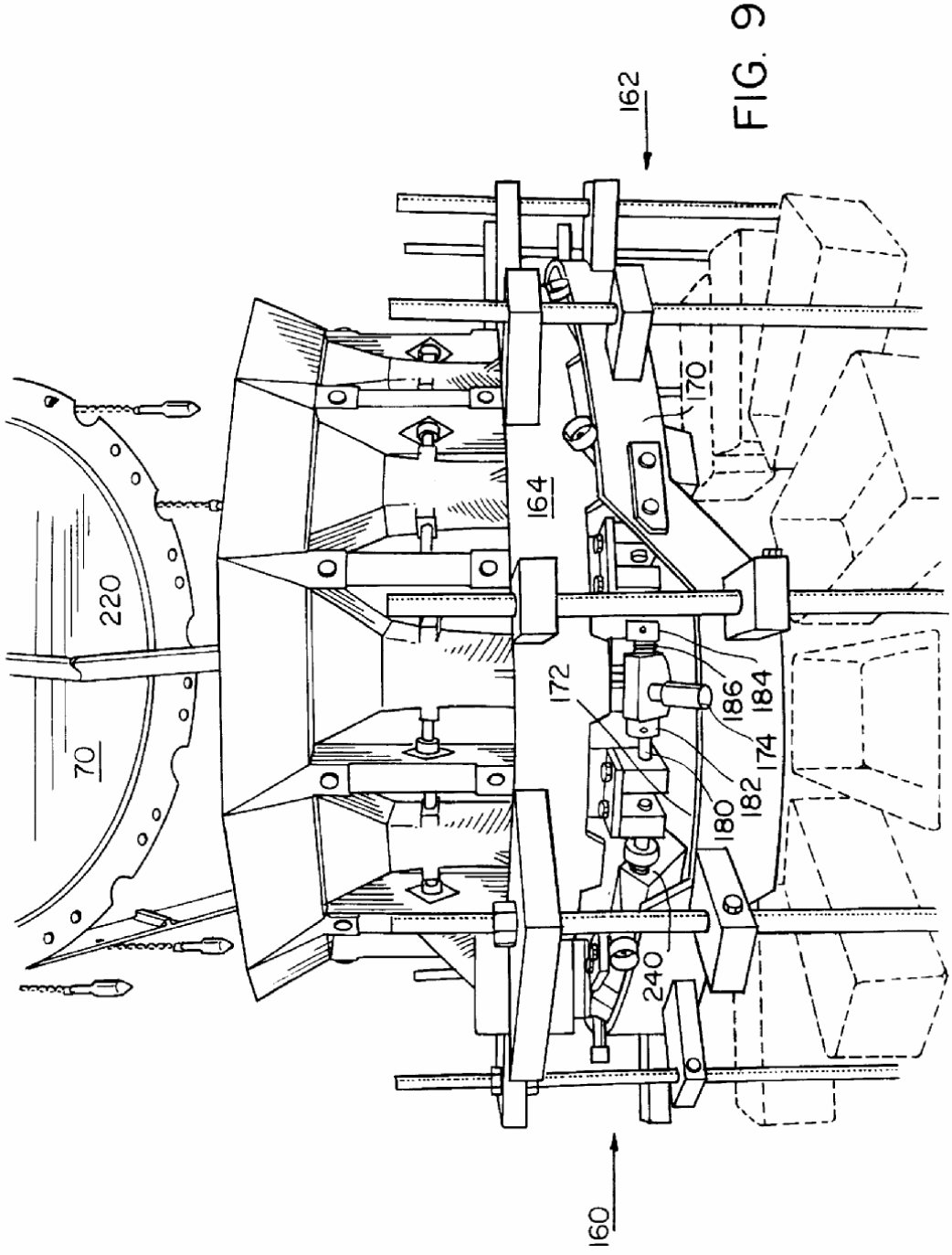


FIG. 9

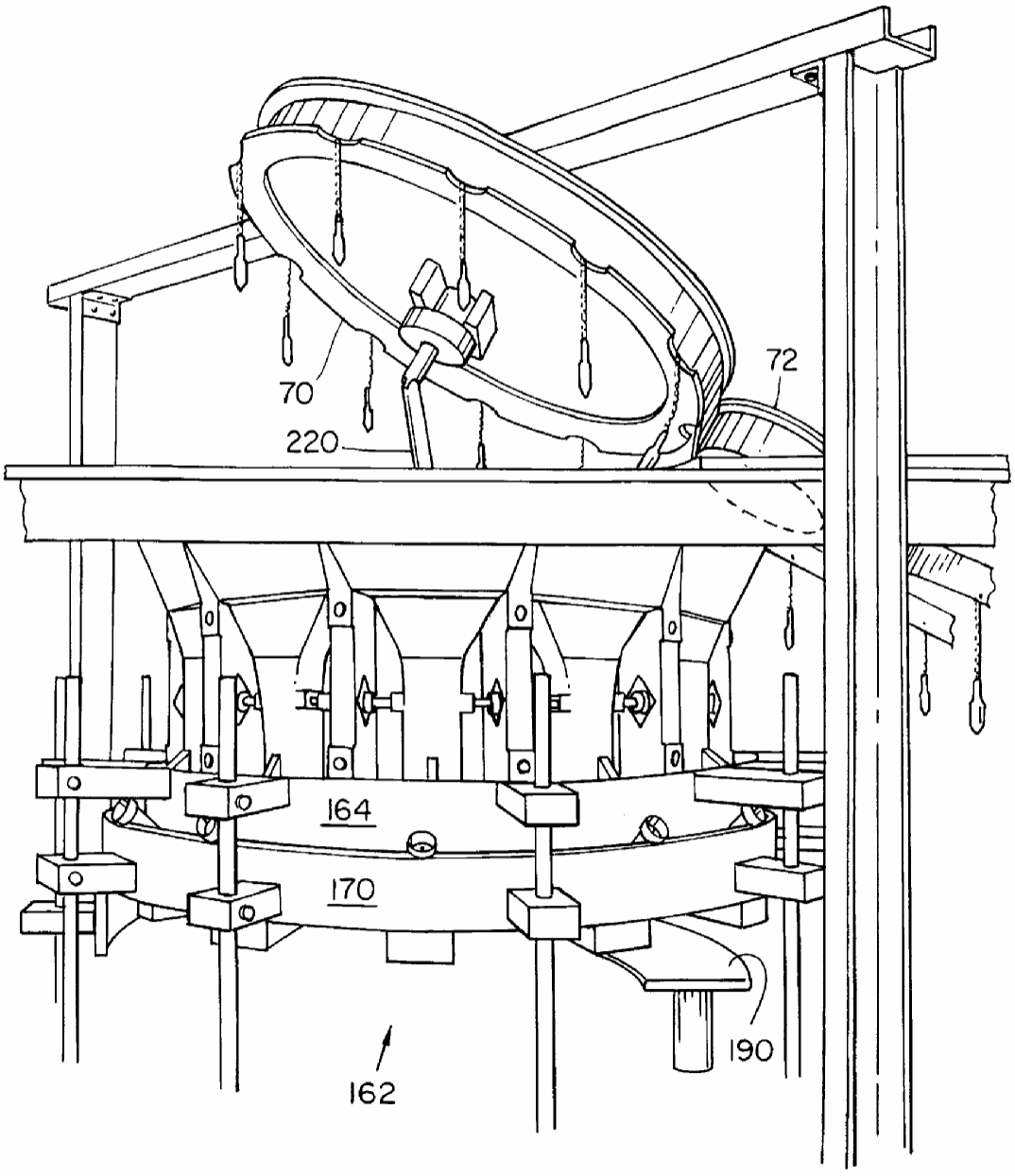


FIG. 10

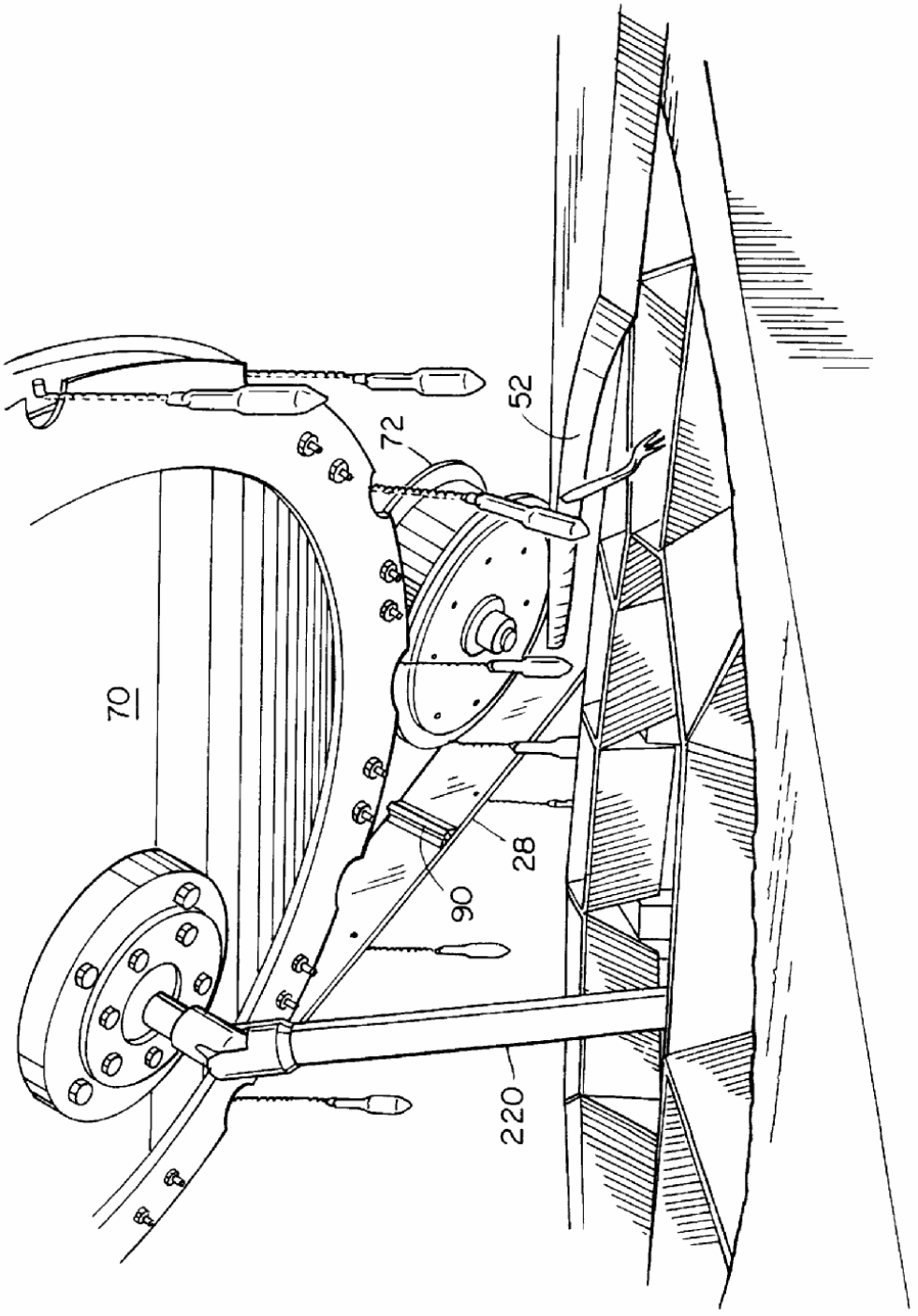


FIG. 11

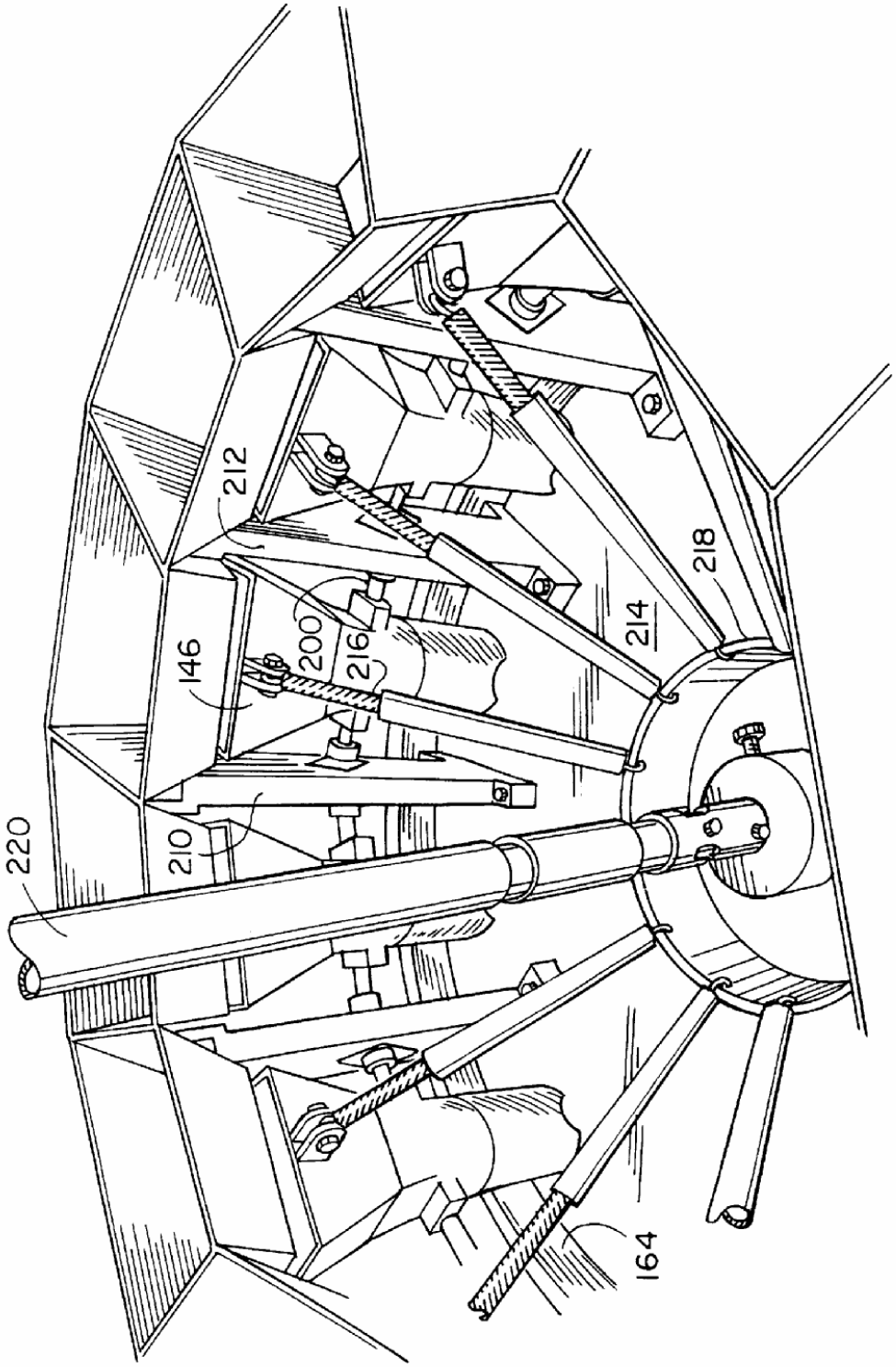


FIG. 12

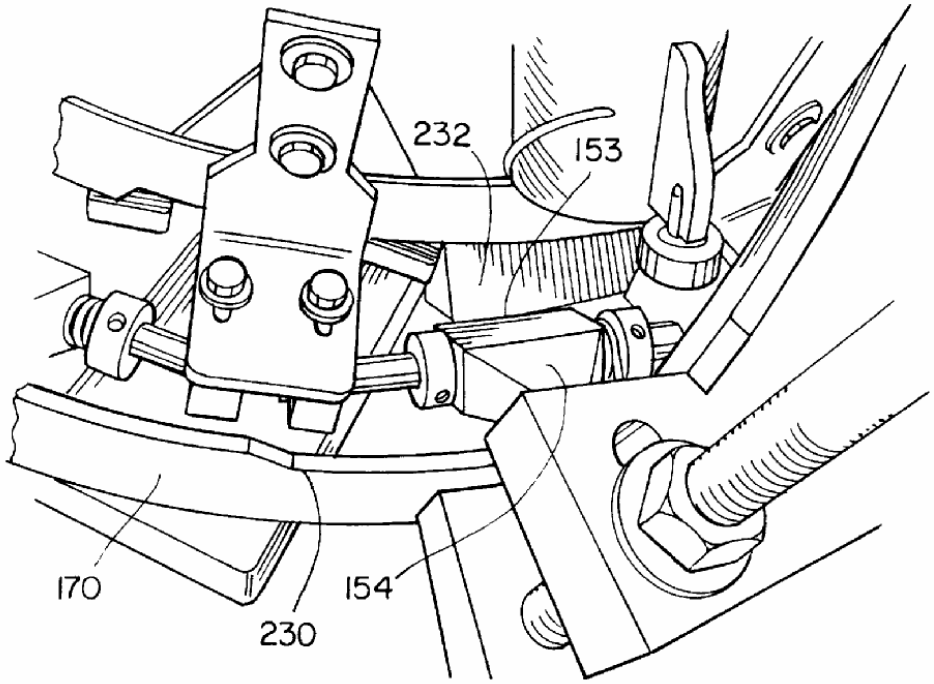


FIG. 13

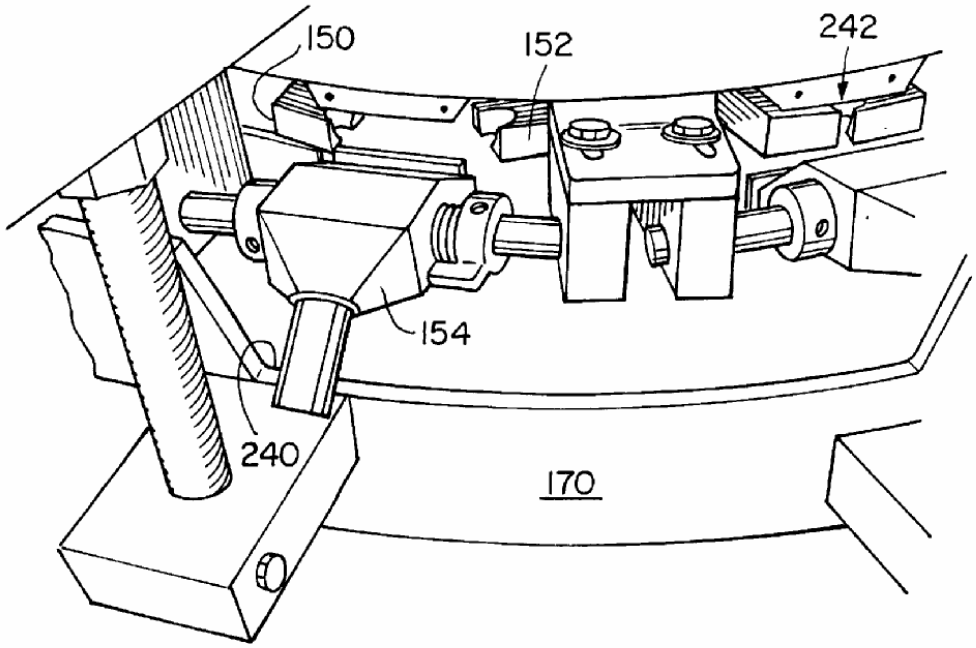


FIG. 14

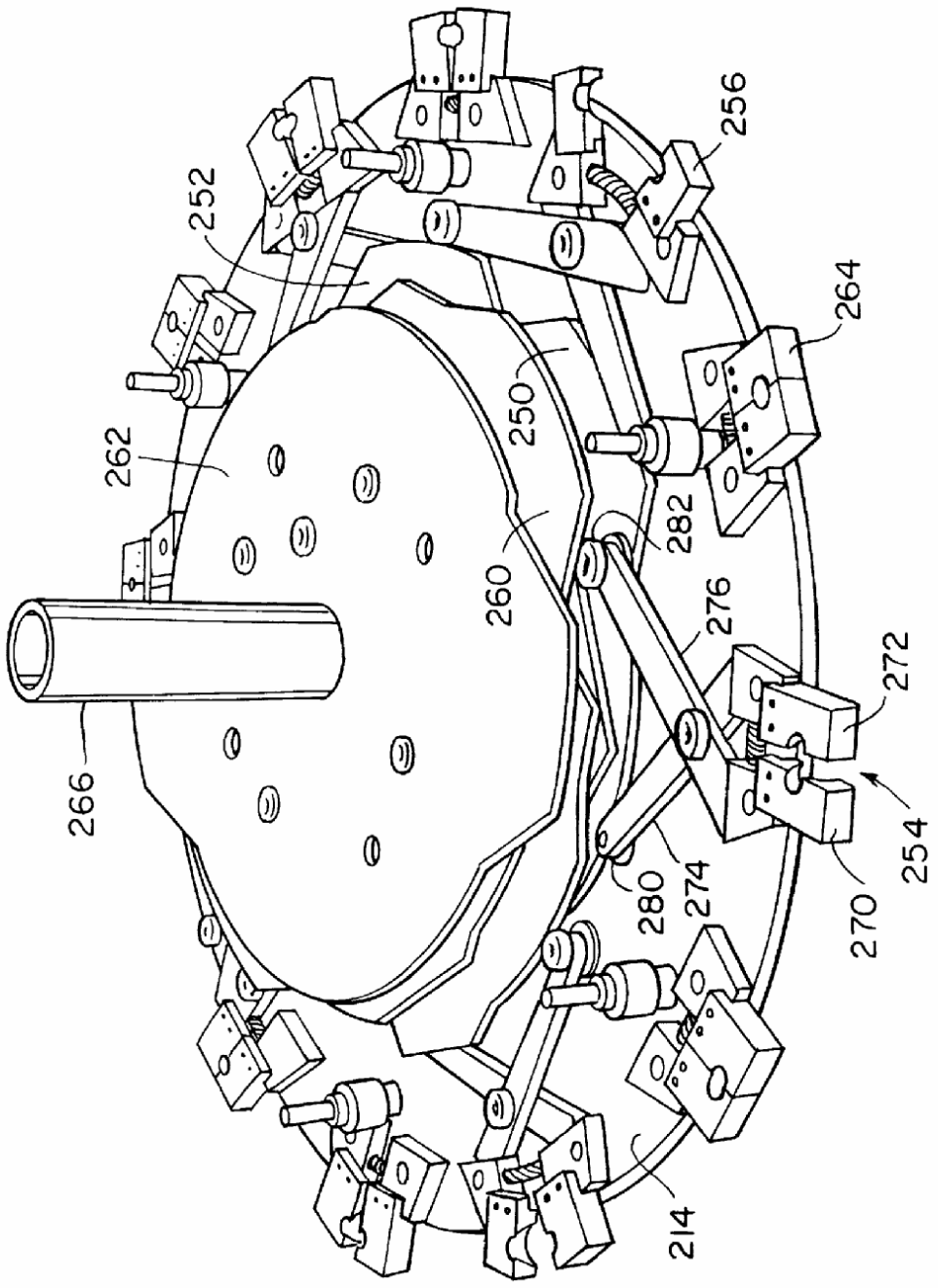


FIG. 15

FLATWARE SORTING MACHINE

FIELD OF INVENTION

This invention relates to a flatware sorting machine which, in its preferred embodiment, automatically sorts flatware not only according to type (fork, teaspoon, soup spoon and knife) but also according to orientation (handle up, head down; handle down, head up).

BACKGROUND OF INVENTION

Manually sorting flatware according to type and orientation is a time consuming and tedious labor intensive task at restaurants and cafeterias such as cafeterias at major universities where thousands of pieces of flatware are used and must be washed each day.

At such facilities, dirty flatware is normally dumped unsorted into a tray for washing in an automatic dishwasher. After washing, the individual pieces of flatware are then manually sorted according to type and placed handle down in individual knife, fork, teaspoon, and soup spoon bins for a sanitizing cycle in the dishwasher. The reason the flatware is placed handle down is so that the sanitizing solution drips off the head of the flatware during the sanitizing cycle.

After sanitization, the flatware is then manually transferred to serving trays or bins, usually handle end up.

The need for automatic flatware sorting machines was recognized in U.S. Pat. No. 4,954,250. Unfortunately, the apparatus disclosed therein was excessively large, did not always sort the flatware properly according to type, and, in any case, did not automatically orient the flatware for the sanitizing cycle. Thus, this apparatus still required a fair amount of manual labor.

Other attempts at manufacturing a fully automatic flatware sorting machine have also failed. As discussed in the '250 patent, complex image recognition systems have been developed in an attempt to sort flatware both according to type and orientation but such systems exhibit high failure rates, low reliability, and are not robust enough to withstand the harsh kitchen environment where they are used.

Thus, there is a need for a fairly compact, robust, highly reliable, and fully automatic flatware sorting machine which sorts flatware not only according to type but also according to orientation to eliminate the tedious manual labor associated with sorting operations in restaurants and cafeterias.

SUMMARY OF INVENTION

It is therefore an object of this invention to provide an improved flatware sorting machine.

It is a further object of this invention to provide such a flatware sorting machine which sorts flatware not only according to type but also according to orientation.

It is a further object of this invention to provide such a flatware sorting machine which eliminates the time consuming and tedious labor intensive task of sorting flatware according to type and orientation.

If is a further object of this invention to provide such a flatware sorting machine which is relatively compact, and highly reliable.

It is a further object of this invention to provide such a flatware sorting machine which is robust enough to withstand the harsh kitchen environment wherein it is to be used.

This invention results from the realization that a properly working and reliable flatware sorting machine which sorts the flatware according to both type and orientation can be accomplished by a unique sombrero-shaped rotating feed bin which initially orients the unsorted flatware to all lie in the same general direction, and a magnetic-based flatware pick-up and transport system which transfers the flatware one piece at a time from the feed bin to a sorting system which includes two sorting stations: a first station which sorts all handle end down flatware according to type and a second sorting station which sorts all handle end up flatware according to type. If, however, there is no need to orient the flatware handle end up or handle end down in a particular implementation, the sorting system can be simplified or replaced with compatible sorting systems. Thus, one primary focus of the invention herein is the unique flatware pick-up and transfer system.

This invention features a flatware sorting machine including a feed bin for holding unsorted flatware, a sorting system for sorting the flatware, and a flatware pick-up and transport system for retrieving the flatware from the feed bin and transporting them to the sorting system. The flatware pick-up and transport system includes a transport mechanism such as a belt, a plurality of individual flatware grasping mechanisms such as magnetic members connected to the belt for retrieving individual pieces of flatware from the feed bin, and a drive subsystem such as a pair of spaced pulleys for driving the belt to bring the magnetic members into contact with the unsorted flatware in the feed bin and for transporting the magnetic members and the individual pieces of flatware attached thereto to the sorting system. Finally, there are some means, such as a knock-off bar, for transferring the flatware from the magnetic member to the sorting system.

The feed bin preferably includes a circular trough for orienting all the unsorted flatware to lie in the same general direction. Further included is a motor for rotating the feed bin, preferably at a rate slower than the speed of the transport belt.

The magnetic members typically are connected to the belt grasping via a flexible member such as a chain. The magnetic members preferably have a blunt tip portion.

In an alternative embodiment, there are means for varying the magnetic strength of each magnetic member. For example, there may be a pair of magnets disposed within a hollow body and separated by a spacing spring. A driver set screw in contact with one magnet through the body allows adjustment of the spacing between the two magnets.

The drive subsystem typically includes an upper pulley and a lower pulley for the belt. The upper pulley is disposed over the sorting system and the lower pulley is disposed over the feed bin. Also included is a tensioner for maintaining the tension on the belt. The upper pulley is preferably disposed at a different elevation than the lower pulley. The drive subsystem further includes a motor for rotating one of the upper and lower pulleys. The flatware pick-up and transport mechanism system preferably includes a knock-down mechanism for dislodging a piece of flatware picked up by two adjacent magnetic members.

The sorting system typically includes a frame portion defining a first sorting station for sorting flatware handle-end down and a second sorting station for sorting flatware handle-end up, and a rotating portion disposed within the frame. The rotating portion includes a plurality of feed hoppers disposed to receive flatware from the pick-up and transport mechanism, a corresponding plurality of sorting jaw members disposed beneath the feed hoppers and operable between a closed position and plurality of sequentially wider open positions, and means such as a cam mechanism

for sequentially opening and closing the jaw members to sort the flatware according to type.

The frame portion may include a stationary upper cam having an open section proximate the first sorting station. Each vertically oriented feed hopper includes a cam follower which cooperates with the stationary upper cam and a spring based pivoting mechanism which allows the feed hoppers to tilt at the open section of the stationary upper cam proximate the first sorting station. The frame portion also may include a stationary lower cam having a step down portion section between the first sorting station and the second sorting station.

The rotating portion then includes a plurality of spring-biased lifter blocks each disposed beneath the sorting jaw members. The lifter blocks each include a cam follower which cooperates with the lower stationary cam to allow the lifter blocks to spring up towards the jaw members at the step down portion of the stationary lower cam. The pivoting feed hoppers function to trap handle-up flatware pieces therein until they pass the first sorting station and the lifter blocks function to push the flatware up above the sorting jaws to allow them to close prior to sorting at the second sorting station.

In more general terms, the sorting system includes: means for sorting flatware according to type, and means for sorting flatware according to orientation. The means for sorting flatware according to type includes a plurality of sorting jaw members operable between a closed position and a plurality of different open positions. The means for sorting flatware according to orientation includes two separate sorting stations: a first sorting station for sorting flatware oriented handle end down according to type and a second sorting station for sorting flatware oriented handle end up according to type. The first station includes means for capturing the handle of flatware oriented handle end up until it reaches the second sorting station. The means for capturing includes a stationary upper cam and a plurality of pivotable, spring-biased feed hoppers disposed above the sorting jaw members. Each feed hopper includes a cam follower which cooperates with the upper stationary cam to maintain the hoppers in a vertical orientation, the upper stationary cam including an open portion proximate the first sorting station where the hoppers are free to pivot thereby wedging the handle of the flatware oriented handle end up in the feed hopper. The means for sorting further includes a lower stationary cam and a plurality of spring-biased pivotable lifter blocks disposed below the sorting jaw members. Each lifter block includes a cam follower which cooperates with a lower stationary cam to selectively orient the lifter blocks with respect to the sorting jaw members. The stationary lower cam has a step down portion between the first sorting station and the second sorting station for allowing the lifter blocks to pivot upward thereby pushing flatware oriented handle end up above the jaw members so they can close prior to the second sorting station.

The sorting system further includes a camming mechanism for sequentially opening the sorting jaw members to wider spacings at the first sorting station, for closing the jaw members before the second sorting station, and for again sequentially opening the jaw members to wider spacings at the second sorting station, and for then closing the jaw members.

In a preferred embodiment, the distal ends of adjacent magnetic members are oriented with the same polarity to prevent attraction therebetween and there are means for driving the flatware pick-up and transport system at a rate faster than the rotation speed of the feed bin.

This invention also features a flatware pick-up and transport system for a flatware sorting machine. The sorting machine may be as disclosed in this specification or may be of a different configuration. The pick-up and transport system includes a transport mechanism such as a belt or chain, a plurality of magnetic members coupled to the transport mechanism for retrieving individual pieces of flatware, and a drive subsystem for driving the transport mechanism to bring the magnetic members into contact with unsorted flatware and for transporting the magnetic members to the sorting device.

This invention also includes a flatware sorting machine comprising a rotatable feed bin including a circular trough, a sorting device for sorting flatware, a flatware pick-up and transport system including a plurality of individual magnetic members coupled to a rotating member to bring the magnetic members into contact with unsorted flatware in the rotating feed bin and for transporting the magnetic members proximate the sorting device, and means for transferring the flatware from the magnetic members to the sorting device. Further included may be means for driving the rotatable feed bin at a rate slower than the rotating member of the flatware pick-up and transport system. The rotating member is preferably a belt but may also be a chain.

DISCLOSURE OF PREFERRED EMBODIMENT

Other objects, features and advantages will occur to those skilled in the art from the following description of a preferred embodiment and the accompanying drawings, in which:

FIG. **1** is a schematic view of the flatware sorting machine of this invention;

FIG. **2** is a schematic view of a single magnetic flatware grasping member of this invention;

FIG. **3** is a top view of the flatware transport mechanism and drive subsystem of this invention;

FIG. **4** is a schematic view of the upper pulley of the subsystem shown in FIG. **3**;

FIG. **5** is a more detailed schematic view of the feed bin section of the flatware sorting machine shown in FIG. **1**;

FIG. **6** is a schematic view of the knock-down mechanism of this invention for dislodging a piece of flatware picked up by two adjacent magnetic members;

FIG. **7** is a side view of a variable strength magnetic flatware grasping member in accordance with this invention;

FIG. **8** is a front schematic view of the sorting system shown in FIG. **1**;

FIG. **9** is a right side schematic view of the sorting system shown in FIG. **8**;

FIG. **10** is a rear schematic view of the sorting system shown in FIG. **8**;

FIG. **11** is a schematic view of the flatware sorting machine of this invention showing the operation of the knock-off bar which transfers flatware from the individual magnetic grasping members to the sorting system in accordance with this invention;

FIG. **12** is a schematic view of the interior of the sorting system of this invention showing the spring-biased pivotable feed hoppers in accordance with this invention;

FIG. **13** is a schematic view of the lifter blocks of the sorting system of this invention;

FIG. **14** is a schematic view depicting the operation of the lifter blocks of the sorting system of the subject invention;

FIG. **15** is a schematic view of the cam mechanism for operating the sorting jaws of the sorting system of this invention; and

FIG. **16** is a schematic view of the jaw heads of the sorting jaws shown in FIG. **15**.

Flatware sorting machine **10**, FIG. **1**, according to this invention includes sombrero-shaped feed bin **12** rotatable in the direction shown by arrow **14** by motor **16** and chain or belt drive **18**. Unsorted flatware **20** is urged down towards circular trough **22** of feed bin **12** which functions to orientate all unsorted flatware to lie in the same general direction.

Machine **10** also includes sorting system **24** which sorts flatware delivered to it by flatware pick-up and transfer system **26** according to both type (fork, teaspoon, soup spoon, and knife) and orientation (handle up, handle down).

Pick-up and transport system **26** includes a transport mechanism, preferably belt **28** (but a chain drive could be used), and a plurality of individual flatware grasping means **30**, **32**, **34**, **36**, **38**, and **40**.

In a preferred embodiment, such means include magnetic member **42**, FIG. **2**, connected to shaft **44** which is flexibly coupled to belt **28**, FIG. **1**, via flexible chain **46**, FIG. **2**. Conical shaped blunt tip **48** of magnetic member **42** has a diameter of about 0.125 inches. This configuration allows the flatware to hang properly during the transport from the feed bin to the sorting system. Adjacent magnetic members **30**, **32**, FIG. **1**, for example, are oriented to have the same polarity on the distal blunt tip end thereof to prevent magnetic member **32** from being attracted to magnetic member **30**. Plastic or insulative sleeve **47** also helps to keep adjacent magnets from being attracted to each other. The spacing between adjacent magnetic members **30**, **32** on belt **28** is approximately 6 inches and chain **46**, FIG. **2** is approximately 3 inches long. Magnetic member **42** is approximately 0.38 inches in diameter and when coupled to shaft **44** is approximately 2.38 inches long. Magnetic members **30**, **32** could be permanent magnets or electromagnets.

In operation, belt **28** rotates in the direction shown by arrow **50**, FIG. **1**, to bring all the individual magnetic members, e.g., **30**, **32**, and **34** into contact with the unsorted flatware in rotating feed bin **12**. The flatware is then transported by belt **28** one piece at a time to sorting system **24** until the magnetic members strike knock-off bar **52** which dislodges the flatware from the magnetic members to fall into the upper hopper receptacles of sorting system **24**, discussed in more detail in reference to FIGS. **8–11**.

In the preferred embodiment of this invention, feed bin **12** rotates at a speed approximately 30–40 percent slower than the speed of belt **28**. So, for example, if feed bin **12** operates at approximately 4 rpm, belt **28** operates at approximately 6 rpm.

This feature insures that each magnetic member is dragged over the multiple pieces of flatware in feed bin **12** for a sufficient period of time to contact one piece of flatware. In addition, the dragging action helps to urge the blunt tip portion **48**, FIG. **2**, of each magnetic member towards the distal end of an individual piece of flatware for easier sorting operations. It is also important that belt **28** be tilted at approximately a 30° angle from horizontal so that the magnetic members are first brought into contact with the flatware in feed bin **12** and then transported up and over sorting system **24**. Feed bin **12** is placed at an elevation with respect to belt **28** so that the blunt tip portion **48**, FIG. **2**, of each magnetic member almost touches the bottom of trough **22**, FIG. **1**, of feed bin **12** thus insuring that the pick-up and transfer system works properly irrespective of whether feed bin **12** is completely full, or nearly empty. Sorting system **24** is placed at an elevation relative to belt **28** so that blunt tip portion **48**, FIG. **2**, of each magnetic member just clears the upper extent of each upper hopper receptacle of sorting system **24**, FIG. **1**, shown in more detail in FIGS. **8–11**. In practice, machine **10** reliably sorts one piece of flatware both according to type and orientation approximately each second.

Pick-up and transport system **26**, FIG. **3**, includes frame members **60**, **62**, **64**, and **66** for fixing lower rotating pulley **68** at the desired 30° angle over feed bin **12**, FIG. **1**, and upper pulley **70**, FIG. **3**, disposed at the same angle over sorting system **24**, FIG. **1**. The general orientation of lower pulley **68** with respect to feed bin **12** of flatware pick-up and transport system **26** is shown in FIG. **5**. Tensioning mechanism **72**, FIG. **3**, operates to keep the proper tension on belt **28** as is known. Upper pulley **70**, FIG. **4**, includes cut-out portions **80**, **82** on the lower portion thereof for allowing the individual magnetic members to maintain their vertically hanging orientation when the transport belt contacts upper pulley **70**. Lower pulley **68**, FIG. **5**, includes the same cut-out portions. Upper pulley **70**, FIG. **4** also includes slots **84**, **86**, defined by spaced adjacent dowels **88** and **90** as shown for slot **84** which cooperate with spaced ribs on belt **28**, FIG. **3** to prevent slippage of belt **28** relative to pulley **70**. One such rib is shown at **90** in FIG. **6**.

Also shown in FIG. **6** is knock-down mechanism **96**. In instances where an individual piece of flatware, such as a knife, is picked up by adjacent magnetic members **98** and **100**, knock-down plate **102** is driven up and down in the direction shown by arrow **104** to dislodge the knife from magnetic member **98** so that it hangs vertically only from magnetic member **100**. Knock-down plate **102** is attached to vertical bar **106** which, in turn, is attached to horizontal bar **108** which pivots about point **110**. Horizontal bar **108** includes angled face **112** which rests on shaft **114** of fastener **116** which connects each magnetic member **98**, **100** via their respective chains to belt **28**. In this way, knock-down plate **102** travels upward and out of the way until the furthest extent of angled face **112** as shown at **120** is reached. Then, horizontal member **108** drops down into recess **122** thereby driving knock-down plate **102** downward at a point directly between adjacent magnetic members **98** and **100** to dislodge a piece of flatware attached to both members **98** and **100** so that it only hangs vertically from one member.

In an alternative embodiment, each magnetic member includes some means for varying its magnetic strength as shown for magnetic member **36***a*, FIG. **7**. Magnetic member **36***a* has an aluminum outer hollow body **120** and a pair of magnets **122** and **124** disposed therein and separated by spacing spring **126**. A driver, such as set screw **128** is then adjusted to adjust the spacing between magnets **122** and **124** to thereby tune the strength of the magnetic member for a specific implementation depending on the type and weight of the flatware used at the facility where the sorting machine is installed.

The components of sorting system **24**, FIG. **1**, are shown in more detail in FIGS. **8–16**. Sorting system **24**, FIG. **8**, includes rotating portion **140** and fixed frame portion **142**. Rotating portion **140** includes twelve upper hopper receptacles **144**, and twelve corresponding pivotable feed hoppers **146**. There are also twelve corresponding lower hopper receptacles **148** disposed under each feed hopper. There are also twelve corresponding pairs of sorting jaws **150**, **152** disposed under each lower hopper receptacle and operable between a closed position and a plurality of different open positions. There are also twelve corresponding lifter blocks disposed adjacent to and partially beneath each pair of sorting jaws as shown for lifter block **154**.

Upper hopper receptacle **144** receives a single piece of flatware at a time after it is separated from the magnetic

members via knock-off bar **52**. Thus, each upper hopper receptacle functions to urge individual pieces of flatware delivered to it from pick-up and transport system **26**, FIG. **1**, into each feed hopper which, in turn, functions to feed the individual flatware pieces through the lower hopper receptacles and to the sorting jaws.

The combination of rotating portion **140**, FIG. **8**, and fixed frame portion **142** of sorting system **24** defines two opposing sorting stations. At first sorting station **160**, FIGS. **8** and **9**, the flatware is sorted according to type handle side down. At second sorting station **162**, FIGS. **9** and **10**, which is directly opposite first sorting station **160**, all handle side up flatware is sorted according to type.

To accomplish this task, fixed frame portion **142** includes upper stationary cam **164**, FIG. **9**, which has an open portion proximate first sorting station **160** as shown in FIG. **8**. Each vertically oriented feed hopper includes cam follower **166** in the form of a roller which cooperates with upper stationary cam **164** and a spring-biased pivoting mechanism shown in more detail in FIG. **12** which allows each feed hopper to tilt at the open portion of upper stationary cam **164** proximate first sorting station **160** as shown for feed hopper **146**, FIG. **8**.

Fixed frame portion **142** further includes lower stationary cam **170** which is uniform in width except at step down portion **230** just after first sorting station **160** and also at step down portion **172**, FIG. **9**, located just before second sorting station **162**. Each lifter block, as shown for lifter block **154**, includes a cam follower in the form of roller **174** which cooperates with lower stationary cam **170** to change the angle of each lifter block as a function of the width of lower stationary cam **170**. Each lifter block is disposed to rotate beneath its corresponding jaw members as shown in FIG. **9** and pivotably resides on shaft **180** via bearings **182**, **184**, and spring **186** which is biases cam follower **174** against lower fixed cam **170**.

Fixed frame portion **142**, FIG. **8**, of sorting system **24** further includes utensil stop plate **190**, FIG. **10** and knock-off bar **52** shown more clearly in FIG. **11**. Each feed hopper, such as shown for hopper **146**, FIG. **12**, is pivotably attached to shaft **200** extending between upright members **210** and **212** fixed to rotating table **214**. In this way, hopper **146** is biased to tilt outward as shown in FIG. **8** at the open portion of upper stationary cam **164** the interior of which is shown in FIG. **12**, via spring mechanism **216** attached to collar **218**. Also shown in FIG. **12** is shaft **220** which is connected to motor **222**, FIG. **1**, which rotates both the rotating portion **140** of sorting system **24**, FIG. **8**, and upper pulley **70**, FIG. **3** of pick-up and transport system **26**, FIG. **1**, to insure that the rotation of the pick-up and transport belt and the rotation of the rotating portion of sorting system **24** are synchronized. In this way, only one piece of flatware is delivered to each upper hopper receptacle **144**, FIG. **8**, at a type via knock-off bar **52**, FIG. **11**.

The operation of flatware sorting machine **10**, FIG. **1**, is best explained from the perceptive of an individual piece of flatware. The individual piece of flatware is initially lying in rotating feed bin **12**, FIG. **6**, and is picked up by magnetic member **100**. If it is also picked up by adjacent magnetic member **98**, knock-down mechanism **96** dislodges it from magnetic member **98**. The individual piece of flatware is now hanging vertically from and oriented on the magnetic member either handle up as shown for spoon **37**, FIG. **1**, or handle down, as shown for fork **41**. Belt **28** now brings the piece of flatware up and over sorting system **24** until knock-off bar **52**, FIG. **11**, dislodges it from the magnetic member.

The handle of each piece of flatware oriented handle down is then guided by upper hopper receptacle **144** into feed hopper **146**, FIG. **8**, which is kept vertical by upper stationary cam **164** at the point and time when knock off bar **52** separates the piece of flatware from its magnetic carrier. The handle is then fed by lower hopper receptacle **148** and through an opening in closed sorting jaws **150** and **152** until the head of the flatware is stopped by the jaws. Stop **190**, FIG. **10**, is used to prevent the knife serrations from coming into contact with the metal jaws to prevent wear thereof and to stop the handle of all flatware oriented handle down.

At first sorting station **160**, FIG. **8**, pivotable hopper **146** is now free to pivot into the position shown in FIG. **8** due to the open section of upper stationary cam **164**. Since the pieces of flatware are oriented handle down, however, this pivoting action has no effect on flatware oriented handle down as the handle is clear of the feed hopper. Sorting jaws **150**, **152** then open sightly to let knives pass therethrough first, then open a little bit more to allow forks to pass therethrough, then open a little bit more to allow teaspoons to pass therethrough, and finally open all the way to allow soup spoons to pass therethrough. Thus all handle down flatware is properly sorted according to type at first sorting station **160**, FIG. **8**. The extent to which the sorting jaws open at each portion of the sorting stations will depend on the particular type of flatware used at the site of installation.

If, on the other hand, the flatware drops into feed hopper **146** handle end up, when hopper **146** pivots into the position shown in FIG. **8**, the handle is wedged against lower hopper receptacle **148** thus preventing flatware oriented handle side up from being sorted at first sorting station **160**. Just after first sorting station **160**, FIG. **8**, the pivotable hoppers are again driven into a vertical orientation via upper stationary cam **164**. At this point, lower stationary cam **170** dips slightly as shown at **230**, FIG. **8** and FIG. **13**, thus allowing lifter block **154** to pivot upwards until it mates with fixed ledge **232**, FIG. **13**, attached to stationary frame portion **142**, FIG. **8**, of sorting system **24** between first sorting station **160** and second sorting station **162**.

It is also at this point and time when the sorting jaws completely open and the flatware oriented handle end up drops down until stopped by the V-shaped trough **153** defined by lifter block **154** and fixed ledge **232**, FIG. **13**. Lower stationary cam then steps down even further as shown at **240**, FIG. **14** allowing lifter block **154** to rotate to an almost horizontal position thus pushing the head of each piece of flatware up through fully open jaws **150** and **152** so they can close as shown at **242**. This action rests the head of the piece of flatware in jaws **150** and **152** and allows for sorting at second sorting station **162**, FIG. **10**, where, again, the jaws open slightly to sort knives, open more to sort forks, open even more to sort teaspoons, and open fully to sort soup spoons thus properly sorting all handle end flatware at second sorting station **162**. In this way, sorting system **24**, FIG. **8**, sorts flatware both according to type and orientation.

The operation of the sorting jaws is discussed in more detail with reference to FIG. **15**. Cams **250**, **252**, **260**, and **262** sequentially open and close the jaw members to sort the flatware according to type at both sorting stations. Lower cams **250** and **252** operate every other pair of jaws **254**, **256** while upper cams **260** and **262** operate each pair of jaws therebetween, such as jaw pair **264**. Cams **250**, **252**, **260**, and **262** do not rotate and are held fixed in place about fixed collar **266** surrounding the drive shaft (not shown) for the upper belt pulley and the rotating portion of the sorting system. Each sorting jaw assembly includes jaw heads **270** and **272** attached to scissor arms **274** and **276**. Scissor arm

276 includes cam follower 280 which cooperates with cam 250 while scissor arm 274 includes cam follower 282 which cooperates with cam 252. Sorting jaw pair 264 is similar except its scissor arms (not shown) are raised above the plane of scissor arms 276 and 274 to save space and includes similar cam followers which cooperate with cams 260 and 262, respectively.

The jaw heads 270, 272, FIG. 16, in the fully closed position define opening 290 which, as discussed above, allows the handle of each individual piece of flatware oriented handle end down to slide therethrough and concave cup-shaped portion 292 and 294 for retaining the head of an individual piece of flatware and also for urging the flatware to twist until it lies generally parallel to longitudinal axis 296 and to remain captured by the jaw heads in that position until they successively open wider and wider, as discussed above, to properly sort first knives, then forks, then teaspoons, and finally soup spoons into their correct receiving bin.

Thus, in summary, the flatware sorting machine of this invention includes rotating feed bin 12, FIGS. 1, 5 and 6; and flatware pick-up and transport system 26, FIG. 1. Flatware pick-up and transport system 26, FIG. 1, includes knock-down mechanism 96, FIGS. 5 and 6, magnetic grasping members 36, 38 and 40 attached via a flexible chain to transport belt 28, FIGS. 1, 2, 5, 6, and 7. Flatware pick-up and transport system 26, FIG. 1 also includes upper pulley 70, FIGS. 3, 4, and 11 and lower pulley 68, FIGS. 3, 5, and 6 and tensioning mechanism 72, FIGS. 3, 5, and 11. The other primary component of flatware pick-up and transport system 26, FIG. 1, is flatware knock-off bar 52, FIGS. 1, 8, and 11.

Flatware sorting machine 10, FIG. 1, of this invention also includes sorting system 24, FIG. 1, which includes fixed frame portion 142, FIGS. 8–10, and rotating portion 140. The rotating portion 140 includes twelve upper hopper receptacles, twelve pivotable feed hoppers, twelve lower hopper receptacles, twelve pairs of corresponding sorting jaws, and twelve corresponding lifter blocks.

Fixed frame portion 142 includes an upper stationary cam 164, FIG. 8, which functions to keep the hoppers horizontal except at the first sorting station where the upper stationary cam has an open section which allows the hoppers to spring to a tilted position as shown in FIG. 8. This action ensures that handle-up flatware retained in the feed hoppers and not sorted at the first sorting station. There is also lower stationary cam 170, which functions to keep the lifter blocks vertical and clear from the sorting operation except in two places: first, right after the first sorting station where the lower stationary cam includes a step down portion as shown at 230, FIGS. 8 and 13 which allows the lifter blocks to tilt slightly and cooperate with fixed ledge 232, FIG. 13, to keep flatware oriented handle end up from dropping between the jaws when they are fully open and second, directly before the second sorting station where the stationary lower cam includes even a larger step down portion 240, FIGS. 9 and 14 which allows the lifter blocks to spring to a nearly horizontal position thereby pushing the handle end up flatware back up through the jaws so the jaws can properly close before the sorting operation again begins at second sorting station 162, FIGS. 9 and 10, which sorts handle end up flatware according to type.

The drive mechanisms of this invention include motor 222, FIG. 1, for driving the rotating portion of the sorting system and, via shaft 220, FIGS. 8–12, to drive upper pulley 70, FIGS. 3, 4, and 9–11 of the flatware pick-up and transport system. Motor 16, FIG. 1, drives rotating sombrero-shaped feed bin 12, FIGS. 1, and 5–6. The cam mechanism which operates the opening and closing of sorting jaws 150, 152, FIGS. 8, 14, 15, and 16 is discussed with reference to FIG. 15. In an alternative embodiment, one motor could be used in conjunction with the appropriate reduction mechanisms and drive mechanism to operate all the moving components of the sorting machine of this invention.

Although specific features of this invention are shown in some drawings and not others, this is for convenience only as each feature may be combined with any or all of the other features in accordance with the invention. For example, the pick-up and transport system may be used in conjunction with other sorting devices.

Other embodiments will occur to those skilled in the art and are within the following claims:

What is claimed is:

1. A flatware sorting machine comprising:

a feed bin for holding unsorted flatware;

a sorting system for sorting the flatware; and

a flatware pick-up and transport system for retrieving the flatware from said feed bin and transporting them to said sorting system, the flatware pick-up and transport system including:

a transport mechanism,

a plurality of individual flatware grasping means connected to said transport mechanism for retrieving individual pieces of flatware from said feed bin, and

a drive subsystem for driving said transport mechanism to bring the grasping means into contact with the unsorted flatware in the feed bin and for transporting the grasping means to the sorting system, and

means for transferring flatware from the grasping means to the sorting system, each said grasping means including a hollow body, a pair of magnets disposed within said hollow body and separated by a spacing spring, and a driver in contact with one magnet through the body for adjusting the spacing between the two magnets to thereby vary the magnetic strength of the grasping means.

2. A flatware sorting machine comprising:

a feed bin for holding unsorted flatware;

a sorting system for sorting the flatware, the sorting system including:

a frame portion defining a first sorting station for sorting flatware handle end down and a second sorting station for sorting flatware handle end up, and

a rotating portion disposed within said frame; and

a flatware pick-up and transport system for retrieving the flatware from said feed bin and transporting them to said sorting system, the flatware pick-up and transport system including:

a transport mechanism,

a plurality of individual flatware grasping means connected to said transport mechanism for retrieving individual pieces of flatware from said feed bin, and a drive subsystem for driving said transport mechanism to bring the grasping means into contact with the unsorted flatware in the feed bin and for transporting the grasping means to the sorting system, and

means for transferring flatware from the grasping means to the sorting system.

3. The flatware sorting machine of claim 2 in which said rotating portion includes:

a plurality of feed hoppers disposed to receive flatware from said pick-up and transport mechanism;

a corresponding plurality of sorting jaw members disposed beneath said feed hoppers and operable between a closed position and plurality of open positions; and

means for sequentially opening and closing said jaw members to sort said flatware according to type.

4. The sorting machine of claim **2** in which said frame portion includes a stationary upper cam having an open section proximate said first sorting station.

5. The sorting machine of claim **4** in which each feed hopper includes a cam follower which cooperates with said stationary upper cam and a spring biased pivoting mechanism which allows the hoppers to tilt at the open section of said stationary upper cam proximate said first sorting station.

6. The flatware sorting machine of claim **2** in which said frame portion further includes a stationary lower cam having a step down portion section between said first sorting station and said second sorting station.

7. The flatware sorting machine of claim **6** in which said rotating portion further includes a plurality of spring-biased lifter blocks each disposed beneath said sorting jaw members.

8. The flatware sorting machine of claim **7** in which said lifter blocks each include a cam follower which cooperates with said lower stationary cam to allow said lifter blocks to spring up towards said jaw members at the step down portion of said stationary lower cam.

9. A flatware sorting machine comprising:

a feed bin for holding unsorted flatware;

a sorting system for sorting the flatware, said sorting system including:

means for sorting flatware according to type including a plurality of sorting jaw members operable between a closed position and a plurality of different open positions, and

means for sorting flatware according to orientation; and

a flatware pick-up and transport system for retrieving the flatware from said feed bin and transporting them to said sorting system, the flatware pick-up and transport system including:

a transport mechanism,

a plurality of individual flatware grasping means connected to said transport mechanism for retrieving individual pieces of flatware from said feed bin, and

a drive subsystem for driving said transport mechanism to bring the grasping means into contact with the unsorted flatware in the feed bin and for transporting the grasping means to the sorting system; and

means for transferring flatware from the grasping means to the sorting system.

10. The flatware sorting machine of claim **9** in which said means for sorting flatware according to orientation includes two separate sorting stations, a first sorting station for sorting flatware oriented handle end down according to type and a second sorting station for sorting flatware oriented handle end up according to type.

11. The flatware sorting machine of claim **10** in which said first station includes means for capturing the handle of flatware oriented handle end up until it reaches said second sorting station.

12. The flatware sorting machine of claim **11** in which said means for capturing includes a stationary upper cam and a plurality of pivotable, spring-biased feed hoppers disposed above said sorting jaw members, each said feed hopper including a cam follower which cooperates with said upper stationary cam to maintain the hoppers in a vertical orientation, said upper stationary cam including an open portion proximate said first sorting station where said hoppers are free to pivot thereby wedging the handle of said flatware oriented handle end up in said feed hopper.

13. The flatware sorting machine of claim **10** in which said means for sorting further includes a lower stationary cam and a plurality of spring-biased pivotable lifter blocks disposed below said sorting jaw members, each said lifter block including a cam follower which cooperates with a lower stationary cam to selectively orient said lifter blocks with respect to said sorting jaw members.

14. The flatware sorting machine of claim **13** in which said stationary lower cam has a step down portion between said first sorting station and said second sorting station for allowing said lifter blocks to pivot upward thereby pushing flatware oriented handle end up above said jaw members.

15. The flatware sorting machine of claim **10** in which said sorting system further includes a camming mechanism for sequentially opening said sorting jaw members to wider spacings at said first sorting station, for closing said jaw members before the second sorting station, and for again sequentially opening said jaw members to wider spacings at said second sorting station, and for then closing said jaw members.

16. A flatware sorting machine comprising:

a feed bin for holding unsorted flatware;

a sorting system for sorting the flatware including:

a frame portion defining a first sorting station for sorting flatware handle end down and a second sorting station for sorting flatware handle end up, and

a rotating portion disposed within said frame, said rotating portion including:

a plurality of feed hoppers disposed to receive flatware from said pick-up and transport mechanism,

a corresponding plurality of sorting jaw members disposed beneath said feed hoppers and operable between a closed position and plurality of open positions, and

means for sequentially opening and closing said jaw members to sort said flatware according to type.

* * * * *

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Boyer

(10) **Patent No.: US 6,237,779 B1**
(45) **Date of Patent: May 29, 2001**

(54) **UTENSIL SORTING APPARATUS**

(76) Inventor: **Jay M. Boyer**, 1250 S. 900 East, Springville, UT (US) 84663

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

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(22) Filed: **Jan. 19, 2000**

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(52) **U.S. Cl.** **209/680**; 209/659
(58) **Field of Search** 209/606, 629, 209/634, 659, 680

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3,625,356		12/1971	Jackson .	

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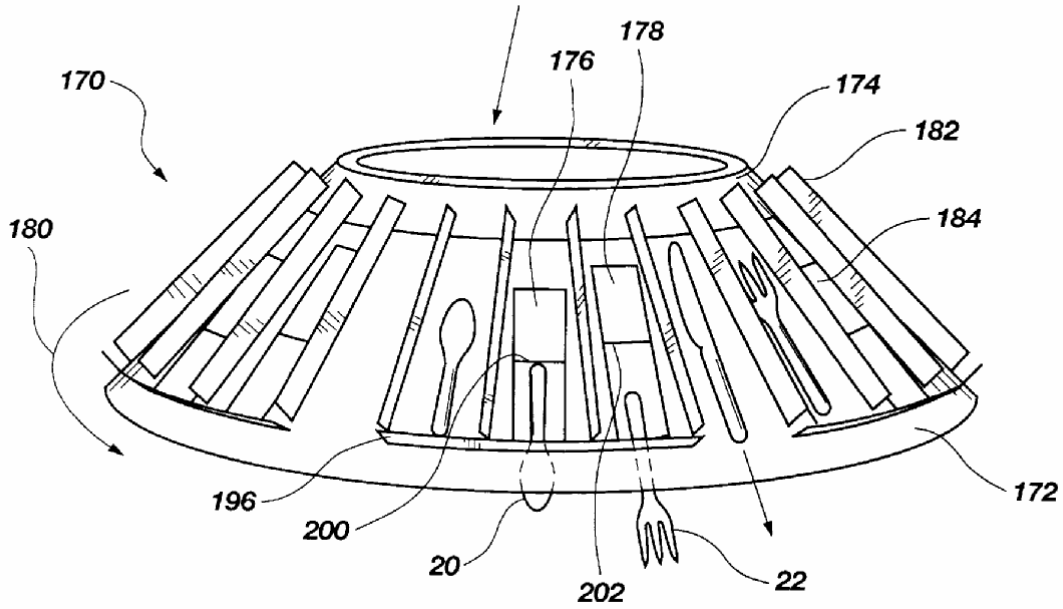
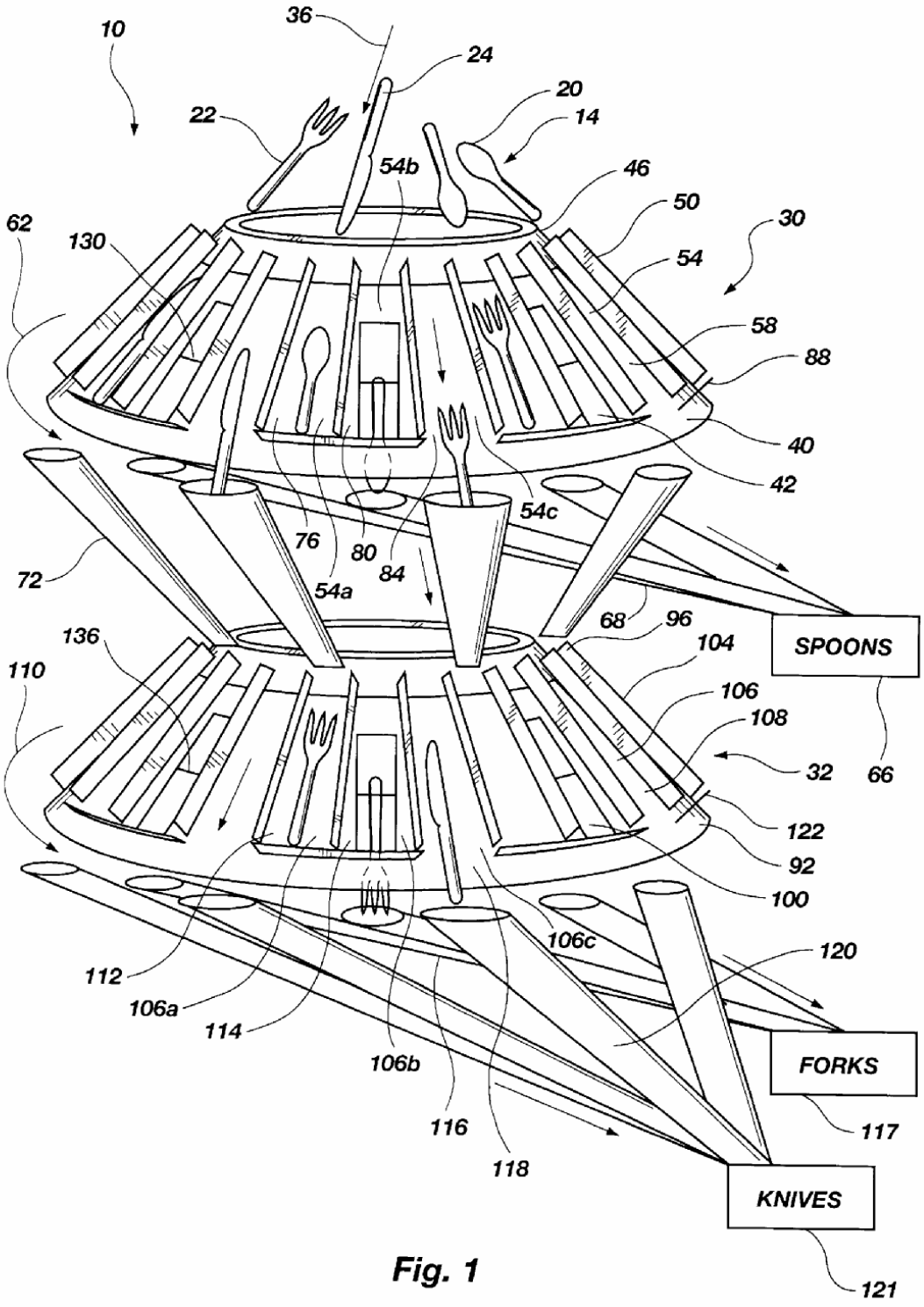
Primary Examiner—Donald P. Walsh
Assistant Examiner—Mark J Beauchaine
(74) *Attorney, Agent, or Firm*—Thorpe North & Western, L.L.P.

(57) **ABSTRACT**

A utensil sorting apparatus simultaneously sorts and/or orients a plurality of utensils, such as spoons, forks, and knives. A first movable conveyor is movably disposed over a first template having at least one first aperture sized to receive therethrough only the spoons. The first conveyor sequentially moves the utensils through at least three locations, including a receiving location, a sorting and orienting location, and a discharge location. A bar may be disposed laterally across the first aperture in the first template at a location configured to correspond to a midpoint of the spoon. The center of gravity of the spoon causes the spoon to pass over one side of the bar to orient the spoon as it passes through the aperture. The apparatus has a first stage, including the first template and first conveyor, to separate the spoons, and a second stage, including a second template and a second conveyor, to separate the forks from the knives.

27 Claims, 5 Drawing Sheets

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SPOONS
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KNIVES
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Fig. 1

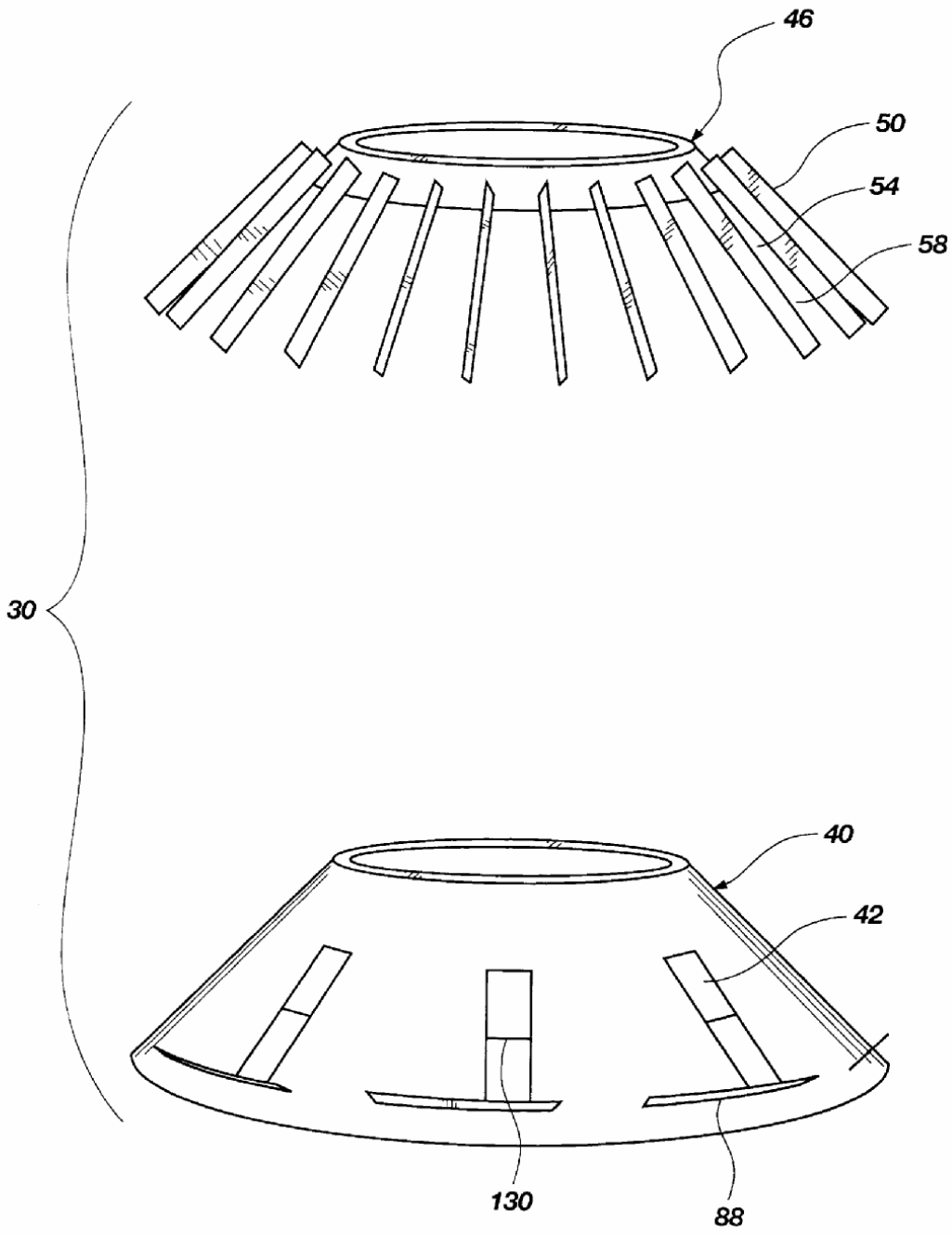

Fig. 4

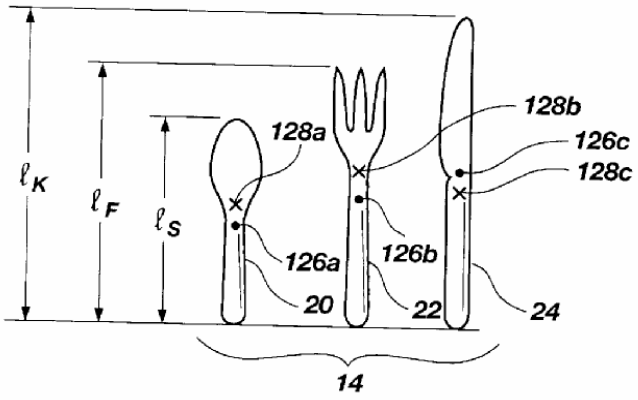
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Fig. 2

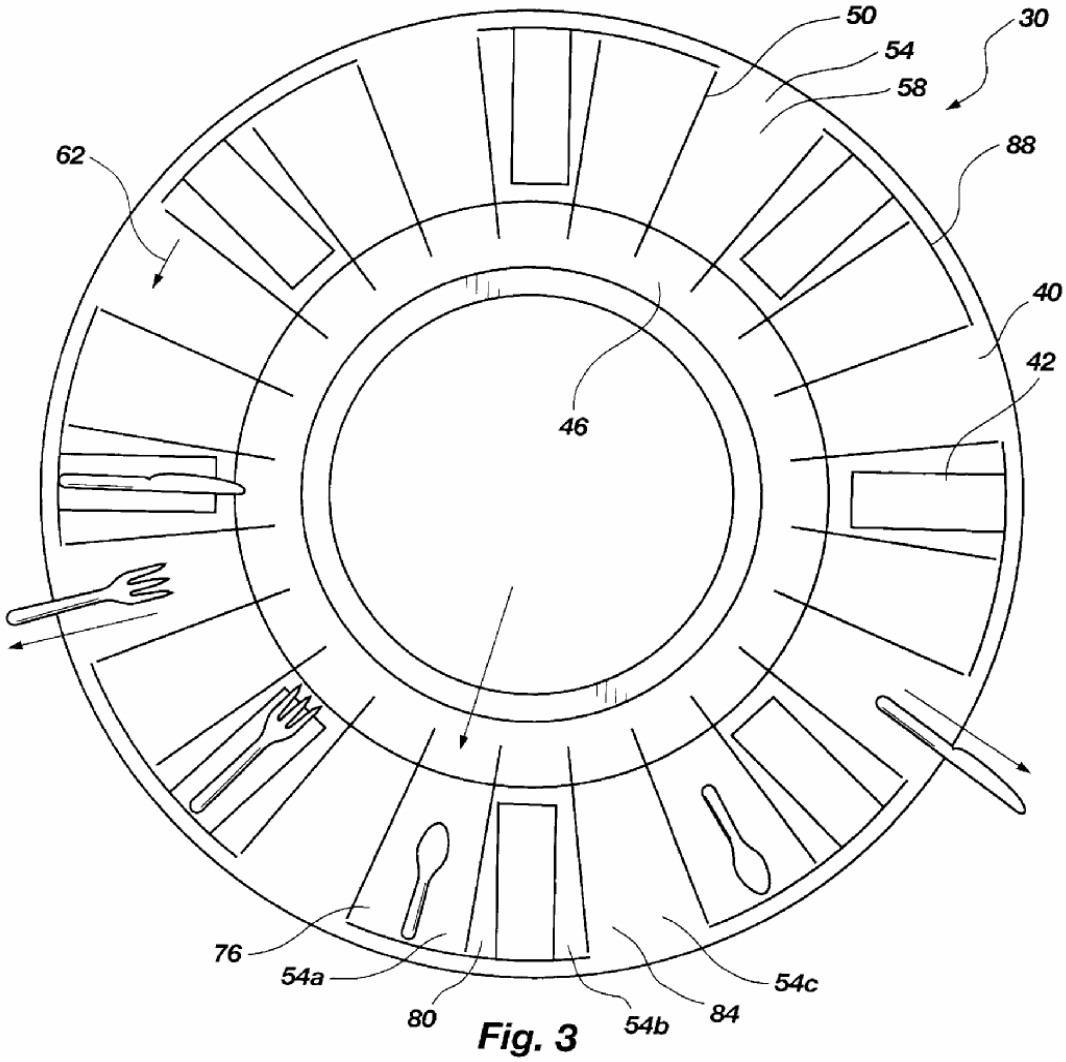
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Fig. 3

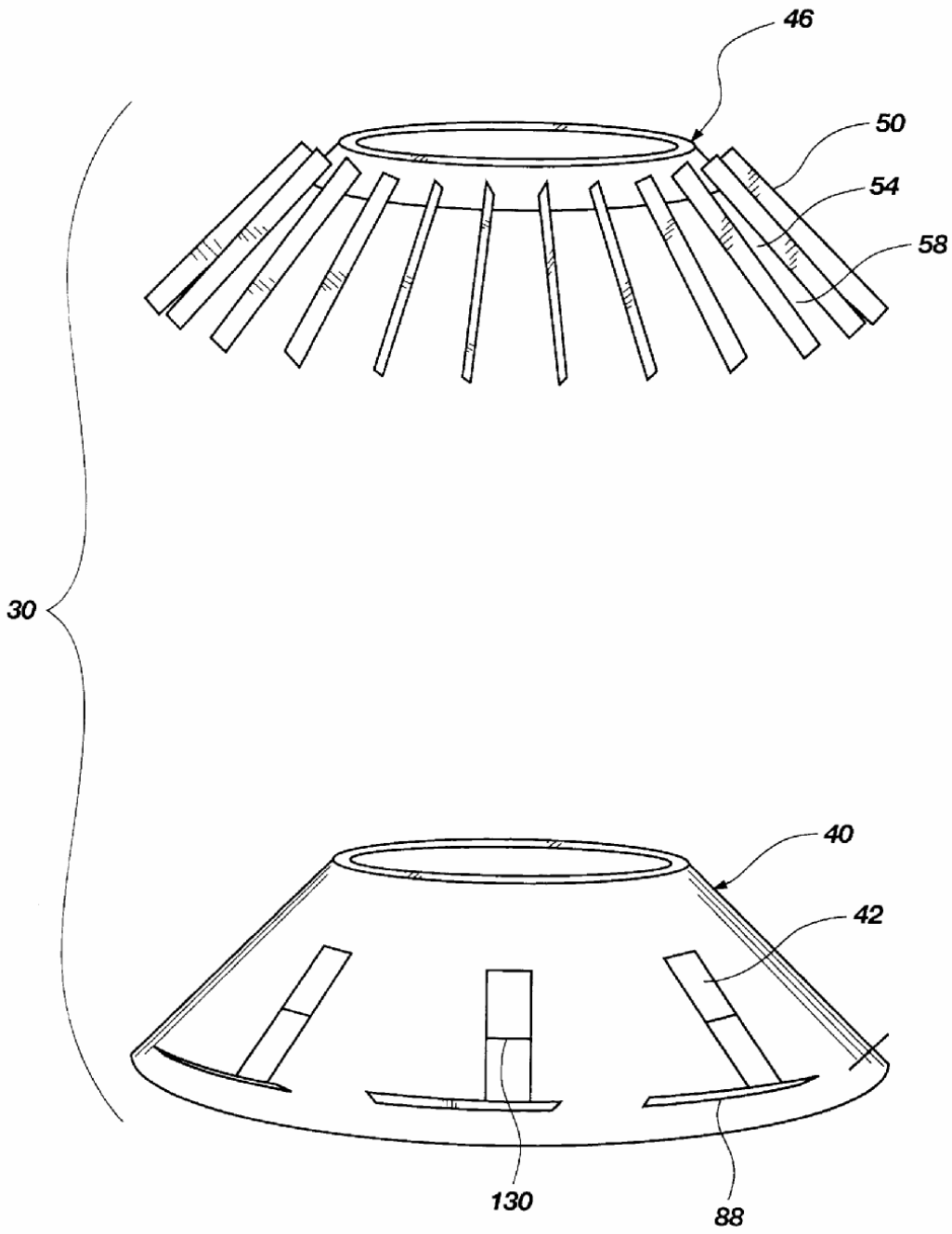

Fig. 4

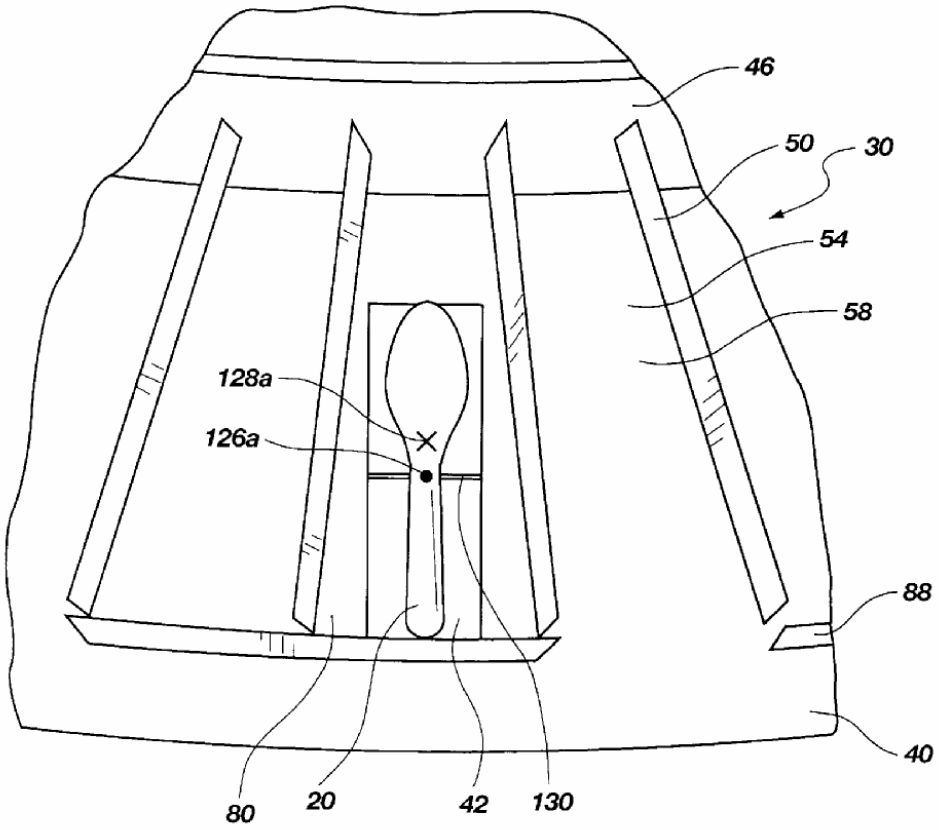

Fig. 5

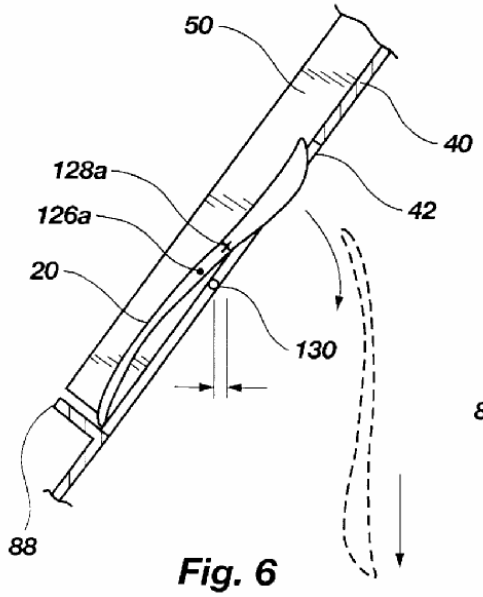

Fig. 6

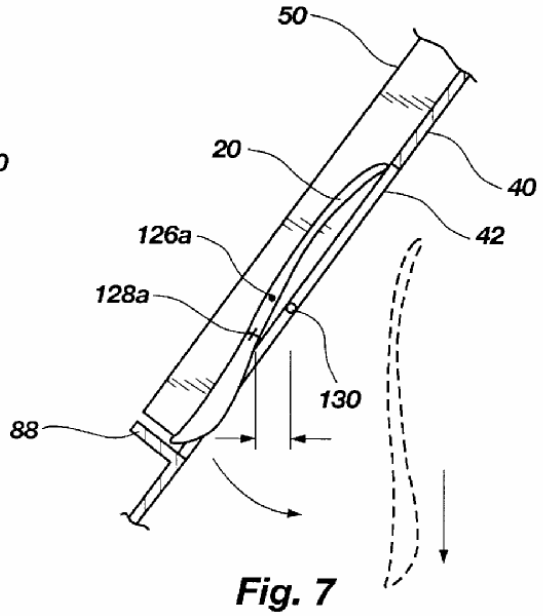

Fig. 7

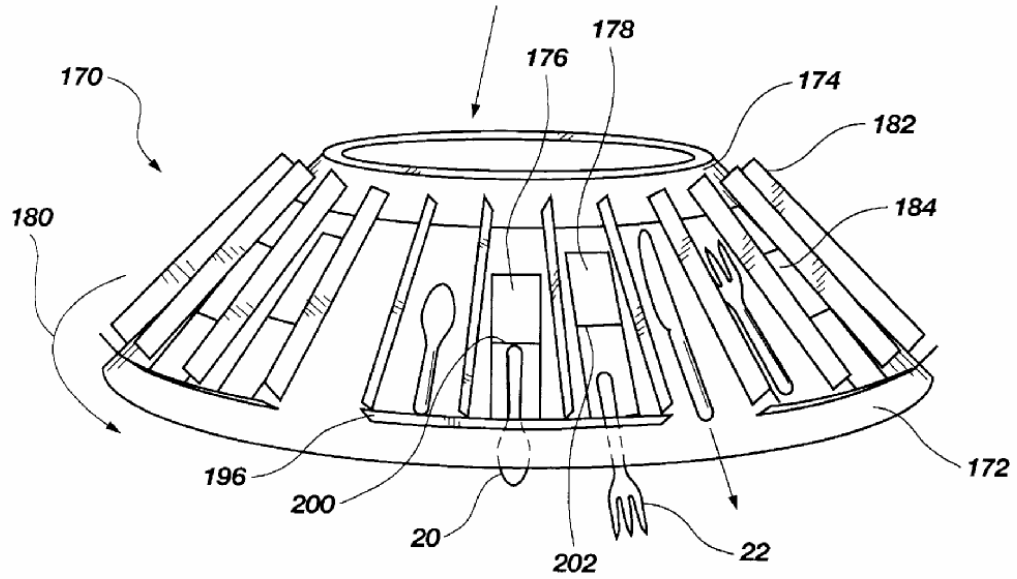
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Fig. 8

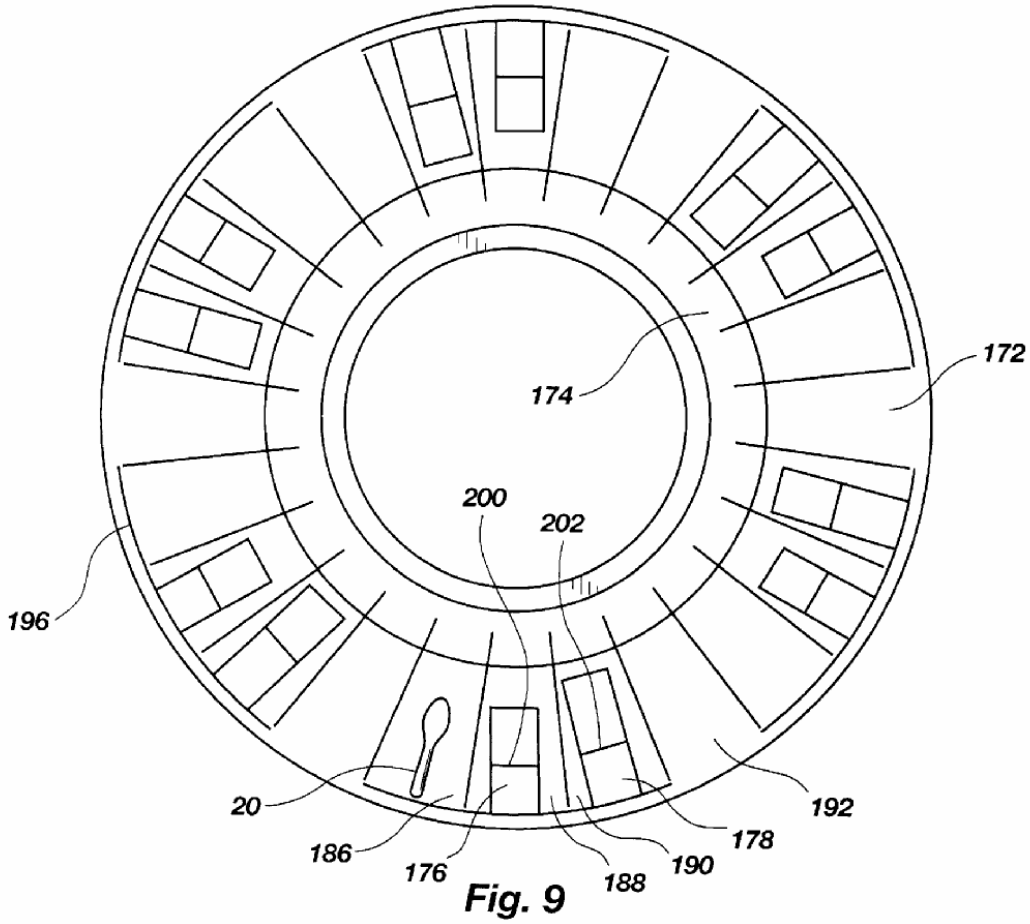
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Fig. 9

UTENSIL SORTING APPARATUS

BACKGROUND OF THE INVENTION

1. The Field of the Invention

The present invention relates generally to an apparatus for sorting utensils or silverware, such as spoons, forks and knives. More particularly, the present invention relates to a utensil sorting apparatus which continuously receives utensils, simultaneously sorts a plurality of the utensils, and simultaneously orients the utensils as they are sorted.

2. The Background Art

Large food preparation entities or eating establishments, such as restaurants, hotels, hospitals, cafeterias, etc., may serve hundreds to thousands of people per day or per meal. The large number of people served results in thousands of utensils or silverware which must be washed, sorted, and reoriented prior to reuse. These washing and sorting operations are typically performed by unskilled labor who collect the utensils, wash the utensils using either manual or large capacity washing machines, and then sort and orient the utensils. Because sorting the utensils requires the unskilled laborer to touch and handle the utensils, they must typically be rewashed to satisfy health and sanitation issues. One disadvantage with this system is the time and cost involved in unskilled labor manually sorting and orienting the utensils.

It is desirable to provide a system and/or apparatus for sorting and orienting utensils which is efficient and capable of rapidly sorting the utensils. It is also desirable that such a system or apparatus be accurate, simple, and sanitary.

A few different types of devices have been developed for sorting utensils. For example, U.S. Pat. No. 3,625,356 issued Dec. 7, 1979, to Jackson, discloses a device in which utensils pass through a chute with a twisted shape so that the utensils are caused to pivot about their lower end and swing outward towards a set of different height, gauged bars. The gauged bars are positioned at heights to allow shorter utensils to pass under the gauge bars while the higher gauge bars prevent longer utensils from passing underneath.

As another example, U.S. Pat. No. 3,389,790 issued Jun. 25, 1968 to Braunheim et al., discloses a device in which the utensils are disposed between partitions on the exterior of an angled drum. The drum rotates causing the utensils to rotate past a shield disposed about the lower portion of the drum. The shield is provided with three differently sized apertures for receiving three differently sized utensils as they are rotated past the apertures by the drum.

As another example, U.S. Pat. No. 3,545,613 issued Dec. 8, 1970, to Nystuen, discloses a device in which utensils are received between partitions on a conveyer belt. The conveyer belt moves the utensils past a plurality of different sized openings which are each sized to receive one of the utensils.

As another example, U.S. Pat. No. 3,389,711 issued Jun. 25, 1968, to Slayton, discloses a device with a plurality of open-ended pockets or tapered tubes which are rotated about a horizontal axis. The device has a first row of tapered tubes with an open bottom end sized to pass therethrough the narrowest utensils. As the tubes rotate about the horizontal axis, a utensil is disposed in each tube such that the narrowest utensil passes through the bottom of the tube while wider utensils will be trapped within the tube. As the tube rotates upwardly, it turns upside down such that wider utensils will fall out and be guided toward a next row of tapered tubes with wider openings.

One disadvantage with these types of devices is that they are designed to sort the utensils only one at a time. Thus, the utensils must be separated and fed into the devices one at a time, so that each utensil is disposed within a separate pocket or separate tube. In addition, the utensils are presented to a gauging opening one at a time.

Another disadvantage with these devices is that they only sort the utensils. Orientation of the utensils is performed as a separate step after sorting, if at all. Thus, after being sorted, some of the devices direct the utensils to other devices which are intended to orient the utensils in a common orientation.

Therefore, it would be advantageous to develop a method and/or apparatus for sorting a plurality of different utensils, which is simple, efficient, accurate, and sanitary. It would also be advantageous to develop such a method and/or apparatus which is capable of sorting a plurality of different utensils simultaneously. It would also be advantageous to develop such a method and/or apparatus which simultaneously sorts and orients the utensils.

OBJECTS AND SUMMARY OF THE INVENTION

It is therefore an object of the present invention to provide a method and/or apparatus for sorting a plurality of different utensils which is simple, efficient, accurate, and sanitary.

It is another object of the present invention to provide such a method and/or apparatus for sorting multiple utensils simultaneously.

It is yet another object of the present invention to provide a method and/or apparatus which sorts and orients the utensils simultaneously.

In accordance with one aspect of the present invention, the system includes a utensil sorting apparatus configured to simultaneously sort and/or orient a plurality of utensils. The plurality of utensils may include first utensils, such as spoons, second utensils, such as forks, and third utensils such as knives. The utensils preferably have different lengths.

The apparatus includes a first template having at least one first aperture sized to receive therethrough only the first utensils, or spoons. A first movable conveyor is movably disposed over the first template, and the at least one first aperture. The first conveyor sequentially moves the utensils through at least three locations. The first location is a receiving location to receive at least one of the first and second utensils. The second location is a sorting and orienting location to pass any first utensil through the aperture in the template, and to orient any first utensil passing through the aperture. The third location is a discharge location to discharge any second utensil.

In accordance with one aspect of the present invention, the first conveyor has a plurality of partitions formed thereon defining a plurality of pockets therebetween configured to receive the utensils. Each pocket has an opening movable across the first template, and the at least one first aperture. A flange is disposed on and extends outwardly from the template adjacent a side of the first aperture and at an end of the partitions to further define the pocket between the flange, the partitions, and the template. The flange extends laterally the length of the first and second locations, but leaves open the third location, such that any second or third utensil contained in the pocket may exit the pocket in the third location.

In accordance with another aspect of the present invention, a bar is disposed laterally across the first aperture

in the template at a location configured to correspond to a midpoint of the first utensils, or spoon. Thus, the centers of gravity of the first utensils are disposed on either side of the bar as the first utensils are moved across the first aperture in the first template. Therefore, the first utensils tend to pass through the first aperture in the first template on a same side of the bar as the center of gravity, thus orienting the first utensils.

In accordance with another aspect of the present invention, the at least one first aperture includes a plurality of first apertures in the first template configured to simultaneously sort a plurality of the first utensils, or spoons.

In accordance with another aspect of the present invention, the apparatus has a first stage, comprising the first template and first conveyor, to separate the first utensils, or spoons. In addition the apparatus has a second stage, comprising a second template and a second conveyor, to separate the second utensils, or forks, from third utensils, or knives. The second template has at least one second aperture sized to receive therethrough the second utensils, or forks. The second movable conveyor is movably disposed over the second template and the at least one second aperture, and sequentially moves the utensils through at least three locations, including a receiving location, a sorting and orienting location, and a discharge location. A bar may be disposed laterally across the second aperture in the second template at a location configured to correspond to a midpoint of the second utensils, or forks.

In accordance with another aspect of the present invention, the templates are frusto-conical interior cores, and the conveyors are frusto-conical exterior shells, rotatably disposed on the respective cores.

In accordance with another aspect of the present invention, the first template may include at least one second aperture sized to receive therethrough the second utensils. Thus, the same template may be used to separate spoons and forks.

A method for sorting a plurality of utensils includes simultaneously receiving a plurality of utensils on a first movable conveyor. Each of the plurality of utensils are simultaneously moved past one of a plurality of first apertures in a first template by moving the first conveyor. The first apertures are sized to receive only the first utensils therethrough. Any remaining utensils, or second or third utensils, are simultaneously moved past the plurality of apertures and simultaneously removed from the first movable conveyor.

As indicated above, the utensils may be simultaneously received each into one of a first plurality of pockets on the first movable conveyor. Additional utensils may be simultaneously received each into one of a second plurality of pockets on the first movable conveyor while the first plurality of utensils are moved past one of a plurality of first apertures in a first template.

In addition, the first utensils may be simultaneously oriented while passing through the apertures. The plurality of utensils may be moved past a plurality of bars, each disposed over one of the first apertures at a location corresponding to a midpoint of the first utensils. A center of gravity of the first utensils causes them to pass through the apertures on a side of the bar corresponding to the center of gravity of the first utensils, thus orienting the first utensils.

Furthermore, any remaining second or third utensils may be simultaneously received on a second movable conveyor. The second and third utensils are simultaneously moved past one of a plurality of second apertures in a second template by moving the second conveyor. The second apertures are sized to receive only the second utensils.

Additional objects and advantages of the invention will be set forth in the description which follows, and in part will be apparent from the description, or may be learned by the practice of the invention without undue experimentation. The objects and advantages of the invention may be realized and obtained by means of the instruments and combinations particularly pointed out in the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other objects, features and advantages of the invention will become apparent from a consideration of the subsequent detailed description presented in connection with the accompanying drawings in which:

FIG. **1** is a perspective schematic view of a preferred embodiment of a utensil sorting apparatus in accordance with the present invention;

FIG. **2** is a side view of a preferred embodiment of utensils of the present invention;

FIG. **3** is a top view of the preferred embodiment of the utensil sorting apparatus in accordance with the present invention;

FIG. **4** is an exploded view of a preferred embodiment of a first stage of the utensil sorting apparatus in accordance with the present invention;

FIG. **5** is a partial side view of the preferred embodiment of the first stage of the utensil sorting apparatus in accordance with the present invention;

FIG. **6** is a partial cross-sectional view of the preferred embodiment of the first stage of the utensil sorting apparatus in accordance with the present invention;

FIG. **7** is a partial cross-sectional view of the preferred embodiment of the first stage of the utensil sorting apparatus in accordance with the present invention;

FIG. **8** is a perspective view of an alternative embodiment of a utensil sorting apparatus in accordance with the present invention; and

FIG. **9** is a top view of an alternative embodiment of a utensil sorting apparatus in accordance with the present invention.

DETAILED DESCRIPTION

For the purposes of promoting an understanding of the principles in accordance with the invention, reference will now be made to the embodiments illustrated in the drawings and specific language will be used to describe the same. It will nevertheless be understood that no limitation of the scope of the invention is thereby intended. Any alterations and further modifications of the inventive features illustrated herein, and any additional applications of the principles of the invention as illustrated herein, which would normally occur to one skilled in the relevant art and having possession of this disclosure, are to be considered within the scope of the invention claimed.

As illustrated in FIG. **1**, an apparatus, indicated generally at **10**, in accordance with the present invention is shown for sorting and/or orienting a plurality of utensils, indicated generally at **14**. Referring to FIG. **2**, the utensils **14** may include: a first plurality of utensils or spoons **20**; a different second plurality of utensils or forks **22**; and a different third plurality of utensils or knives **24**. The first utensils or spoons **20** may have a first, shorter length l_S; the second utensils or forks **22** may have a second, intermediate length l_F; and the

third utensils or knives may have a third, longer length l_K. Although the present invention will be described with respect to knives, forks, and spoons with respective longer, intermediate, and shorter lengths, it will of course be understood that the apparatus **10** of the present invention may be configured to sort and/or orient any number of different utensils or instruments with varying dimensions.

Referring again to FIG. **1**, the apparatus **10** includes: a first stage, indicated generally at **30**, to separate the spoons **20** from the forks **22** and knives **24**; and a separate, second stage, indicated generally at **32**, to separate the forks **22** from the knives **24**. The utensils **14** may be cleaned and separate prior to being sorted by the present apparatus **10**. In accordance with one aspect of the present invention, the apparatus **10** advantageously sorts the plurality of utensils **14** simultaneously, rather than sorting individual utensils one at a time. The plurality of utensils **14** are received by the apparatus **10** as indicated by arrow **36**, such as by chutes (not shown) or other means.

Referring to FIGS. **1**, **3** and **4**, the first stage **30** of the apparatus **10** includes a first template **40** having a plurality of first apertures **42**. The first apertures **42** are sized and configured to receive therethrough only the spoons **20**. Thus, the first apertures **42** may have a height or length which is slightly larger than the length l_S of the spoons **20** so that the spoons **20** may pass through the first apertures **42**. The first template **40** is configured to receive the utensils **14** thereon. Thus, the first template **40** preferably is angled or has an angled inclined surface. The first template **40** preferably and advantageously has a frusto-conical shape forming a frusto-conical interior core. The conical shape of the first template **40** advantageously provides an angled surface to receive the utensils **14** thereon. In addition, the conical shape of the first template **40** advantageously provides a narrow upper end where the utensils **14** can be received from a common area, as shown in FIG. **1**. The angled surface of the first template **40** also allows utensils **14** to slide downwardly under the force of gravity, as will be discussed in greater detail below.

The first stage **30** also includes a first movable conveyer **46** movably disposed on the first template **40**. The first conveyer **46** moves the utensils **14** across the template **40** and across the apertures. The first conveyer **46** preferably includes a plurality of partitions or vanes **50** which define a plurality of pockets **54** between the partitions to receive the utensils **14**. The pockets **54** have openings **58** disposed adjacent to, or proximal, the first template **40**. Thus, as the conveyer **46** moves on the template **40**, the partitions **50**, pockets **54**, and openings **58** are also moved across the template **40** and the apertures **42**.

The first conveyer **46** preferably and advantageously has a frusto-conical shape forming a frusto-conical exterior shell movably disposed on the frusto-conical interior core or template. In addition, the first conveyer **46** is rotatably disposed on the template **40**, as indicated by arrow **62**.

Referring to FIGS. **1** and **3**, the utensils **14** are received at the upper ends of the first stage **30**, or template **40**, and conveyer **46**. The utensils **14** slide under the force of gravity down the conveyer **46** and template **40** so that they are received in the open upper ends of the pockets **54**. The utensils **14** continue to slide until they reach the bottom of the pockets **54**. The conveyer **46** rotates **62** with the partitions **50** sliding the utensils **14** across the template **40** in a circular direction. The partitions **50** of the conveyer **46** continue to move the utensils **14** across the apertures **42**. Because the spoons **20** are the same size or slightly smaller than the size of the openings **42**, the spoons **20** pass through the openings **58** in the pockets **54** and through the apertures **42** in the template **40**. The spoons **20** are gathered as they pass through the apertures **42** and may be directed towards a common spoon receptacle **66** by chutes **68**, tubes or the like. Thus, the spoons **20** are separated from the forks **22** and knives **24**. Because the forks **22** and knives **24** are longer than the apertures **42**, they continue to pass over the apertures **42** as moved by the partitions **50**. The forks **22** and knives **24** then pass out of the pockets **54** and are gathered, such as by chutes **72**, and are directed to the second stage **32**.

The conveyer **46** sequentially moves the pockets **54**, and thus any utensils **14** contained therein, through at least three different locations. The first location is a receiving location **76** in which one or more utensils are received in the pockets **54**. In the receiving location **76**, the pocket **54***a* is disposed over the template **40** adjacent an aperture **42**. The second location is a sorting and/or orienting location **80** in which any spoon **20** passes through the aperture **42** in the template **40**. In addition, the spoon **20** preferably and advantageously is oriented simultaneously as it passes through the aperture **42**, as discussed in greater detail below. In the sorting and orienting location **80**, a pocket **54***b* is disposed over an aperture **42**. The third location is a discharge location **84** in which any remaining utensil or fork **22** or knife **24** is discharged or removed from a pocket **54***c*. In the discharge location **84**, the pocket **54***c* is disposed adjacent an opening opposite the receiving location **76**.

Referring again to FIGS. **1**, **3** and **4**, the first stage **30** or template **40** includes a plurality of flanges **88** disposed on and extending outwardly from the template **40**. Each flange **88** is disposed adjacent a lower side of the aperture **42** and at a lower end of the partitions **50**. Thus, the flanges **88** act as the bottom of the pockets **54**. As utensils **14** enter the pockets **54** and slide down the template **40**, they are stopped by the flange **88**. Thus, in the first location **76**, the pocket **54***a* is defined by the partitions **50**, the template **40**, and the flange **88**. As the conveyer **46** rotates, the partitions **50** slide the utensils **14** along the template **40** and the flange **88**. Each flange **88** extends laterally the length of the first and second locations **76** and **80**, but leaves open the third location **84**. Thus, in the third location **84**, the utensils may slide out of the pocket **54***c* under the force of gravity.

Referring to FIG. **1**, the second stage **32** includes a second template **92** and second conveyer movably disposed on the second template **92**. The second template **92** has a plurality of second apertures **100** which are sized and configured to receive therethrough only the forks **22**. Thus, the second apertures **100** have a length of height which is the same as or slightly longer than the length l_F of the forks **22**.

The second stage **32** is similar in many respects to the third stage **30**. The second conveyer **96** has a plurality of partitions **104** creating a plurality of pockets **106** with openings **108**. The second template **92** and second conveyer **96** also may have a frusto-conical shapes defining a frusto-conical core and a frusto-conical interior shell. The second conveyer **96** is rotatably disposed on the second template **92**, as indicated by arrow **110**. Thus, the second conveyer **96** rotates, moving the partitions **104**, pockets **106** and openings **108** across the second template **92** and across the second apertures **100**.

The second conveyer **96** sequentially moves the pockets **106** and thus the utensils through three different locations, including a first location **112**, or receiving location, where the forks **22** and knives **24** are received from chute **72** extending from the first stage **30**. In the first location, the pocket **106***a* is disposed adjacent an aperture **100**. In a

second location **114**, or receiving and orienting location, a pocket **106***b* is disposed over an aperture **100**. Any fork **22** disposed in the pocket **106** passes through the aperture **100** and is collected, such as by chutes **116** extending to a fork receptacle **117**, tubes, or the like. In the third location, or discharge location **118**, any knives **24** remaining in the pocket **106***c* are discharged from the pocket and collected, such as by chutes **120** extending to a knife receptacle **121**. The second stage **32** also has a plurality of flanges **122** extending from the second template **92**, and extending across the first and second locations **112** and **114**, but leaving the third location **118** open, such that knives **24** may slide out of the pocket **106***c* and be collected by the chute **120**.

The first and second stages **30** and **32** may be vertically oriented with the second stage **32** located below the first stage **30**. Thus, forks **22** and knives **24** leaving the first stage **30** may proceed through the chute **72** to the second stage **32** under the force of gravity.

As indicated above, the first stage **30** advantageously is configured to receive a plurality of utensils **14** simultaneously. In addition, the first template **40** advantageously has a plurality of first openings **42** so that the first stage **30** advantageously may sort the plurality of utensils simultaneously. The ability to simultaneously sort the plurality of utensils **14** provides a distinct advantage over prior art devices which are configured to sort utensils individually, or one at a time. In addition, the first stage **30** advantageously may continue to receive a plurality of utensils **14**. For example, a first stage **30** may receive a first plurality of utensils **14** into the plurality of pockets **54***a* at a plurality of receiving locations **76**. As the first conveyer **46** rotates **62**, the first plurality of utensils **14** simultaneously are rotated from the first location **76** to the second or sorting location **80**, where the first plurality of utensils **14** are simultaneously sorted. It will be appreciated that a second plurality of utensils may then be received in the pockets **54** at the plurality of receiving locations **76**. Similarly, the second stage **32** simultaneously sorts a plurality of forks **22** and knives **24**. The plurality of forks and knives **22** and **24** are received in a plurality of pockets **106***a* at the first or receiving location **112**, the second conveyer **96** rotates **110** to simultaneously move the forks and knives **22** and **24** to the second or sorting location **114**, where the forks **22** and knives **24** are simultaneously sorted. In addition, the second stage **32** can continuously receive a second plurality of forks and knives into the first receiving locations **112**.

As indicated above, the utensils **14** may be oriented simultaneously as they are sorted, or as they pass through an aperture in a template. It will be appreciated that the utensils may be received by the apparatus **10**, or first and second stages **30** and **32** in any orientation, such as pointing downward or pointing upward. The first stage **30** advantageously orients the spoons **20** simultaneously as they pass through the first aperture **42**. Similarly, the second stage **32** simultaneously orients the forks **22** as they pass through the second apertures **100**.

Referring again to FIG. **2**, each utensil **14** has a center or midpoint, represented by a dot, and a center of gravity, represented by an x. It will be noted that the centers of gravity x of the utensils **14** do not coincide with the midpoints.

Referring to FIG. **5**, a plurality of first bars **130** are each disposed laterally across one of the first apertures **42**. The first bar **130** is located to correspond to the midpoint **126***a* of the spoon **20**. Thus, the first bar **130** is disposed across the opening **42** generally at a midpoint of the length of the opening **42**. Because the center of gravity **128***a* of the spoon **20** does not correspond with the midpoint **126***a,* the center of gravity **128***a* of the spoon **20** will be disposed on one side of the bar **130**, or above or below the bar **130**, as the spoon **20** is moved across the opening **42** by the conveyer **46**. Because the template **40** and conveyer **36** are disposed at an angle, the spoon **20** is also disposed at an angle. Because the bar **130** is located at the midpoint **126***a* of the spoon **20**, rather than the center of gravity **128***a,* the spoon **20** will not balance on the bar **130**, but tend to pass through the aperture **42** on a same side of the bar **130** as the center of gravity **128***a*.

Referring to FIG. **6**, the spoon **20** is disposed upright, or to face or point upwardly. Thus, as the spoon **20** is moved across the opening **42**, the center of gravity **128***a* is located above, and to one side of, the bar **130**. Thus, the weight of the spoon **20** will tend to cause the spoon **20** to pass through the opening **42** above the bar **130**, so that the spoon **20** pivots or rotates about the bar **130**, so that the spoon **20** now points downwardly, as indicated by the dash lines. Referring to FIG. **7**, if the spoon **20** is oriented to face or point downwardly, then the center of gravity **128***a* will be below, and to the other side of, the bar **130**. Thus, as the spoon **20** passes over the aperture **42**, the weight of the spoon **20** will tend to cause the spoon **20** to pass through the aperture **42** below the bar **130**, thus causing the spoon **20** to pivot around the bar **130** so that the spoon is pointing downwardly, as shown by the dashed lines. Thus, regardless of how the spoon **20** is oriented as it passes over the aperture **42**, the bar **130** and the center of gravity **128***a* of the spoon **20** cause the spoon **20** to pass through the aperture **42**, and around the bar **130**, in such a way that the spoon **20** will always be oriented to point or face downwardly after passing through the aperture **42**. It will be appreciated that the above description with respect to the spoon applies equally to the fork **22** and knife **24**.

Referring to FIG. **1**, the second stage **32** similarly has a plurality of second bars **136** each disposed laterally across one of the second apertures **100** at a location configured to correspond to the midpoints **126***b* of the forks **22**. Similarly, as the forks **22** are moved across the apertures **100**, the centers of gravity **128***b* of the forks **22** are disposed above or below the second bar **136**, tending to cause the forks **22** to pass through the aperture **100** above or below the bar **136** depending on the location of the center of gravity **128***b*. Thus, like the spoons **20**, the forks **22** are oriented as they pass through the aperture **100** to face or point downwardly.

It will of course be understood that the knives **24** may be similarly passed across an aperture with a bar in order to orient the knives, similar to that described above for the spoons and forks.

Therefore, as indicated above, the spoons **20** and forks **22** are oriented simultaneously as they pass through their respective apertures so that the spoons and forks not only are separated from the plurality of utensils **14**, but oriented to have a common orientation. Utilizing the apparatus **10** of the present invention to both sort and orient the utensils **14** provides a significant advantage over prior art devices, which use one structure or mechanism for sorting the utensils, and another structure or mechanism for then orienting the utensils, thus requiring additional space and structure.

It is of course understood that additional stages may be provided depending on the number of items to sort. For example, additional stages could be added to sort or separate soup spoons or salad forks, etc.

Referring now to FIGS. **8** and **9**, an alternative embodiment indicated generally at **170** is shown for sorting and/or orienting the plurality of utensils **14**. The apparatus **170** is similar in many respects to the apparatus **10** described above. The apparatus **170** includes a template **172** and a conveyer **174** movably disposed on the template **172**. The template **172**, however, has a plurality of first apertures **176** sized to receive therethrough only the spoons **20**, and a plurality of second apertures **178** sized and configured to receive therethrough only the forks **22**. The first and second apertures **176** and **178** may be disposed adjacent one another. Thus, as the conveyer **172** rotates, indicated by arrow **180**, the conveyer **178** moves the partitions **182**, pockets **184** and utensils **14** sequentially through four different locations. In the first or receiving location, a pocket **184** is located adjacent the first aperture **176** to receive at least one of the plurality of utensils **14**. The second location is a first sorting location **188** in which the pocket **184** and utensils **14** are disposed over the first aperture **176** to separate the spoons **20** from the remaining utensils **14**. The third location is a second sorting location **190** in which the pocket **184** is disposed over the second aperture **178** such that any fork **22** passes through the aperture **178**. The fourth location is a discharge location **192** in which any remaining knife **24** is discharged from the pocket **184**. As described above, the apparatus **170** may have a plurality of flanges **196** disposed on the template **172** and extending across the first, second and third locations **186**, **188**, and **190**, but leaving the fourth location **192** open for the discharging of knives.

As described above, the apparatus **170** advantageously receives a plurality of utensils and continuously sorts the plurality of utensils **14**. In addition, the apparatus **170** separates both the spoons and the forks with single template **172** and conveyer **174**, to reduce space.

It is of course understood that the apparatus **170** may be provided with collection chutes to collect the spoons, forks and knives as described above. In addition, the template **172** may be provided with a plurality of third apertures sized to receive the knives therethrough, which is similar to the first and second apertures **176** and **178**.

Furthermore, a plurality of first and second bars **200** and **202** may be disposed across first and second apertures **176** and **178** as described above.

A method for sorting a plurality of utensils **14** using the apparatuses described above includes simultaneously receiving or providing the plurality of utensils **14** to a movable conveyer. The utensils may be received or provided to a first plurality of pockets formed in the movable conveyer. The plurality of utensils **14** are simultaneously moved past or across the apertures in the template by moving the conveyer. Simultaneously sorting a plurality of utensils provides a distinct advantage over prior art devices which individually provide and sort a utensil. Simultaneously sorting a plurality of utensils is faster and more efficient. Furthermore, after the conveyer has moved the first plurality of utensils over the apertures, a second plurality of utensils may be received simultaneously onto the conveyer, or onto a second plurality of pockets on the conveyer. Thus, the first plurality of utensils is being sorted while the second plurality of utensils are being received.

Any spoons are allowed to pass through the aperture in a template. Any remaining utensils such as forks or knives are simultaneously moved past the apertures, and simultaneously removed from the conveyer.

In addition, the plurality of utensils may be oriented simultaneously as they pass through the apertures. As indicated above, the plurality of utensils may be moved past a plurality of bars each disposed over one of the apertures at a location corresponding to the midpoints of the first utensils. The centers of gravity of the utensils are allowed to cause the utensils to pass through the apertures on one side of the bar due to the weight of the utensil, causing the utensils to have a common orientation.

Any remaining knives or forks may be received or provided simultaneously to a second movable conveyer which simultaneously moves the knives and forks past a plurality of second apertures or second template.

It is to be understood that the above-described arrangements are only illustrative of the application of the principles of the present invention. Numerous modifications and alternative arrangements may be devised by those skilled in the art without departing from the spirit and scope of the present invention and the appended claims are intended to cover such modifications and arrangements. Thus, while the present invention has been shown in the drawings and fully described above with particularity and detail in connection with what is presently deemed to be the most practical and preferred embodiment(s) of the invention, it will be apparent to those of ordinary skill in the art that numerous modifications, including, but not limited to, variations in size, materials, shape, form, function and manner of operation, assembly and use may be made without departing from the principles and concepts set forth herein.

What is claimed is:

1. A utensil sorting apparatus configured to simultaneously sort and orient a plurality of utensils, including at least first and second different utensils, the apparatus comprising:

a) a template having at least one aperture sized to receive therethrough only the first utensils;

b) a movable conveyor, movably disposed over the template and the at least one aperture, to sequentially move the first and second utensils through at least three locations, including:

i) a receiving location to receive at least one of the first and second utensils;

ii) a sorting and orienting location to pass any first utensil through the aperture in the template, and configured to simultaneously orient any first utensil passing through the aperture; and

iii) a discharge location to discharge any second utensil.

2. The apparatus of claim **1**, wherein the conveyor has a plurality of partitions formed thereon defining a plurality of pockets therebetween configured to receive the first and second utensils, each pocket having an opening movable across the template and the at least one aperture; and wherein the pockets are sequentially movable through the at least three locations.

3. The apparatus of claim **2**, further comprising:

a flange, disposed on and extending outwardly from the template adjacent a side of the aperture and at an end of the partitions, further defining the pocket between the flange, the partitions, and the template, the flange extending laterally the length of the first and second locations, but leaving open the third location, such that any second utensil contained in the pocket may exit the pocket in the third location.

4. The apparatus of claim **1**, further comprising:

a bar, disposed laterally across the aperture in the template at a location configured to correspond to a midpoint of the first utensils, such that centers of gravity of the first utensils are disposed on either side of the bar as the first

utensils are moved across the aperture in the template, tending to cause the first utensils to pass through the aperture in the template on a same side of the bar as the center of gravity, thus orienting the first utensils.

5. The apparatus of claim **1**, further comprising a plurality of apertures in the template configured to simultaneously sort a plurality of utensils.

6. The apparatus of claim **1**, wherein the template and the movable conveyor define a first stage configured to separate the first utensils; and further comprising a second stage configured to separate the second utensils from third utensils, the second stage including:

a) a second template having at least one aperture sized to receive therethrough the second utensils;

b) a second movable conveyor, movably disposed over the second template and the at least one aperture, to sequentially move the second and third utensils through at least three locations, including:

i) a receiving location to receive at least one of the second and third utensils;

ii) a sorting and orienting location to pass any second utensil through the aperture in the second template, and configured to simultaneously orient any second utensil passing through the aperture; and

iii) a discharge location to discharge any third utensil.

7. The apparatus of claim **6**, wherein the second conveyor has a plurality of partitions formed thereon defining a plurality of pockets therebetween configured to receive the second and third utensils, each pocket having an opening movable across the second template and the at least one aperture; and wherein the pockets are sequentially movable through the at least three locations.

8. The apparatus of claim **7**, further comprising:

a second bar, disposed laterally across the aperture in the second template at a location configured to correspond to a midpoint of the second utensils, such that centers of gravity of the second utensils are disposed on either side of the second bar as the second utensils are moved across the aperture in the second template, tending to cause the second utensils to pass through the aperture in the template on a same side of the second bar as the center of gravity, thus orienting the second utensils.

9. The apparatus of claim **1**, wherein the template is a frusto-conical interior core, and wherein the conveyor is a frusto-conical exterior shell, rotatably disposed on the core.

10. The apparatus of claim **1**, wherein the template further includes at least a second aperture sized to receive therethrough the second utensils.

11. A utensil sorting apparatus configured for sorting a plurality of utensils, including knives, forks and spoons, the apparatus comprising:

a) a first stage configured to separate the spoons from the knives and forks, including:

i) a first template having at least one first aperture sized to receive therethrough only the spoons; and

ii) a first movable conveyor, movably disposed over the template and the at least one first aperture, configured to move the utensils across the first aperture in the first template; and

b) a separate second stage configured to separate the forks from the knives, including:

i) a second template having at least one second aperture sized to receive therethrough only the forks; and

ii) a second movable conveyor, movably disposed over the second template and the at least one second aperture, configured to move the utensils across the second aperture in the second template.

12. The apparatus of claim **11**, wherein the first conveyor has a plurality of partitions formed thereon defining at least one pocket therebetween configured to receive the utensils, the pocket having an opening movable across the first template and the at least one aperture, the first conveyor configured to move the pocket, and thus the utensils, across the aperture in the first template, such that any spoon in the pocket passes through the opening in the pocket and the aperture in the first template, thus separating the spoons from the knives and forks; and

wherein the second conveyor has a plurality of partitions formed thereon defining at least one pocket therebetween configured to receive the utensils, the pocket having an opening movable across the second template and the at least one second aperture, the second conveyor configured to move the pocket, and thus the utensils, across the second aperture in the second template, such that any fork in the pocket passes through the opening in the pocket and the second aperture in the second template, thus separating the forks from the knives.

13. The apparatus of claim **11**, wherein the first and second stages are vertically oriented with the second stage located beneath the first stage.

14. The apparatus of claim **11**, wherein the first template is configured to simultaneously separate a plurality of spoons and has a plurality of apertures sized to receive therethrough only the spoons; and wherein the second template is configured to simultaneously separate a plurality of forks and has a plurality of second apertures sized to receive therethrough only the forks.

15. The apparatus of claim **11**, further comprising:

a) a first bar, disposed laterally across the at least one aperture in the first template at a location configured to correspond to midpoints of the spoons, such that centers of gravity of the spoons are disposed on either side of the first bar as the spoons are moved across the aperture in the first template, tending to cause the spoons to pass through the aperture in the first template on a same side of the first bar as the center of gravity, thus orienting the spoons; and

b) a second bar, disposed laterally across the at least one second aperture in the second template at a location configured to correspond to midpoints of the forks, such that centers of gravity of the forks are disposed on either side of the second bar as the forks are moved across the second aperture in the second template, tending to cause the forks to pass through the second aperture in the second template on a same side of the second bar as the center of gravity, thus orienting the forks.

16. The apparatus of claim **11**, wherein the first and second templates are frusto-conical interior cores, and wherein the first and second conveyors are frusto-conical exterior shells, rotatably disposed on the respective first and second cores.

17. A utensil sorting apparatus for sorting utensils, including at least first and second utensils, the apparatus comprising:

a) a template having (i) a plurality of first apertures sized to receive therethrough only the first utensils, and (ii) a plurality of second apertures sized to receive therethrough only the second utensils; and

b) a movable conveyor, movably disposed across the template and the first and second apertures, configured to move the first and second utensils across the first and

second apertures in the template, and sequentially through at least three locations, including:

i) a receiving location to receive at least one of the first and second utensils;

ii) a first sorting location to pass and orient any first utensil through the first aperture in the template; and

iii) a second sorting location to pass and orient any second utensil through the second aperture in the template.

18. The apparatus of claim **17**, wherein the conveyor has a plurality of partitions formed thereon defining a plurality of pockets therebetween configured to receive the first and second utensils, each pocket having an opening movable across the template and the first and second apertures.

19. The apparatus of claim **18**, further comprising:

a plurality of bars, each disposed laterally across one of the first and second apertures in the template at a location configured to correspond to midpoints of the respective first and second utensils, such that centers of gravity of the first and second utensils are disposed on either side of the respective bar as the first and second utensils are moved across the respective first and second apertures in the template, tending to cause the first and second utensils to pass through the respective first and second apertures in the template on a same side of the respective bar as the center of gravity, thus orienting the first and second utensils.

20. The apparatus of claim **17**, wherein the template is a frusto-conical interior core, and wherein the conveyor is a frusto-conical exterior shell, rotatably disposed on the core.

21. A method for sorting a plurality of utensils, including at least first and second utensils, the method comprising the steps of:

a) simultaneously receiving a plurality of utensils on a movable conveyor;

b) simultaneously moving each of the plurality of utensils past one of a plurality of apertures in a template by moving the conveyor, the apertures being sized to receive only the first utensils;

c) simultaneously moving any remaining second utensils past the plurality of apertures; and

d) simultaneously removing any remaining second utensils from the movable conveyor.

22. The method of claim **21**, wherein step a) further comprises simultaneously receiving the plurality of utensils each into one of a first plurality of pockets on the movable conveyor.

23. The method of claim **22**, wherein step b) further comprises simultaneously receiving an additional plurality of utensils each into one of a second plurality of pockets on the movable conveyor.

24. The method of claim **21**, wherein step b) further comprises simultaneously orienting the first utensils while the first utensils pass through the apertures.

25. The method of claim **24**, further comprising moving the plurality of utensils past a plurality of bars each disposed over one of the apertures at a location corresponding to midpoints of the first utensils; and allowing centers of gravity of the first utensils to cause the first utensils to pass through the apertures on a side of the bar corresponding to the centers of gravity of the first utensils, thus orienting the first utensils.

26. The method of claim **21**, further comprising:

e) simultaneously receiving any remaining second utensils and any remaining third utensils on a second movable conveyor;

f) simultaneously moving each of the second and third utensils past one of a plurality of apertures in a second template by moving the second conveyor, the apertures being sized to receive only the second utensils.

27. The method of claim **21**, wherein the template is a frusto-conical interior core, and wherein the conveyor is a frusto-conical exterior shell, rotatably disposed on the core.

* * * * *

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Boyer

(10) **Patent No.: US 6,460,707 B2**
(45) **Date of Patent: *Oct. 8, 2002**

(54) **UTENSIL SORTING APPARATUS**

(76) Inventor: **Jay M. Boyer**, 1250 S. 900 East, Springville, UT (US) 84663

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **09/825,494**

(22) Filed: **Apr. 3, 2001**

(65) **Prior Publication Data**

US 2001/0054577 A1 Dec. 27, 2001

Related U.S. Application Data

(63) Continuation-in-part of application No. 09/487,836, filed on Jan. 19, 2000, now Pat. No. 6,237,779.

(51) **Int. Cl.**[7] **B07C 5/12**
(52) **U.S. Cl.** **209/680**; 209/919; 209/926
(58) **Field of Search** 209/659, 680, 209/683, 684, 919, 926, 634

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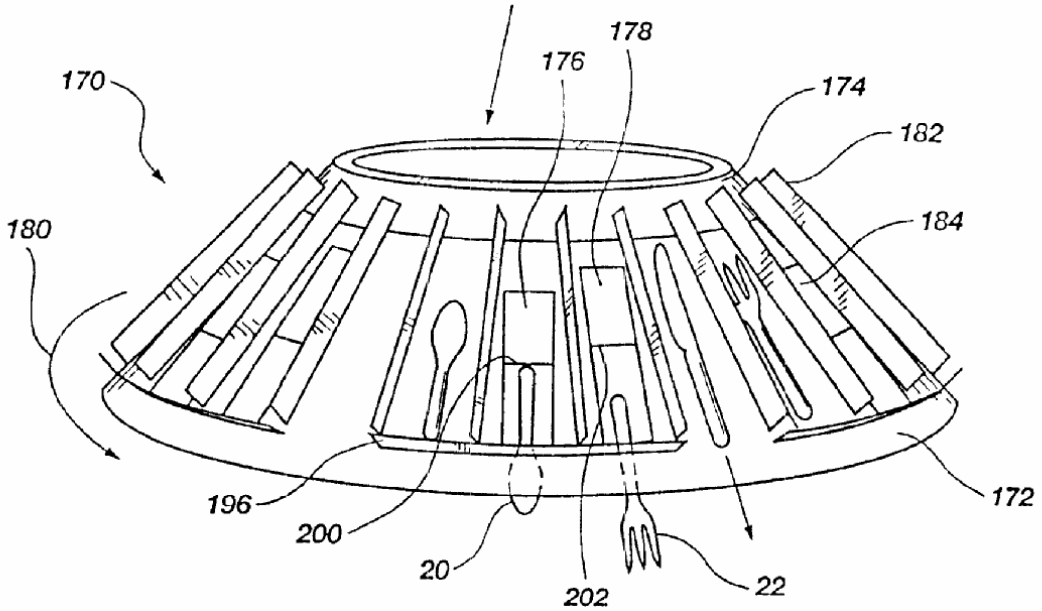
Primary Examiner—Tuan N. Nguyen
(74) *Attorney, Agent, or Firm*—Thorpe North & Western

(57) **ABSTRACT**

A utensil sorting apparatus simultaneously sorts and/or orients a plurality of utensils, such as spoons, forks, and knives. A movable conveyor is movably disposed over a template having a plurality of first aperture sized to receive therethrough only the spoons. The conveyor sequentially moves the utensils through locations, including a receiving location, and a sorting location.

20 Claims, 6 Drawing Sheets



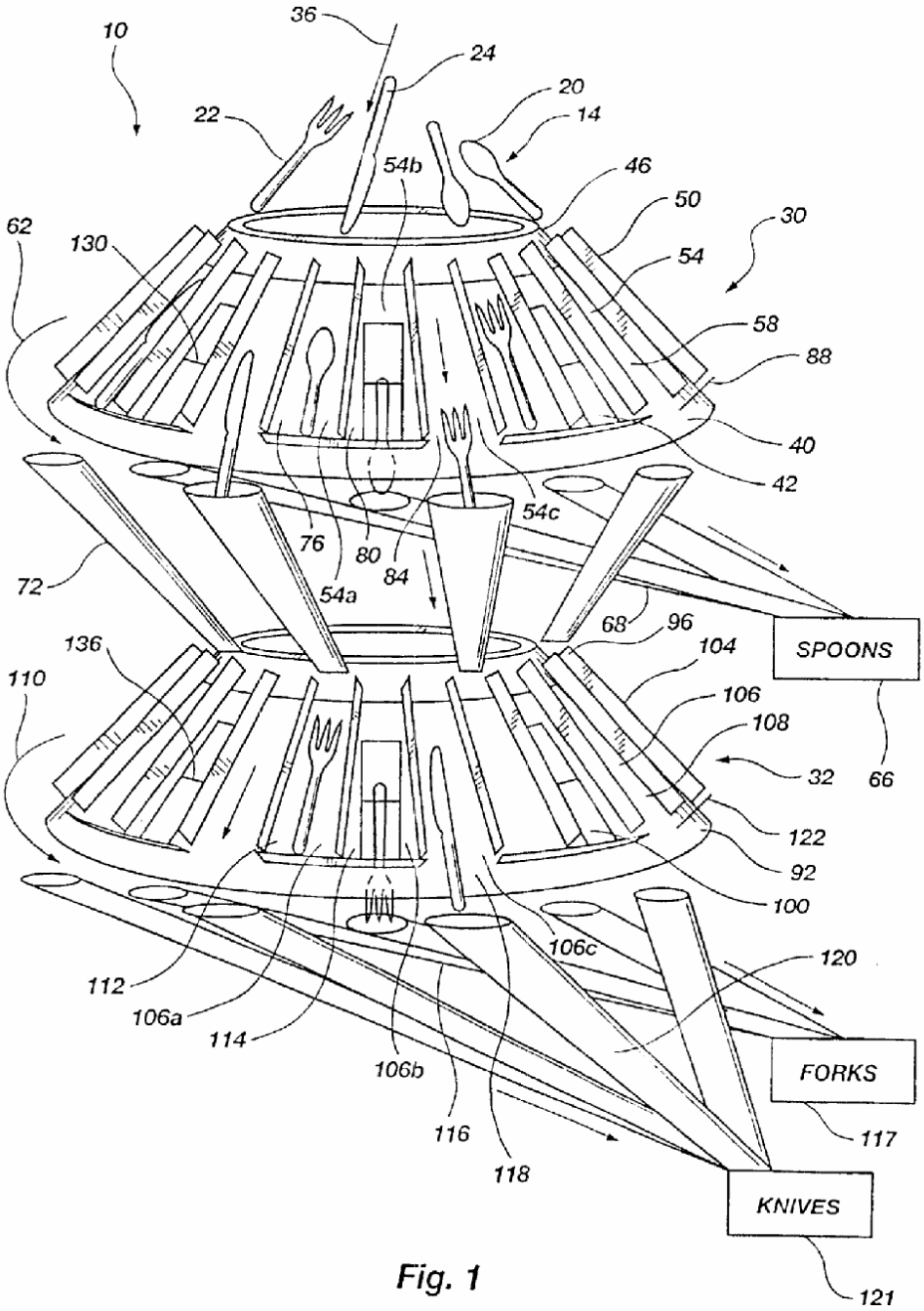

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Fig. 1

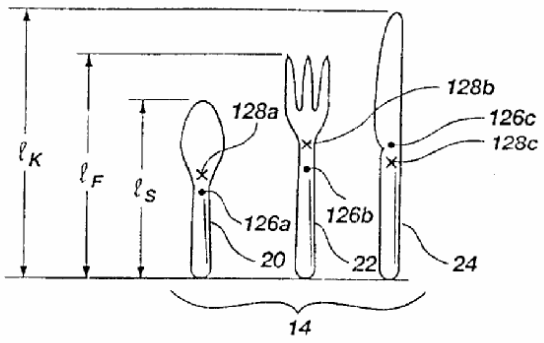
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Fig. 2

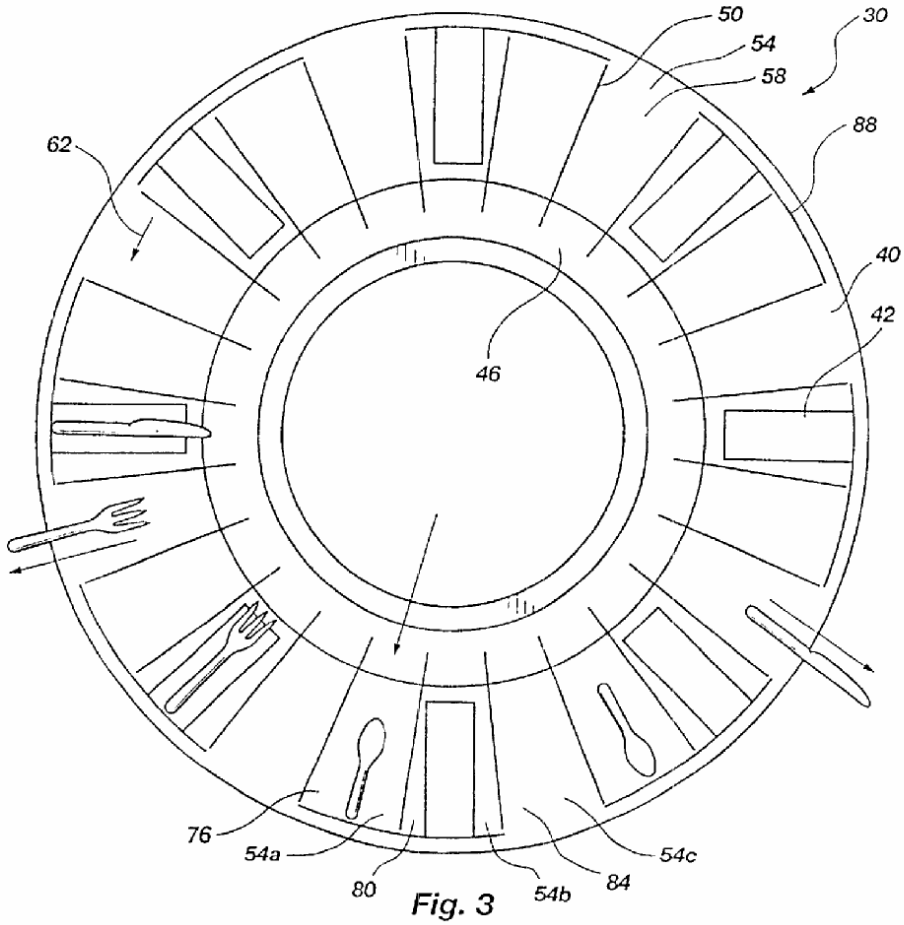
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Fig. 3

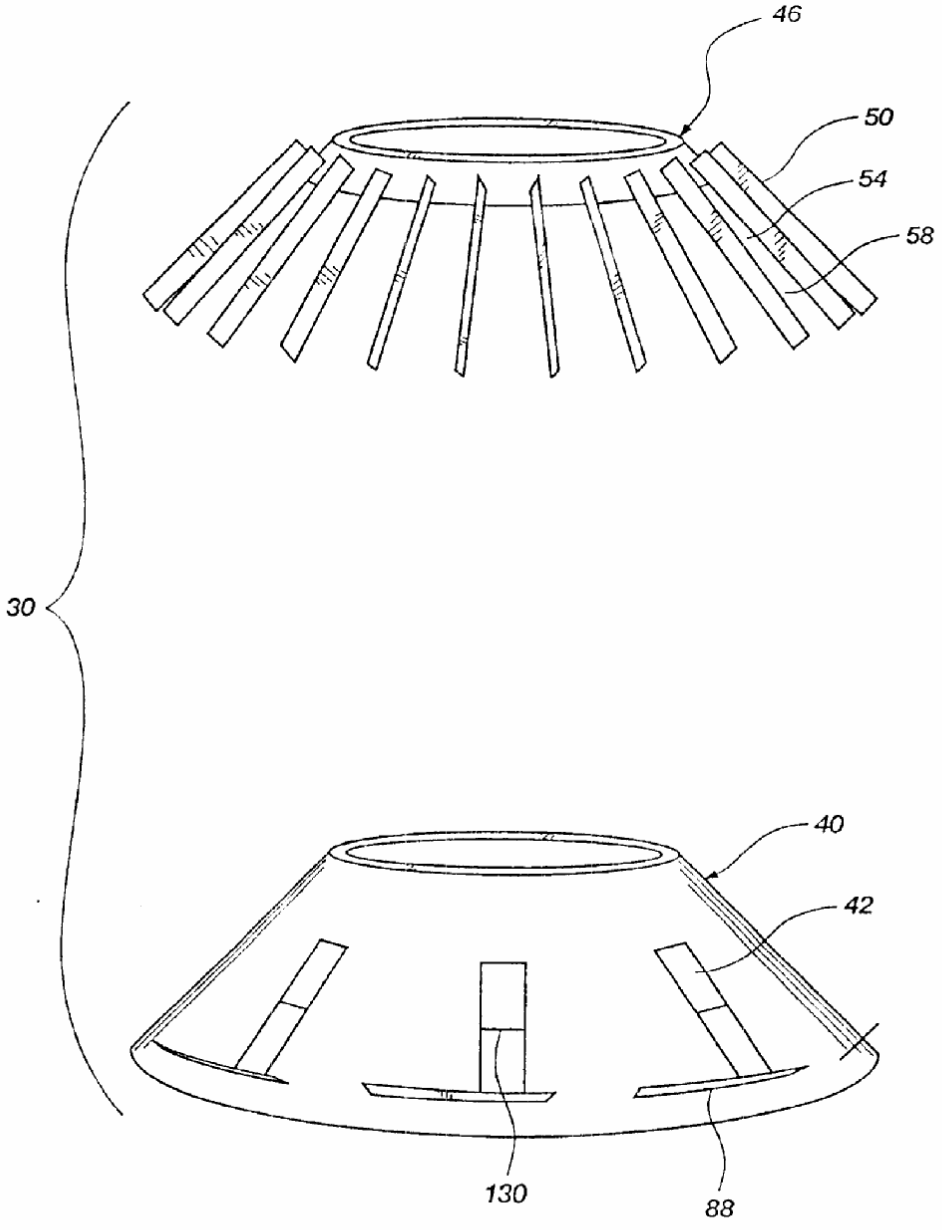

Fig. 4

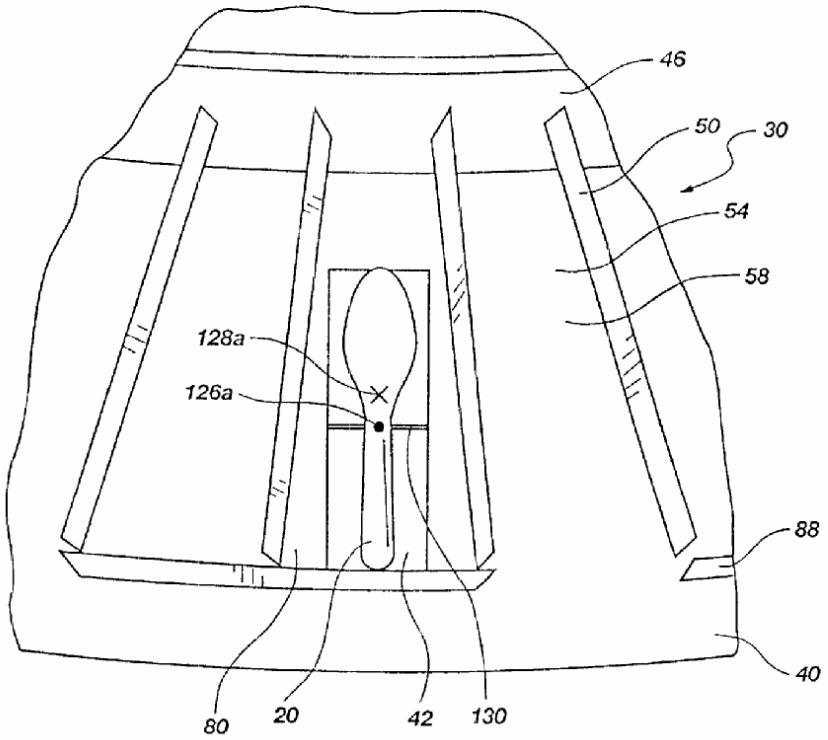

Fig. 5

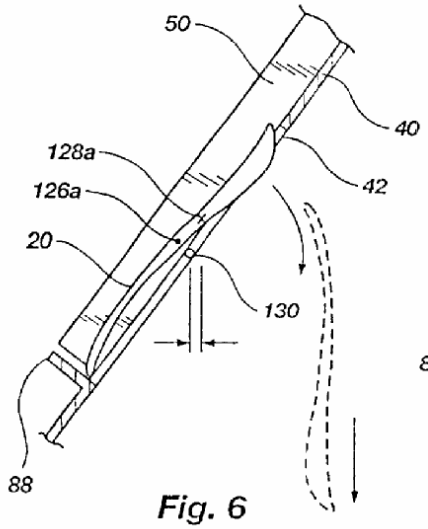

Fig. 6

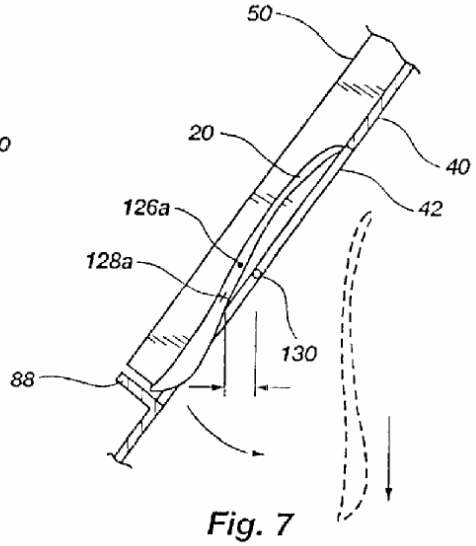

Fig. 7

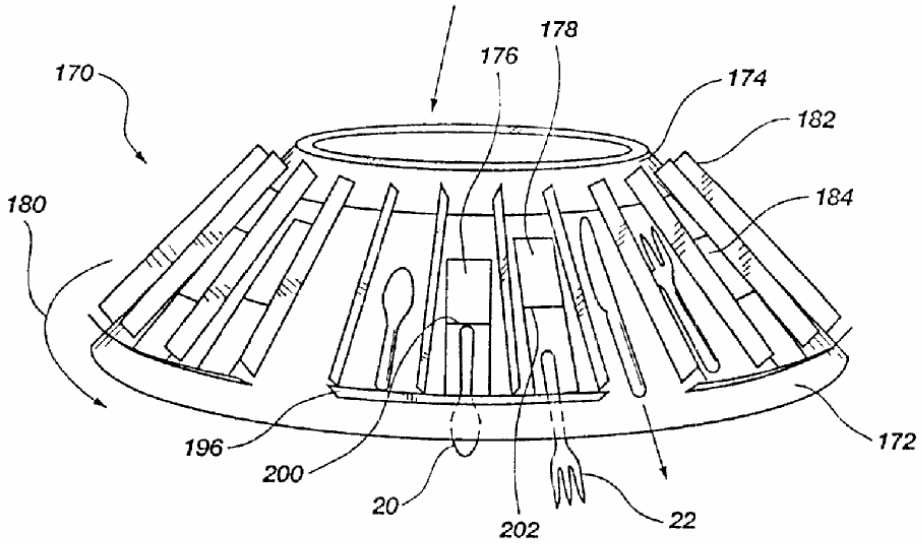
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Fig. 8

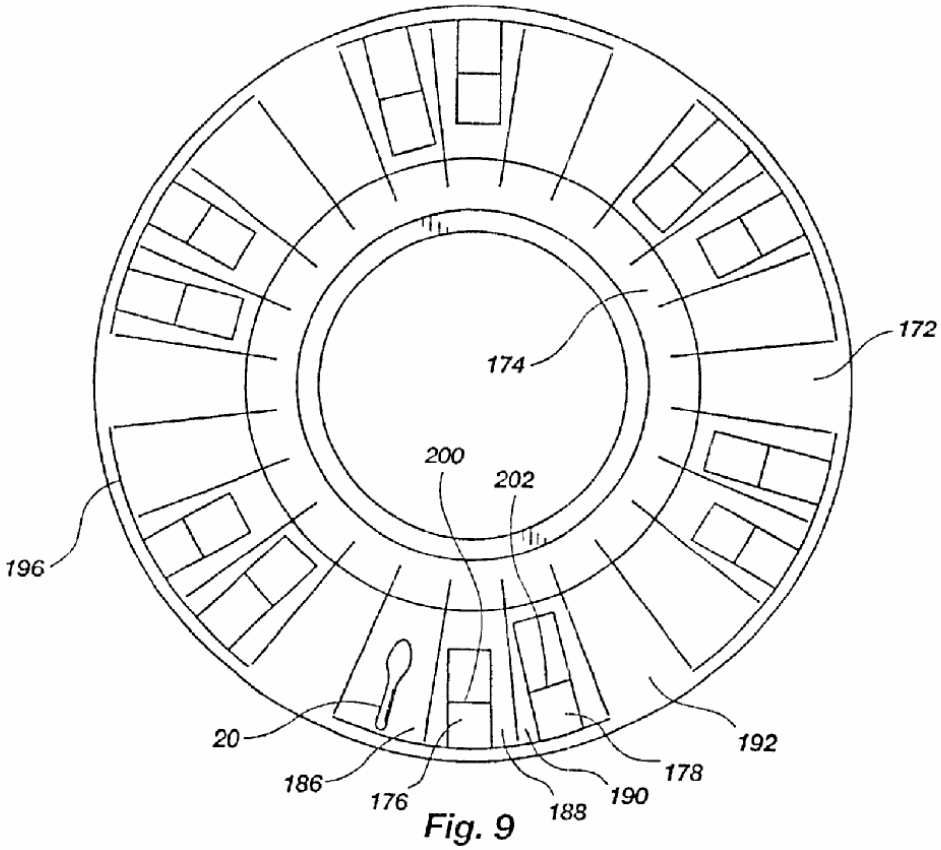
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Fig. 9

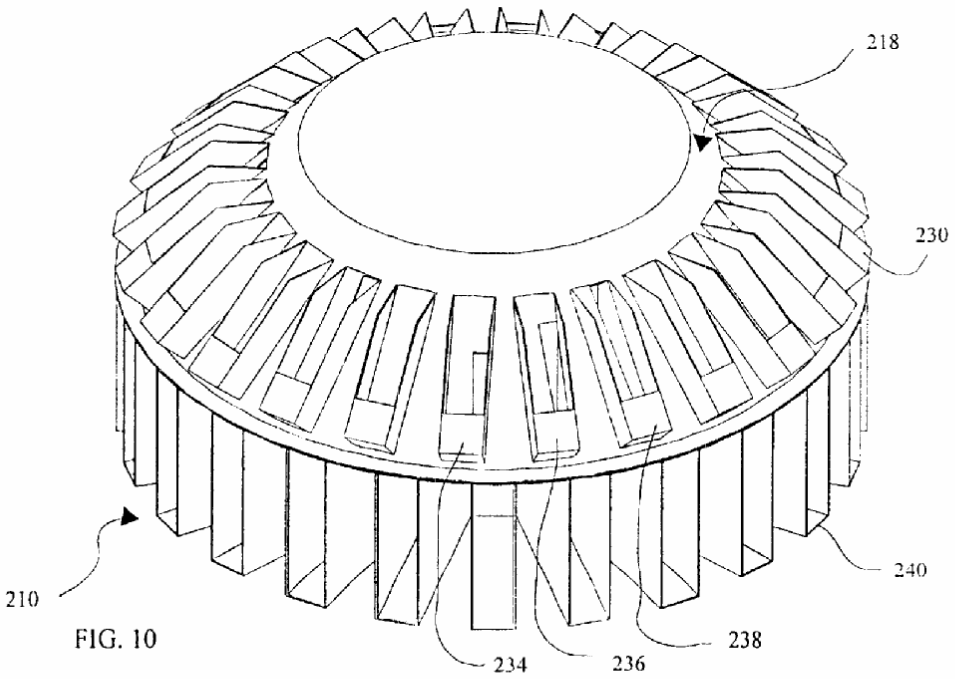


FIG. 10

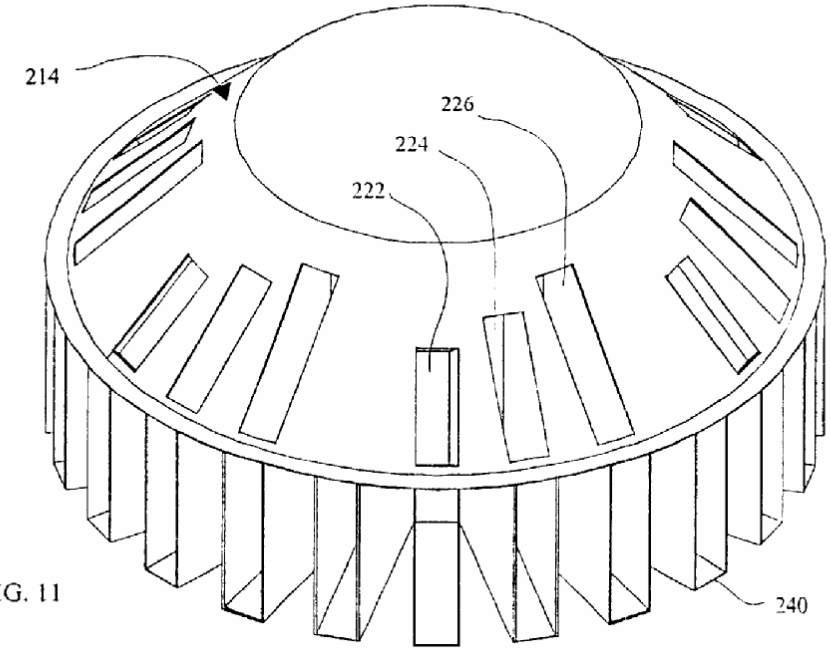


FIG. 11

UTENSIL SORTING APPARATUS

This application is a continuation-in-part of U.S. patent application Ser. No. 09/487,836, filed Jan. 19, 2000 now U.S. Pat. No. 6,237,779.

BACKGROUND OF THE INVENTION

1. The Field of the Invention

The present invention relates generally to an apparatus for sorting utensils or silverware, such as spoons, forks and knives. More particularly, the present invention relates to a utensil sorting apparatus which continuously receives utensils, simultaneously sorts a plurality of the utensils, and simultaneously orients the utensils as they are sorted.

2. The Background Art

Large food preparation entities or eating establishments, such as restaurants, hotels, hospitals, cafeterias, etc., may serve hundreds to thousands of people per day or per meal. The large number of people served results in thousands of utensils or silverware which must be washed, sorted, and reoriented prior to reuse. These washing and sorting operations are typically performed by unskilled labor who collect the utensils, wash the utensils using either manual or large capacity washing machines, and then sort and orient the utensils. Because sorting the utensils requires the unskilled laborer to touch and handle the utensils, they must typically be rewashed to satisfy health and sanitation issues. One disadvantage with this system is the time and cost involved in unskilled labor manually sorting and orienting the utensils.

It is desirable to provide a system and/or apparatus for sorting and orienting utensils which is efficient and capable of rapidly sorting the utensils. It is also desirable that such a system or apparatus be accurate, simple, and sanitary.

A few different types of devices have been developed for sorting utensils. For example, U.S. Pat. No. 3,625,356 issued Dec. 7, 1979, to Jackson, discloses a device in which utensils pass through a chute with a twisted shape so that the utensils are caused to pivot about their lower end and swing outward towards a set of different height, gauged bars. The gauged bars are positioned at heights to allow shorter utensils to pass under the gauge bars while the higher gauge bars prevent longer utensils from passing underneath.

As another example, U.S. Pat. No. 3,389,790 issued Jun. 25, 1968 to Braunheim et al., discloses a device in which the utensils are disposed between partitions on the exterior of an angled drum. The drum rotates causing the utensils to rotate past a shield disposed about the lower portion of the drum. The shield is provided with three differently sized apertures for receiving three differently sized utensils as they are rotated past the apertures by the drum.

As another example, U.S. Pat. No. 3,545,613 issued Dec. 8, 1970, to Nystuen, discloses a device in which utensils are received between partitions on a conveyer belt. The conveyer belt moves the utensils past a plurality of different sized openings which are each sized to receive one of the utensils.

As another example, U.S. Pat. No. 3,389,711 issued Jun. 25, 1968, to Slayton, discloses a device with a plurality of open-ended pockets or tapered tubes which are rotated about a horizontal axis. The device has a first row of tapered tubes with an open bottom end sized to pass therethrough the narrowest utensils. As the tubes rotate about the horizontal axis, a utensil is disposed in each tube such that the narrowest utensil passes through the bottom of the tube while wider utensils will be trapped within the tube. As the tube rotates upwardly, it turns upside down such that wider utensils will fall out and be guided toward a next row of tapered tubes with wider openings.

One disadvantage with these types of devices is that they are designed to sort the utensils only one at a time. Thus, the utensils must be separated and fed into the devices one at a time, so that each utensil is disposed within a separate pocket or separate tube. In addition, the utensils are presented to a gauging opening one at a time.

Another disadvantage with these devices is that they only sort the utensils. Orientation of the utensils is performed as a separate step after sorting, if at all. Thus, after being sorted, some of the devices direct the utensils to other devices which are intended to orient the utensils in a common orientation.

Therefore, it would be advantageous to develop a method and/or apparatus for sorting a plurality of different utensils, which is simple, efficient, accurate, and sanitary. It would also be advantageous to develop such a method and/or apparatus which is capable of sorting a plurality of different utensils simultaneously. It would also be advantageous to develop such a method and/or apparatus which simultaneously sorts and orients the utensils.

OBJECTS AND SUMMARY OF THE INVENTION

It is therefore an object of the present invention to provide a method and/or apparatus for sorting a plurality of different utensils which is simple, efficient, accurate, and sanitary.

It is another object of the present invention to provide such a method and/or apparatus for sorting multiple utensils simultaneously.

It is yet another object of the present invention to provide a method and/or apparatus which sorts and orients the utensils simultaneously.

The invention provides a utensil sorting apparatus configured to simultaneously sort and/or orient a plurality of utensils. The plurality of utensils may include first utensils, such as spoons, second utensils, such as forks, and third utensils such as knives. The utensils preferably have different lengths.

The utensil sorting apparatus includes a template having a plurality of first apertures sized to receive therethrough only the first utensils. A movable conveyor is movably disposed across the template and the first apertures, and is configured to move the first and second utensils across the first apertures in the template. The movable conveyor also is configured to move sequentially through at least two locations, including a receiving location, and a first sorting location. In the receiving location, the movable conveyor is configured to receive at least one of the first and second utensils. In the first sorting location, the movable conveyor is configured to pass any first utensil through the first apertures in the template.

In accordance with another aspect of the present invention, the template further includes a plurality of second apertures sized to receive therethrough only the second utensils. The conveyor is further configured to move through a second sorting location to pass any second utensil through the second apertures in the template. The template further can include a plurality of third apertures sized to receive therethrough only third utensils. Again, the conveyor is further configured to move through a third sorting location to pass any third utensil through the third apertures in the template.

In accordance with another aspect of the present invention, a plurality of bars are each disposed laterally across one of the first apertures in the template at a location configured to correspond to midpoints of the respective first utensils. Thus, the centers of gravity of the first utensils are disposed on either side of the respective bar as the first utensils are moved across the first apertures in the template, tending to cause the first utensils to pass through the first apertures in the template on a same side of the respective bar as the center of gravity, and thus orienting the first utensils.

In accordance with another aspect of the present invention, the template is a frusto-conical interior core. The conveyor is a frusto-conical exterior shell, rotatably disposed on the core.

A method for sorting a plurality of utensils includes simultaneously receiving a plurality of utensils on the movable conveyor. Each of the plurality of utensils is simultaneously moved past one of a plurality of apertures in a template by moving the conveyor. Any remaining second utensils are simultaneously moved past the plurality of apertures.

In accordance with another aspect of the present invention, any remaining second utensils are simultaneously moved past one of a plurality of second apertures in the template by moving the conveyor. Any remaining third utensils are simultaneously moved past one of a plurality of third apertures in the template by moving the conveyor.

In accordance with another aspect of the present invention, the first utensils are simultaneously oriented while the first utensils pass through the apertures.

Additional objects and advantages of the invention will be set forth in the description which follows, and in part will be apparent from the description, or may be learned by the practice of the invention without undue experimentation. The objects and advantages of the invention may be realized and obtained by means of the instruments and combinations particularly pointed out in the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other objects, features and advantages of the invention will become apparent from a consideration of the subsequent detailed description presented in connection with the accompanying drawings in which:

FIG. **1** is a perspective schematic view of a preferred embodiment of a utensil sorting apparatus in accordance with the present invention;

FIG. **2** is a side view of a preferred embodiment of utensils of the present invention;

FIG. **3** is a top view of the preferred embodiment of the utensil sorting apparatus in accordance with the present invention;

FIG. **4** is an exploded view of a preferred embodiment of a first stage of the utensil sorting apparatus in accordance with the present invention;

FIG. **5** is a partial side view of the preferred embodiment of the first stage of the utensil sorting apparatus in accordance with the present invention;

FIG. **6** is a partial cross-sectional view of the preferred embodiment of the first stage of the utensil sorting apparatus in accordance with the present invention;

FIG. **7** is a partial cross-sectional view of the preferred embodiment of the first stage of the utensil sorting apparatus in accordance with the present invention;

FIG. **8** is a perspective view of an alternative embodiment of a utensil sorting apparatus in accordance with the present invention;

FIG. **9** is a top view of an alternative embodiment of a utensil sorting apparatus in accordance with the present invention;

FIG. **10** is a perspective view of another utensil sorting apparatus in accordance with the present invention; and

FIG. **11** is a perspective view of a template of the utensil sorting apparatus of FIG. **10**.

DETAILED DESCRIPTION

For the purposes of promoting an understanding of the principles in accordance with the invention, reference will now be made to the embodiments illustrated in the drawings and specific language will be used to describe the same. It will nevertheless be understood that no limitation of the scope of the invention is thereby intended. Any alterations and further modifications of the inventive features illustrated herein, and any additional applications of the principles of the invention as illustrated herein, which would normally occur to one skilled in the relevant art and having possession of this disclosure, are to be considered within the scope of the invention claimed.

As illustrated in FIG. **1**, an apparatus, indicated generally at **10**, in accordance with the present invention is shown for sorting and/or orienting a plurality of utensils, indicated generally at **14**. Referring to FIG. **2**, the utensils **14** may include: a first plurality of utensils or spoons **20**; a different second plurality of utensils or forks **22**; and a different third plurality of utensils or knives **24**. The first utensils or spoons **20** may have a first, shorter length l_S; the second utensils or forks **22** may have a second, intermediate length l_F; and the third utensils or knives may have a third, longer length l_K. Although the present invention will be described with respect to knives, forks, and spoons with respective longer, intermediate, and shorter lengths, it will of course be understood that the apparatus **10** of the present invention may be configured to sort and/or orient any number of different utensils or instruments with varying dimensions.

Referring again to FIG. **1**, the apparatus **10** includes: a first stage, indicated generally at **30**, to separate the spoons **20** from the forks **22** and knives **24**; and a separate, second stage, indicated generally at **32**, to separate the forks **22** from the knives **24**. The utensils **14** may be cleaned and separate prior to being sorted by the present apparatus **10**. In accordance with one aspect of the present invention, the apparatus **10** advantageously sorts the plurality of utensils **14** simultaneously, rather than sorting individual utensils one at a time. The plurality of utensils **14** are received by the apparatus **10** as indicated by arrow **36**, such as by chutes (not shown) or other means.

Referring to FIGS. **1**, **3** and **4**, the first stage **30** of the apparatus **10** includes a first template **40** having a plurality of first apertures **42**. The first apertures **42** are sized and configured to receive therethrough only the spoons **20**. Thus, the first apertures **42** may have a height or length which is slightly larger than the length l_S of the spoons **20** so that the spoons **20** may pass through the first apertures **42**. The first template **40** is configured to receive the utensils **14** thereon. Thus, the first template **40** preferably is angled or has an angled inclined surface. The first template **40** preferably and advantageously has a frusto-conical shape forming a frusto-conical interior core. The conical shape of the first template **40** advantageously provides an angled surface to receive the utensils **14** thereon. In addition, the conical shape of the first template **40** advantageously provides a narrow upper end where the utensils **14** can be received from a common area, as shown in FIG. **1**. The angled surface of the first template

40 also allows utensils 14 to slide downwardly under the force of gravity, as will be discussed in greater detail below.

The first stage 30 also includes a first movable conveyer 46 movably disposed on the first template 40. The first conveyer 46 moves the utensils 14 across the template 40 and across the apertures. The first conveyer 46 preferably includes a plurality of partitions or vanes 50 which define a plurality of pockets 54 between the partitions to receive the utensils 14. The pockets 54 have openings 58 disposed adjacent to, or proximal, the first template 40. Thus, as the conveyer 46 moves on the template 40, the partitions 50, pockets 54, and openings 58 are also moved across the template 40 and the apertures 42.

The first conveyer 46 preferably and advantageously has a frusto-conical shape forming a frusto-conical exterior shell movably disposed on the frusto-conical interior core or template. In addition, the first conveyer 46 is rotatably disposed on the template 40, as indicated by arrow 62.

Referring to FIGS. 1 and 3, the utensils 14 are received at the upper ends of the first stage 30, or template 40, and conveyer 46. The utensils 14 slide under the force of gravity down the conveyer 46 and template 40 so that they are received in the open upper ends of the pockets 54. The utensils 14 continue to slide until they reach the bottom of the pockets 54. The conveyer 46 rotates 62 with the partitions 50 sliding the utensils 14 across the template 40 in a circular direction. The partitions 50 of the conveyer 46 continue to move the utensils 14 across the apertures 42. Because the spoons 20 are the same size or slightly smaller than the size of the openings 42, the spoons 20 pass through the openings 58 in the pockets 54 and through the apertures 42 in the template 40. The spoons 20 are gathered as they pass through the apertures 42 and may be directed towards a common spoon receptacle 66 by chutes 68, tubes or the like. Thus, the spoons 20 are separated from the forks 22 and knives 24. Because the forks 22 and knives 24 are longer than the apertures 42, they continue to pass over the apertures 42 as moved by the partitions 50. The forks 22 and knives 24 then pass out of the pockets 54 and are gathered, such as by chutes 72, and are directed to the second stage 32. The conveyer 46 sequentially moves the pockets 54, and thus any utensils 14 contained therein, through at least three different locations. The first location is a receiving location 76 in which one or more utensils are received in the pockets 54. In the receiving location 76, the pocket 54*a* is disposed over the template 40 adjacent an aperture 42. The second location is a sorting and/or orienting location 80 in which any spoon 20 passes through the aperture 42 in the template 40. In addition, the spoon 20 preferably and advantageously is oriented simultaneously as it passes through the aperture 42, as discussed in greater detail below. In the sorting and orienting location 80, a pocket 54*b* is disposed over an aperture 42. The third location is a discharge location 84 in which any remaining utensil or fork 22 or knife 24 is discharged or removed from a pocket 54*c*. In the discharge location 84, the pocket 54*c* is disposed adjacent an opening opposite the receiving location 76.

Referring again to FIGS. 1, 3 and 4, the first stage 30 or template 40 includes a plurality of flanges 88 disposed on and extending outwardly from the template 40. Each flange 88 is disposed adjacent a lower side of the aperture 42 and at a lower end of the partitions 50. Thus, the flanges 88 act as the bottom of the pockets 54. As utensils 14 enter the pockets 54 and slide down the template 40, they are stopped by the flange 88. Thus, in the first location 76, the pocket 54*a* is defined by the partitions 50, the template 40, and the flange 88. As the conveyer 46 rotates, the partitions 50 slide the utensils 14 along the template 40 and the flange 88. Each flange 88 extends laterally the length of the first and second locations 76 and 80, but leaves open the third location 84. Thus, in the third location 84, the utensils may slide out of the pocket 54c under the force of gravity.

Referring to FIG. 1, the second stage 32 includes a second template 92 and second conveyer movably disposed on the second template 92. The second template 92 has a plurality of second apertures 100 which are sized and configured to receive therethrough only the forks 22. Thus, the second apertures 100 have a length of height which is the same as or slightly longer than the length l_F of the forks 22.

The second stage 32 is similar in many respects to the third stage 30. The second conveyer 96 has a plurality of partitions 104 creating a plurality of pockets 106 with openings 108. The second template 92 and second conveyer 96 also may have a frusto-conical shapes defining a frusto-conical core and a frusto-conical interior shell. The second conveyer 96 is rotatably disposed on the second template 92, as indicated by arrow 110. Thus, the second conveyer 96 rotates, moving the partitions 104, pockets 106 and openings 108 across the second template 92 and across the second apertures 100.

The second conveyer 96 sequentially moves the pockets 106 and thus the utensils through three different locations, including a first location 112, or receiving location, where the forks 22 and knives 24 are received from chute 72 extending from the first stage 30. In the first location, the pocket 106*a* is disposed adjacent an aperture 100. In a second location 114, or receiving and orienting location, a pocket 106*b* is disposed over an aperture 100. Any fork 22 disposed in the pocket 106 passes through the aperture 100 and is collected, such as by chutes 116 extending to a fork receptacle 117, tubes, or the like. In the third location, or discharge location 118, any knives 24 remaining in the pocket 106*c* are discharged from the pocket and collected, such as by chutes 120 extending to a knife receptacle 121. The second stage 32 also has a plurality of flanges 122 extending from the second template 92, and extending across the first and second locations 112 and 114, but leaving the third location 118 open, such that knives 24 may slide out of the pocket 106*c* and be collected by the chute 120.

The first and second stages 30 and 32 may be vertically oriented with the second stage 32 located below the first stage 30. Thus, forks 22 and knives 24 leaving the first stage 30 may proceed through the chute 72 to the second stage 32 under the force of gravity.

As indicated above, the first stage 30 advantageously is configured to receive a plurality of utensils 14 simultaneously. In addition, the first template 40 advantageously has a plurality of first openings 42 so that the first stage 30 advantageously may sort the plurality of utensils simultaneously. The ability to simultaneously sort the plurality of utensils 14 provides a distinct advantage over prior art devices which are configured to sort utensils individually, or one at a time. In addition, the first stage 30 advantageously may continue to receive a plurality of utensils 14. For example, a first stage 30 may receive a first plurality of utensils 14 into the plurality of pockets 54*a* at a plurality of receiving locations 76. As the first conveyer 46 rotates 62, the first plurality of utensils 14 simultaneously are rotated from the first location 76 to the second or sorting location 80, where the first plurality of utensils 14 are simultaneously sorted. It will be appreciated that a second plurality of utensils may then be received in the pockets 54 at the plurality of receiving locations 76. Similarly, the second

stage **32** simultaneously sorts a plurality of forks **22** and knives **24**. The plurality of forks and knives **22** and **24** are received in a plurality of pockets **106***a* at the first or receiving location **112**, the second conveyer **96** rotates **110** to simultaneously move the forks and knives **22** and **24** to the second or sorting location **114**, where the forks **22** and knives **24** are simultaneously sorted. In addition, the second stage **32** can continuously receive a second plurality of forks and knives into the first receiving locations **112**.

As indicated above, the utensils **14** may be oriented simultaneously as they are sorted, or as they pass through an aperture in a template. It will be appreciated that the utensils may be received by the apparatus **10**, or first and second stages **30** and **32** in any orientation, such as pointing downward or pointing upward. The first stage **30** advantageously orients the spoons **20** simultaneously as they pass through the first aperture **42**. Similarly, the second stage **32** simultaneously orients the forks **22** as they pass through the second apertures **100**.

Referring again to FIG. **2**, each utensil **14** has a center or midpoint, represented by a dot, and a center of gravity, represented by an x. It will be noted that the centers of gravity x of the utensils **14** do not coincide with the midpoints.

Referring to FIG. **5**, a plurality of first bars **130** are each disposed laterally across one of the first apertures **42**. The first bar **130** is located to correspond to the midpoint **126***a* of the spoon **20**. Thus, the first bar **130** is disposed across the opening **42** generally at a midpoint of the length of the opening **42**. Because the center of gravity **128***a* of the spoon **20** does not correspond with the midpoint **126***a*, the center of gravity **128***a* of the spoon **20** will be disposed on one side of the bar **130**, or above or below the bar **130**, as the spoon **20** is moved across the opening **42** by the conveyer **46**. Because the template **40** and conveyer **36** are disposed at an angle, the spoon **20** is also disposed at an angle. Because the bar **130** is located at the midpoint **126***a* of the spoon **20**, rather than the center of gravity **128***a*, the spoon **20** will not balance on the bar **130**, but tend to pass through the aperture **42** on a same side of the bar **130** as the center of gravity **128***a*.

Referring to FIG. **6**, the spoon **20** is disposed upright, or to face or point upwardly. Thus, as the spoon **20** is moved across the opening **42**, the center of gravity **128***a* is located above, and to one side of, the bar **130**. Thus, the weight of the spoon **20** will tend to cause the spoon **20** to pass through the opening **42** above the bar **130**, so that the spoon **20** pivots or rotates about the bar **130**, so that the spoon **20** now points downwardly, as indicated by the dash lines. Referring to FIG. **7**, if the spoon **20** is oriented to face or point downwardly, then the center of gravity **128***a* will be below, and to the other side of, the bar **130**. Thus, as the spoon **20** passes over the aperture **42**, the weight of the spoon **20** will tend to cause the spoon **20** to pass through the aperture **42** below the bar **130**, thus causing the spoon **20** to pivot around the bar **130** so that the spoon is pointing downwardly, as shown by the dashed lines. Thus, regardless of how the spoon **20** is oriented as it passes over the aperture **42**, the bar **130** and the center of gravity **128***a* of the spoon **20** cause the spoon **20** to pass through the aperture **42**, and around the bar **130**, in such a way that the spoon **20** will always be oriented to point or face downwardly after passing through the aperture **42**. It will be appreciated that the above description with respect to the spoon applies equally to the fork **22** and knife **24**.

Referring to FIG. **1**, the second stage **32** similarly has a plurality of second bars **136** each disposed laterally across one of the second apertures **100** at a location configured to correspond to the midpoints **126***b* of the forks **22**. Similarly, as the forks **22** are moved across the apertures **100**, the centers of gravity **128***b* of the forks **22** are disposed above or below the second bar **136**, tending to cause the forks **22** to pass through the aperture **100** above or below the bar **136** depending on the location of the center of gravity **128***b*. Thus, like the spoons **20**, the forks **22** are oriented as they pass through the aperture **100** to face or point downwardly.

It will of course be understood that the knives **24** may be similarly passed across an aperture with a bar in order to orient the knives, similar to that described above for the spoons and forks.

Therefore, as indicated above, the spoons **20** and forks **22** are oriented simultaneously as they pass through their respective apertures so that the spoons and forks not only are separated from the plurality of utensils **14**, but oriented to have a common orientation. Utilizing the apparatus **10** of the present invention to both sort and orient the utensils **14** provides a significant advantage over prior art devices, which use one structure or mechanism for sorting the utensils, and another structure or mechanism for then orienting the utensils, thus requiring additional space and structure.

It is of course understood that additional stages may be provided depending on the number of items to sort. For example, additional stages could be added to sort or separate soup spoons or salad forks, etc.

Referring now to FIGS. **8** and **9**, an alternative embodiment indicated generally at **170** is shown for sorting and/or orienting the plurality of utensils **14**. The apparatus **170** is similar in many respects to the apparatus **10** described above. The apparatus **170** includes a template **172** and a conveyer **174** movably disposed on the template **172**. The template **172**, however, has a plurality of first apertures **176** sized to receive therethrough only the spoons **20**, and a plurality of second apertures **178** sized and configured to receive therethrough only the forks **22**. The first and second apertures **176** and **178** may be disposed adjacent one another. Thus, as the conveyer **172** rotates, indicated by arrow **180**, the conveyer **178** moves the partitions **182**, pockets **184** and utensils **14** sequentially through four different locations. In the first or receiving location, a pocket **184** is located adjacent the first aperture **176** to receive at least one of the plurality of utensils **14**. The second location is a first sorting location **188** in which the pocket **184** and utensils **14** are disposed over the first aperture **176** to separate the spoons **20** from the remaining utensils **14**. The third location is a second sorting location **190** in which the pocket **184** is disposed over the second aperture **178** such that any fork **22** passes through the aperture **178**. The fourth location is a discharge location **192** in which any remaining knife **24** is discharged from the pocket **184**. As described above, the apparatus **170** may have a plurality of flanges **196** disposed on the template **172** and extending across the first, second and third locations **186**, **188**, and **190**, but leaving the fourth location **192** open for the discharging of knives.

As described above, the apparatus **170** advantageously receives a plurality of utensils and continuously sorts the plurality of utensils **14**. In addition, the apparatus **170** separates both the spoons and the forks with single template **172** and conveyer **174**, to reduce space.

It is of course understood that the apparatus **170** may be provided with collection chutes to collect the spoons, forks and knives as described above. In addition, the template **172** may be provided with a plurality of third apertures sized to

receive the knives therethrough, which is similar to the first and second apertures **176** and **178**.

Furthermore, a plurality of first and second bars **200** and **202** may be disposed across first and second apertures **176** and **178** as described above.

Referring now to FIGS. **10** and **11**, an alternative embodiment indicated generally at **210** is shown for sorting and/or orienting the plurality of utensils **14**. The apparatus **210** is similar in many respects to those described above. The apparatus **210** includes a template **214** and a conveyer **218** movably disposed on the template **214**. The template **214** can have a plurality of apertures, including a plurality of first, second and third apertures. The first apertures **222** can be sized and configured to receive therethrough only the spoons **20**. The second apertures **224** can be sized and configured to receive therethrough only the forks **22**. The third apertures **226** can be sized and configured to receive therethrough only the knives **24**.

As the conveyer **218** rotates, the conveyer **218** moves pockets **230** and the utensils **14** sequentially through four different locations. In the first or receiving location, the pocket **230** is located adjacent the first aperture **222** to receive at least one of the plurality of utensils **14**. The second location is a first sorting location **234** in which the pocket **230** and utensils **14** are disposed over the first aperture **222** to separate the spoons **20** from the remaining utensils **14**. The third location is a second sorting location **236** in which the pocket **230** is disposed over the second aperture **224** such that any fork **22** passes through the aperture **224**. The fourth location is a third sorting location **238** in which the pocket **230** is disposed over the third aperture **226** such that any knife **24** passes through the third aperture **226**.

As described above, the apparatus **210** advantageously receives a plurality of utensils **14**, and continuously sorts the plurality of utensils **14**. In addition, the apparatus **210** separates the spoons, forks, and knives with a single template **214** and conveyer **218**, to reduce space. The apparatus **210** also can include a plurality of chutes or compartments **240** disposed under each aperture to receive the utensils.

A method for sorting a plurality of utensils **14** using the apparatuses described above includes simultaneously receiving or providing the plurality of utensils **14** to a movable conveyer. The utensils may be received or provided to a first plurality of pockets formed in the movable conveyer. The plurality of utensils **14** are simultaneously moved past or across the apertures in the template by moving the conveyer. Simultaneously sorting a plurality of utensils provides a distinct advantage over prior art devices which individually provide and sort a utensil. Simultaneously sorting a plurality of utensils is faster and more efficient. Furthermore, after the conveyer has moved the first plurality of utensils over the apertures, a second plurality of utensils may be received simultaneously onto the conveyer, or onto a second plurality of pockets on the conveyer. Thus, the first plurality of utensils is being sorted while the second plurality of utensils are being received.

Any spoons are allowed to pass through the aperture in a template. Any remaining utensils such as forks or knives are simultaneously moved past the apertures, and simultaneously removed from the conveyer.

In addition, the plurality of utensils may be oriented simultaneously as they pass through the apertures. As indicated above, the plurality of utensils may be moved past a plurality if bars each disposed over one of the apertures at a location corresponding to the midpoints of the first utensils. The centers of gravity of the utensils are allowed to cause the utensils to pass through the apertures on one side of the bar due to the weight of the utensil, causing the utensils to have a common orientation.

Any remaining knives or forks may be received or provided simultaneously to a second movable conveyer which simultaneously moves the knives and forks past a plurality of second apertures or second template.

It is to be understood that the above-described arrangements are only illustrative of the application of the principles of the present invention. Numerous modifications and alternative arrangements may be devised by those skilled in the art without departing from the spirit and scope of the present invention and the appended claims are intended to cover such modifications and arrangements. Thus, while the present invention has been shown in the drawings and fully described above with particularity and detail in connection with what is presently deemed to be the most practical and preferred embodiment(s) of the invention, it will be apparent to those of ordinary skill in the art that numerous modifications, including, but not limited to, variations in size, materials, shape, form, function and manner of operation, assembly and use may be made without departing from the principles and concepts set forth herein.

What is claimed is:

1. A utensil sorting apparatus for simultaneously sorting a plurality of utensils, including at least first and second utensils, the apparatus comprising:

a) a template having a plurality of first apertures sized to receive therethrough only the first utensils and capable of simultaneously receiving a plurality of the first utensils through the plurality of first apertures; and

b) a movable conveyor, movably disposed across the template and the first apertures, configured to simultaneously move the plurality of utensils across the plurality of first apertures in the template, and sequentially through at least two locations, including:

i) a receiving location to receive the plurality of utensils; and

ii) a first sorting location to simultaneously pass any first utensil through the plurality of first apertures in the template.

2. The apparatus of claim **1**, wherein the template further includes a plurality of second apertures sized to receive therethrough only the second utensils; and wherein the conveyor is further configured to move through a second sorting location to pass any second utensil through the second apertures in the template.

3. The apparatus of claim **2**, wherein the template further includes a plurality of third apertures sized to receive therethrough only third utensils; and wherein the conveyor is further configured to move through a third sorting location to pass any third utensil through the third apertures in the template.

4. The apparatus of claim **1**, wherein the conveyor has a plurality of partitions formed thereon defining a plurality of pockets therebetween configured to receive the first utensils, each pocket having an opening movable across the template and the first apertures.

5. The apparatus of claim **1**, further comprising:

a plurality of bars, each disposed laterally across one of the first apertures in the template at a location configured to correspond to midpoints of the respective first utensils, such that centers of gravity of the first utensils are disposed on either side of the respective bar as the first utensils are moved across the first apertures in the template, tending to cause the first utensils to pass

through the first apertures in the template on a same side of the respective bar as the center of gravity, thus orienting the first utensils.

6. The apparatus of claim **1**, wherein the template is a frusto-conical interior core, and wherein the conveyor is a frusto-conical exterior shell, rotatably disposed on the core.

7. A utensil sorting apparatus configured to sort a plurality of utensils, including at least first and second different utensils, the apparatus comprising:

a) a template having at least one aperture sized to receive therethrough only the first utensils;

b) the template having a frusto-conical shape with an angled surface configured to receive the utensils and to allow the utensils to slide thereon; and

c) a movable conveyor, movably disposed over the template and the at least one aperture, to sequentially move the first and second utensils across the aperture; and

d) the movable conveyor having a frusto-conical shape to match the frusto-conical shape of the template.

8. The apparatus of claim **7**, wherein the moving conveyor is configured to move the first and second utensils across the aperture in the template, and sequentially through at least two locations, including:

a) a receiving location to receive at least one of the first and second utensils; and

b) a sorting location to pass any first utensil through the aperture in the template.

9. The apparatus of claim **7**, wherein the conveyor has a plurality of partitions formed thereon defining a plurality of pockets therebetween configured to receive the first and second utensils, each pocket having an opening movable across the template and the at least one aperture.

10. The apparatus of claim **7**, further comprising:

a bar, disposed laterally across the aperture in the template at a location configured to correspond to a midpoint of the first utensils, such that centers of gravity of the first utensils are disposed on either side of the bar as the first utensils are moved across the aperture in the template, tending to cause the first utensils to pass through the aperture in the template on a same side of the bar as the center of gravity, thus orienting the first utensils.

11. The apparatus of claim **7**, further comprising a plurality of apertures in the template configured to simultaneously sort a plurality of utensils.

12. The apparatus of claim **7**, wherein the template further includes at least a second aperture sized to receive therethrough the second utensils.

13. A method for sorting a plurality of utensils, including at least first and second utensils, the method comprising the steps of:

a) simultaneously receiving a plurality of utensils on a movable conveyor;

b) simultaneously moving each of the plurality of utensils past one of a plurality of first apertures in a template by moving the conveyor, the first apertures being sized to receive only the first utensils; and

c) simultaneously moving any remaining second utensils past the plurality of apertures.

14. The method of claim **13**, further comprising the step of:

simultaneously moving any remaining second utensils past one of a plurality of second apertures in the template by moving the conveyor, the second apertures being sized to receive only the second utensils.

15. The method of claim **14**, further comprising the step of:

simultaneously moving any remaining third utensils past one of a plurality of third apertures in the template by moving the conveyor, the third apertures being sized to receive the third utensils.

16. The method of claim **13**, wherein step a) further comprises simultaneously receiving the plurality of utensils each into one of a first plurality of pockets on the movable conveyor.

17. The method of claim **16**, wherein step b) further comprises simultaneously receiving an additional plurality of utensils each into one of a second plurality of pockets on the movable conveyor.

18. The method of claim **13**, wherein step b) further comprises simultaneously orienting the first utensils while the first utensils pass through the apertures.

19. The method of claim **18**, further comprising moving the plurality of utensils past a plurality of bars each disposed over one of the apertures at a location corresponding to midpoints of the first utensils; and allowing centers of gravity of the first utensils to cause the first utensils to pass through the apertures on a side of the bar corresponding to the centers of gravity of the first utensils, thus orienting the first utensils.

20. The method of claim **13**, wherein the template is a frusto-conical interior core, and wherein the conveyor is a frusto-conical exterior shell, rotatably disposed on the core.

* * * * *

APPENDIX B

DAQ-BOARD PCI 6035E DATA SHEET

Low-Cost E Series Multifunction DAQ
12 or 16-Bit, 200 kS/s, 16 Analog Inputs

E Series – Low-Cost

- 16 analog inputs at up to 200 kS/s, 12 or 16-bit resolution
- Up to 2 analog outputs at 10 kS/s, 12 or 16-bit resolution
- 8 digital I/O lines (TTL/CMOS); two 24-bit counter/timers
- Digital triggering
- 4 analog input signal ranges
- NI-DAQ driver simplifies configuration and measurements

Families
- NI 6036E
- NI 6034E
- NI 6025E
- NI 6024E
- NI 6023E

Operating Systems
- Windows 2000/NT/XP
- Real-time performance with LabVIEW (page 134)
- Others such as Linux and Mac OS X (page 187)

Recommended Software
- LabVIEW
- LabWindows/CVI
- Measurement Studio
- VI Logger

Other Compatible Software
- Visual Basic, C/C++, and C#

Driver Software (included)
- NI-DAQ 7

Calibration Certificate Included

See page 21.

Family	Bus	Analog Inputs	Input Resolution	Max Sampling Rate	Input Range	Analog Outputs	Output Resolution	Output Rate	Output Range	Digital I/O	Counter/Timers	Triggers
NI 6036E	PCI, PCMCIA	16 SE/8 DI	16 bits	200 kS/s	±0.05 to ±10 V	2	16 bits	10 kS/s[1]	±10 V	8	2, 24-bit	Digital
NI 6034E	PCI	16 SE/8 DI	16 bits	200 kS/s	±0.05 to ±10 V	0	-	-	-	8	2, 24-bit	Digital
NI 6025E	PCI, PXI	16 SE/8 DI	12 bits	200 kS/s	±0.05 to ±10 V	2	12 bits	10 kS/s[1]	±10 V	8	2, 24-bit	Digital
NI 6024E	PCI, PCMCIA	16 SE/8 DI	12 bits	200 kS/s	±0.05 to ±10 V	2	12 bits	10 kS/s[1]	±10 V	8	2, 24-bit	Digital
NI 6023E	PCI	16 SE/8 DI	12 bits	200 kS/s	±0.05 to ±10 V	0	-	-	-	8	2, 24-bit	Digital

[1] 10 kS/s typical when using the single DMA channel for analog out put. 1kS/s maximum when using the single DMA channel for either analog input or counter/timer operations. 1 kS/s maximum for PCMCIA DAQCards in all cases.

Table 1. NI Low-Cost E Series Model Guide (See page 228 for detailed specifications.)

Overview and Applications

NI low-cost E Series multifunction data acquisition devices provide full functionality at a price to meet the needs of the budget-conscious user. They are ideal for applications ranging from continuous high-speed data logging to control applications to high-voltage signal or sensor measurements when used with NI signal conditioning. Synchronize the operations of multiple devices using the RTSI bus or PXI trigger bus to easily integrate other hardware such as motion control and machine vision to create an entire measurement and control system.

Highly Accurate Hardware Design

NI Low-Cost E Series DAQ devices include the following features and technologies:

Temperature Drift Protection Circuitry – Designed with components that minimize the effect of temperature changes on measurements to less than 0.0010% of reading per °C.

Resolution-Improvement Technologies – Carefully designed noise floor maximizes the resolution.

Onboard Self-Calibration – Precise voltage reference included for calibration and measurement accuracy. Self-calibration is completely software controlled, with no potentiometers to adjust.

NI DAQ-STC – Timing and control ASIC designed to provide more flexibility, lower power consumption, and a higher immunity to noise and jitter than off-the-shelf counter/timer chips.

NI MITE – ASIC designed to optimize data transfer for multiple simultaneous operations using bus mastering with one DMA channel, interrupts, or programmed I/O.

NI PGIA – Measurement and instrument class amplifier that guarantees settling times at all gains. Typical commercial off-the-shelf amplifier components do not meet the settling time requirements for high-gain measurement applications.

PFI Lines – Eight programmable function input (PFI) lines that can be used for software-controlled routing of interboard and intraboard digital and timing signals.

Fig. B.1 DAQ Board PCI- 6035 E Data Sheet (Pages 148-154)

Low-Cost E Series Multifunction DAQ
12 or 16-Bit, 200 kS/s, 16 Analog Inputs

		Full-Featured E Series				Low-Cost E Series		Basic
Models		NI 6030E, NI 6031E, NI 6032E, NI 6033E	NI 6052E	NI 6070E, NI 6071E	NI 6040E	NI 6034E, NI 6036E	NI 6023E, NI 6024E, NI 6025E	PCI-6013, PCI-6014
Measurement Sensitivity* (mV)		0.0023	0.0025	0.009	0.008	0.0036	0.008	0.004
Nominal Range (V)								
Positive FS	**Negative FS**	**Absolute Accuracy (mV)**						
10	-10	1.147	4.747	14.369	15.373	7.560	16.504	8.984
5	-5	2.077	0.876	5.193	5.697	1.790	5.263	2.003
2.5	-2.5	–	1.190	3.605	3.859	–	–	–
2	-2	0.836	–	–	–	–	–	–
1	-1	0.422	0.479	1.452	1.556	–	–	–
0.5	-0.5	0.215	0.243	0.735	0.789	0.399	0.846	0.471
0.25	-0.25	–	0.137	0.379	0.405	–	–	–
0.2	-0.2	0.102	–	–	–	–	–	–
0.1	-0.1	0.061	0.064	0.163	0.176	–	–	–
0.05	-0.05	–	0.035	0.091	0.100	0.0611	0.106	0.069
10	0	0.976	1.232	6.765	7.269	–	–	–
5	0	1.992	2.119	5.391	5.645	–	–	–
2	0	0.802	0.850	2.167	2.271	–	–	–
1	0	0.405	0.428	1.092	1.146	–	–	–
0.5	0	0.207	0.242	0.558	0.583	–	–	–
0.2	0	0.098	0.111	0.235	0.247	–	–	–
0.1	0	0.059	0.059	0.127	0.135	–	–	–

Note: Accuracies are valid for measurements following an internal calibration. Measurement accuracies are listed for operational temperatures within ±1 °C of internal calibration temperature and ±10 °C of external or factory-calibration temperature. One-year calibration interval recommended. The Absolute Accuracy at Full Scale calculations were performed for a maximum range input voltage (for example, 10 V for the ±10 V range) after one year, assuming 100 pt averaging of data.*Smallest detectable voltage change in the input signal at the smallest input range.

Table 2. Low-Cost E Series Analog Input Absolute Accuracy Specifications

		Full-Featured E Series				Low-Cost E Series		Basic
Models		NI 6030E, NI 6031E, NI 6032E, NI 6033E	NI 6052E	NI 6070E, NI 6071E	NI 6040E	PCI-6036E	PCI-6024E, NI 6025E,	NI 6013, NI 6014
Nominal Range (V)								
Positive FS	**Negative FS**	**Absolute Accuracy (mV)**						
10	-10	1.43	1.405	8.127	8.127	2.417	8.127	3.835
10	0	1.201	1.176	5.685	5.685	–	–	–

Table 3. Low-Cost E Series Analog Output Absolute Accuracy Specifications

RTSI or PXI Trigger Bus – Used to share timing and control signals between multiple devices to synchronize operations.

RSE Mode – In addition to differential and nonreferenced single-ended modes, NI low-cost E Series devices offer referenced single-ended (RSE) mode for use with floating signal sources in applications with channel counts higher than eight.

Onboard Temperature Sensor – Included for monitoring the operating temperature of the device to ensure that it is operating within the specified range.

High-Performance, Easy-to-Use Driver Software

NI-DAQ is the robust driver software that makes it easy to access the functionality of your data acquisition hardware, whether you are a beginning or advanced user. Helpful features include:

Automatic Code Generation – The DAQ Assistant is an interactive guide that steps you through configuring, testing, and programming measurement tasks and generates the necessary code automatically for LabVIEW, LabWindows/CVI, or Measurement Studio.

Cleaner Code Development – Basic and advanced software functions have been combined into one easy-to-use yet powerful set to help you build cleaner code and move from basic to advanced applications without replacing functions.

High-Performance Driver Engine – Software-timed single-point input (typically used in control loops) with NI-DAQ achieves rates of up to 50 kHz. NI-DAQ also delivers maximum I/O system throughput with a multithreaded driver.

Test Panels – With NI-DAQ, you can test all of your device functionality before you begin development.

Scaled Channels – Easily scale your voltage data into the proper engineering units using the NI-DAQ Measurement Ready virtual channels by choosing from a list of common sensors and signals or creating your own custom scale.

LabVIEW Integration – All NI-DAQ functions create the waveform data type, which carries acquired data and timing information directly into more than 400 LabVIEW built-in analysis routines for display of results in engineering units on a graph.

For information on device support in NI-DAQ 7, visit ni.com/dataacquisition

Visit ni.com/oem for quantity discount information.

Low-Cost E Series Multifunction DAQ
12 or 16-Bit, 200 kS/s, 16 Analog Inputs

Worldwide Support and Services

NI provides you with a wealth of resources to help you get your application up and running more quickly, including:

Technical Support – Purchase of NI hardware or software gives you access to application engineers all over the world as well as Web resources with more than 3,000 measurement examples and more than 9,000 KnowledgeBase entries. – *ni.com/support*

NI Factory Installation Services (FIS) – Software and hardware installed in PXI and PXI/SCXI systems, tested and ready to use – *ni.com/advisor*

Calibration – Includes NIST-traceable basic calibration certificates, services for ANSI/NCSL-Z540 and periodic calibration – *ni.com/calibration*

Extended Warranty – Meet project life-cycle requirements and maintain optimal performance in a cost-effective way – *ni.com/services*

Data Acquisition Training – Instructor-led courses – *ni.com/training*

Professional Services – Feasibility, consulting, and integration through our Alliance Partners – *ni.com/alliance*

For more information on NI services and support, please visit ni.com/services

Recommended Accessories

Signal conditioning is required for sensor measurements or voltage inputs greater than 10 V. National Instruments SCXI is a versatile, high performance signal conditioning platform, intended for high-channel-count applications. NI SCC products provide portable, flexible signal conditioning options on a per-channel basis. Both signal conditioning platforms are designed to increase the performance and reliability of your DAQ System, and are up to 10X more accurate than terminal blocks (please visit *ni.com/sigcon* for more details). Refer to the table below for more information:

Sensor/Signals (>10 V)

System Description	DAQ Device	Signal Conditioning	Page
High performance	PCI-60xxE, PXI-60xxE, DAQCard-60xxE	SCXI	270
Low-cost, portable	PCI-60xxE, PXI-60xxE, DAQCard-60xxE	SCC	251

Signals (<10 V)[1]

System Description	DAQ Device	Terminal Block	Cable	Page
Shielded	PCI-60xxE	SCB-68	SH6868-EP	214
Shielded	PXI-60xxE	TB-2705	SH6868-EP	214
Shielded	DAQCard-60xxE	SCB-68	SHC6868-EP	214
Low-cost	PCI-6025E/PXI-6025E	Two TBX-68s	SH1006868	214
Low-cost	PCI-60xxE/PXI-60xxE	CB-68LP	R6868	214
Low-Cost	DAQCard-60xxE	CB-68LP	RC6868	214

[1]Terminal Blocks do not provide signal conditioning (ie. filtering, amplification, isolation, etc.), which may be necessary to increase the accuracy of your measurements.

Table 4. Recommended Accessories

Ordering Information

NI PCI-6036E.....778465-01
NI DAQCard-6036E.....778561-01
NI PCI-6034E.....778075-01
NI PXI-6025E.....777798-01
NI PCI-6025E.....777744-01
NI DAQCard-6024E.....778269-01
NI PCI-6024E.....777743-01
NI PCI-6023E.....777742-01

Includes NI-DAQ driver software and calibration certificate.

For more information on warranty and value-added services, see page 20.

BUY ONLINE!
Visit ni.com/dataacquisition

Multifunction DAQ Overview

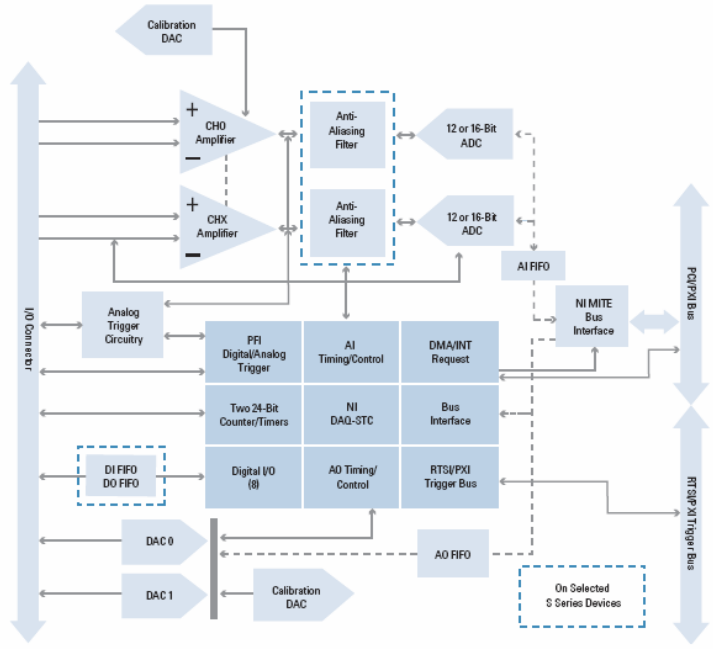


Figure 1. S Series Hardware Block Diagram

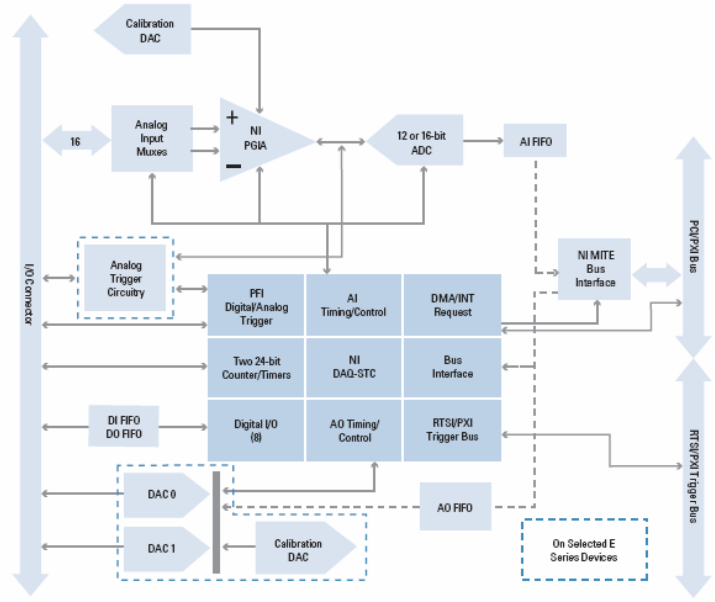


Figure 2. E Series Hardware Block Diagram

16-Bit E Series Multifunction DAQ Specifications

Specifications – NI 6052E and NI 603xE

These specifications are typical for 25 °C unless otherwise noted.

Analog Input

Accuracy specifications ..... See page 228.

Input Characteristics

	Number of Channels
6052E 6030E 6032E 6034E 6036E	16 single-ended or 8 differential (software selectable per channel)
6031E 6033E	64 single-ended or 32 differential (software-selectable per channel)

Resolution..... 16 bits, 1 in 65,536

	Maximum Sampling Rate
6052E	333 kS/s
6034E 6036E	200 kS/s
6030E 6031E 6032E 6033E	100 kS/s

Input signal ranges

Device	Range Software Selectable	Bipolar Input Range	Unipolar Input Range
6052E	20 V	±10 V	–
	10 V	±5 V	0 to 10 V
	5 V	±2.5 V	0 to 5 V
	2 V	±1 V	0 to 2 V
	1 V	±500 mV	0 to 1 V
	500 mV	±250 mV	0 to 500 mV
	200 mV	±100 mV	0 to 200 mV
	100 mV	±50 mV	0 to 100 mV
6030E	20 V	±10 V	–
6031E	10 V	±5 V	0 to 10 V
6032E	5 V	–	0 to 5 V
6033E	4 V	±2 V	–
	2 V	±1 V	0 to 2 V
	1 V	±500 mV	0 to 1 V
	500 mV	–	0 to 500 mV
	400 mV	±200 mV	–
	200 mV	±100 mV	0 to 200 mV
	100 mV	–	0 to 100 mV
6034E	20 V	±10 V	–
6036E	10 V	±5 V	–
	1 V	±500 mV	–
	100 mV	±50 mV	–

Input coupling..... DC

Maximum working voltage
(signal + common mode) ..... Each input should remain within ±11 V of ground

Overvoltage protection
Powered on..... ±25 V
Powered off ..... ±15 V

	Inputs Protected
6052E 6030E 6032E 6034E 6036E	AI<0..15>, AI SENSE
6031E 6033E	AI<0..63>, AI SENSE, AI SENSE2

FIFO buffer size ..... 512 samples, (1024 samples for DAQCard)

Data transfers
PCI, PXI ..... DMA, interrupts, programmed I/O
DAQCard..... Interrupts, programmed I/O

DMA modes
PCI, PXI ..... Scatter-gather (single transfer, demand transfer)

Configuration memory size ..... 512 words

Transfer Characteristics

Relative accuracy (dithered)

Device	Typical	Maximum
6052E 6034E PCI-6036E	±1.5 LSB	±3 LSB
6030E 6031E 6032E 6033E	±0.75 LSB	±1 LSB
DAQCard-6036E	±3.0 LSB	±6 LSB

DNL

Device	Typical	Maximum
6052E 603xE (except DAQCard-6036E)	±0.5 LSB	±1 LSB
DAQCard-6036E	±1.0 LSB	+4, -2 LSB

No missing codes
DAQCard 6036E..... 15 bits, guaranteed
Others ..... 16 bits, guaranteed

Amplifier Characteristics

Input impedance

Device	Normal Powered On	Powered Off	Overload
6052E 603xE	100 GΩ in parallel with 100 pF	820 Ω	820 Ω

Input bias and offset current

Device	Bias Current	Offset Current
6052E 6034E PCI-6036E	±200 pA	±100 pA
6030E 6031E 6032E 6033E	±1 nA	±2 nA
DAQCard-6036E	±800 pA	±100 pA

16-Bit E Series Multifunction DAQ Specifications

Specifications – NI 6052E and NI 603xE (continued)

CMRR, DC to 60 Hz

		CMRR	
Device	Range	Bipolar (dB)	Unipolar (dB)
6052E	20 V	92	–
	10 V	97	97
	5 V	101	101
	2 V	104	104
	100 mV to 1 V	105	105
6030E	20 V	92	–
6031E	10 V	97	92
6032E	5 V	–	97
6033E	4 V	101	–
	2 V	104	101
	1 V	105	104
	100 mV to 500 mV	105	105
6034E	20 V	85	–
6036E	10 V	85	–
	1 V	96	–
	100 mV	96	–

Dynamic Characteristics

Bandwidth

Device	Range	Small Signal (-3 dB)
6052E	All ranges	480 kHz
6030E, 6031E, 6032E, 6033E	All ranges	255 kHz
6034E, 6036E	All ranges	413 kHz

System noise (LSB_{rms}, including quantization)

Device	Range	Bipolar	Unipolar
6052E	2 to 20 V	0.95	0.95
	1 V	1.1	1.1
	500 mV	1.3	1.3
	200 mV	2.7	2.7
	100 mV	5.0	5.0
6030E	2 to 20 V	0.6	0.8
6031E	1 V	0.7	0.8
6032E	400 to 500 mV	1.1	1.1
6033E	200 mV	2.0	2.0
	100 mV	–	3.8
6034E	10 to 20 V	0.8	–
PCI-6036E	1 V	1.0	–
	100 mV	6.2	–
DAQCard-6036E	10 to 20 V	1.5	–

Settling time to full-scale step

		Accuracy				
Device	Range	±0.00076% (±0.5 LSB)	±0.0015% (±1 LSB)	±0.0031% (±2 LSB)	±0.0061% (±4 LSB)	±0.024% (±16 LSB)
6052E	2 to 20 V	–	10 µs max	5 µs max	4 µs max	3 µs max
	1 V	–	15 µs max	5 µs max	4 µs max	3 µs max
	200 to 500 mV	–	15 µs max	10 µs max	4 µs max	3 µs max
	100 mV	–	15 µs typical	10 µs typical	4 µs max	3 µs max
6030E 6032E	All	40 µs max	20 µs max	–	10 µs max	–
6031E 6033E	All	50 µs max	25 µs max	–	10 µs max	–
6034E	1 to 20 V	–	–	5 µs max	–	–
6036E	100 mV	–	–	–	5 µs typical	–
DAQCard-6036E	10 V	–	–	5 µs max	–	–

Crosstalk

Device	Adjacent Channels	All Other Channels
6052E 603xE	-75 dB	-90 dB

Analog Output

Output Characteristics

Number of Channels	
6052E 6030E 6031E 6036E	2 voltage outputs
6032E, 6033E, 6034E	None

Resolution	
6052E 6036E 6030E 6031E	16 bits, 1 in 65,536

Maximum Update Rate	
6052E	333 kS/s
PCI-6036E	10 kS/s, system dependent
6030E 6031E	100 kS/s
DAQCard-6036	1 kS/s, system dependent

Type of DAC ..... Double buffered, multiplying

FIFO Buffer Size	
6052E, 6030E, 6031E	2,048 samples
6036E	None

Data transfers
- PCI, PXI ..... DMA, interrupts, programmed I/O
- DAQCard ..... Interrupts, programmed I/O

DMA modes
- PCI, PXI ..... Scatter-gather (single transfer, demand transfer)

Transfer Characteristics

Relative Accuracy	
6052E	±0.35 LSB typical, ±1 LSB maximum
6030E 6031E	±0.5 LSB typical, ±1 LSB maximum
6036E	±2 LSB maximum

DNL ..... ±1.0 LSB maximum

Monotonicity	
6052E 6036E 6030E 6031E	16 bits, guaranteed

Voltage Output

Ranges	
6052E	±10 V, 0 to 10 V, ±EXTREF, 0 to EXTREF; software selectable
6030E 6031E	±10 V, 0 to 10 V; software selectable
6036E	±10 V

Output coupling ..... DC
Output impedance ..... 0.1 Ω maximum
Current drive ..... ±5 mA maximum
Protection ..... Short-circuit to ground

Power-On State	
6052E 6030E 6031E	0 V (±20 mV)
PCI-6036E	0 V (±44 mV)
DAQCard-6036E	0 V (±60 mV)

16-Bit E Series Multifunction DAQ Specifications

Specifications – NI 6052E and NI 603xE (continued)

External reference input (6052E only)
- Range ..... ±11 V
- Overvoltage protection ..... ±25 V powered on, ±15 V powered off
- Input impedance ..... 10 kΩ
- Bandwidth (-3 dB) ..... 3 kHz
- Slew rate ..... 0.3 V/µs

Dynamic Characteristics

Settling time and slew rate

Device	Settling Time For Full-Scale Step	Slew Rate
6052E	3.5 µs to ±1 LSB accuracy	15 V/µs
6030E	10 µs to ±1 LSB accuracy	5 V/µs
6031E		
PCI-6036E	5 µs to ±1 LSB accuracy	15 V/µs
DAQCard-6036E	5 µs to ±4.5 LSB accuracy	5 V/µs

	Noise
6052E	60 μV_{rms}, DC to 1 MHz
6030E	
6031E	
PCI-6036E	110 μV_{rms}, DC to 400 kHz
DAQCard-6036E	160 μV_{rms}, DC to 400 kHz

Glitch energy (at mid-scale transition)

Device	Magnitude	Duration
6052E	±10 mV	1 µs
PCI-6036E	±10 mV	1 µs

Digital I/O

- Number of channels ..... 8 input/output
- Compatibility ..... 5 V/TTL/CMOS
- Power-on state ..... Input (high impedance)
- Data transfers ..... Programmed I/O

Digital logic levels

Level	Minimum	Maximum
Input low voltage	0.0 V	0.8 V
Input high voltage	2.0 V	5.0 V
Output low voltage (I_{out} = 5 mA)	–	0.4 V
Output high voltage (I_{out} = -3.5 mA)	4.35 V	–

Timing I/O

General-Purpose Up/Down Counter/Timers

Number of channels
- Up/down counter/timers 2
- Frequency Scaler 1

Resolution
- Up/down counter/timers ..... 24 bits
- Frequency Scaler ..... 4 bits

- Compatibility ..... 5 VTTL/CMOS
- Digital logic levels

Base clocks available
- Up/down counter/timers ..... 20 MHz and 100 kHz
- Frequency Scaler ..... 10 MHz and 100 kHz

- Base clock accuracy ..... ±0.01%

Maximum external source frequency
- Up/down counter/timers ..... 20 MHz

- External source selections ..... PFI <0..9>, RTSI <0..6>, analog trigger; software selectable
- External gate selections ..... PFI <0..9>, RTSI <0..6>, analog trigger; software selectable
- Minimum source pulse duration ..... 10 ns, edge-detect mode
- Minimum gate pulse duration ..... 10 ns, edge-detect mode

Data transfers
- PCI/PXI Up/down counter/timer ..... DMA (scatter-gather), interrupts, programmed I/O
- DAQCard Up/down counter/timer ..... Interrupts, programmed I/O
- Frequency Scaler ..... Programmed I/O

Triggers

Analog Triggers

	Number of Triggers
6052E	1
6030E	
6031E	
6032E	
6033E	
6034E	None
6036E	

Purpose
- Analog input ..... Start and stop trigger, gate, clock
- Analog output ..... Start trigger, gate, clock
- General-purpose counter/timers ..... Source, gate

	Source
6052E	AI<0..15>, PFI 0/AI START TRIG
6030E	
6032E	
6031E	AI<0..63>, PFI 0/AI START TRIG
6033E	

Level
- Internal source, AI<0..15/63> ..... ±full-scale
- External source, PFI 0/AI START TRIG ..... ±10 V

- Slope ..... Positive or negative; software-selectable
- Resolution ..... 12 bits, 1 in 4,096
- Hysteresis ..... Programmable

Bandwidth (-3 dB)

Device	Internal Source AI<0..15/63>	External Source PFI 0/AI START TRIG
6052E	700 kHz	700 kHz
PCI-6030E, PCI-6031E, 6032E, 6033E	255 kHz	4 MHz
PXI-6030E, PXI-6031E	255 kHz	255 kHz

- Accuracy ..... ±1% of full-scale range maximum

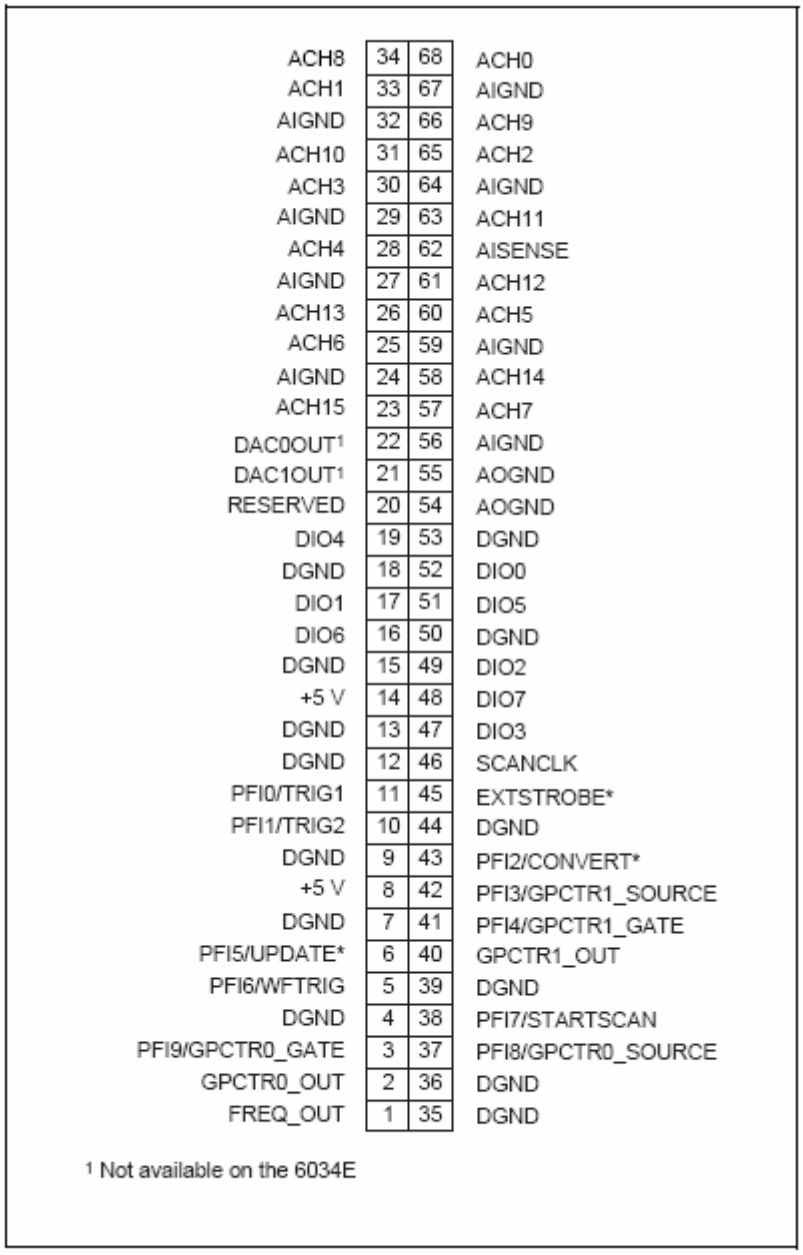
Digital Triggers (all devices)

Purpose
- Analog input ..... Start and stop trigger, gate, clock
- Analog output ..... Start trigger, gate, clock
- General-purpose counter/timers ..... Source, gate

- Source ..... PFI <0..9>, RTSI <0..6>
- Compatibility ..... 5 VTTL
- Response ..... Rising or falling edge
- Pulse width ..... 10 ns minimum

APPENDIX C

PIN DIAGRAM FOR PCI 6035 E



ACH8	34	68	ACH0
ACH1	33	67	AIGND
AIGND	32	66	ACH9
ACH10	31	65	ACH2
ACH3	30	64	AIGND
AIGND	29	63	ACH11
ACH4	28	62	AISENSE
AIGND	27	61	ACH12
ACH13	26	60	ACH5
ACH6	25	59	AIGND
AIGND	24	58	ACH14
ACH15	23	57	ACH7
DAC0OUT[1]	22	56	AIGND
DAC1OUT[1]	21	55	AOGND
RESERVED	20	54	AOGND
DIO4	19	53	DGND
DGND	18	52	DIO0
DIO1	17	51	DIO5
DIO6	16	50	DGND
DGND	15	49	DIO2
+5 V	14	48	DIO7
DGND	13	47	DIO3
DGND	12	46	SCANCLK
PFI0/TRIG1	11	45	EXTSTROBE*
PFI1/TRIG2	10	44	DGND
DGND	9	43	PFI2/CONVERT*
+5 V	8	42	PFI3/GPCTR1_SOURCE
DGND	7	41	PFI4/GPCTR1_GATE
PFI5/UPDATE*	6	40	GPCTR1_OUT
PFI6/WFTRIG	5	39	DGND
DGND	4	38	PFI7/STARTSCAN
PFI9/GPCTR0_GATE	3	37	PFI8/GPCTR0_SOURCE
GPCTR0_OUT	2	36	DGND
FREQ_OUT	1	35	DGND

[1] Not available on the 6034E

Figure 4-1. I/O Connector Pin Assignment for the 6034E/6035E

Fig. C.1 Pin Diagram for PCI-6035E (Pages 156- 160)

Table 4-1 shows the I/O connector signal descriptions for the 6034E and 6035E.

Table 4-1. I/O Connector Signal Descriptions

Signal Name	Reference	Direction	Description
AIGND	—	—	Analog Input Ground—These pins are the reference point for single-ended measurements in RSE configuration and the bias current return point for differential measurements. All three ground references—AIGND, AOGND, and DGND—are connected together on your device.
ACH<0..15>	AIGND	Input	Analog Input Channels 0 through 15—Each channel pair, ACH<*i*, *i*+8> (*i* = 0..7), can be configured as either one differential input or two single-ended inputs.
AISENSE	AIGND	Input	Analog Input Sense—This pin serves as the reference node for any of channels ACH <0..15> in NRSE configuration.
DAC0OUT[1]	AOGND	Output	Analog Channel 0 Output—This pin supplies the voltage output of analog output channel 0.
DAC1OUT[1]	AOGND	Output	Analog Channel 1 Output—This pin supplies the voltage output of analog output channel 1.
AOGND	—	—	Analog Output Ground—The analog output voltages are referenced to this node. All three ground references—AIGND, AOGND, and DGND—are connected together on your device.
DGND	—	—	Digital Ground—This pin supplies the reference for the digital signals at the I/O connector as well as the +5 VDC supply. All three ground references—AIGND, AOGND, and DGND—are connected together on your device.
DIO<0..7>	DGND	Input or Output	Digital I/O signals—DIO6 and 7 can control the up/down signal of general-purpose counters 0 and 1, respectively.
+5 V	DGND	Output	+5 VDC Source—These pins are fused for up to 1 A of +5 V supply. The fuse is self-resetting.
SCANCLK	DGND	Output	Scan Clock—This pin pulses once for each A/D conversion in scanning mode when enabled. The low-to-high edge indicates when the input signal can be removed from the input or switched to another signal.
EXTSTROBE*	DGND	Output	External Strobe—This output can be toggled under software control to latch signals or trigger events on external devices.

Table 4-1. I/O Connector Signal Descriptions (Continued)

Signal Name	Reference	Direction	Description
PFI0/TRIG1	DGND	Input	PFI0/Trigger 1—As an input, this is one of the Programmable Function Inputs (PFIs). PFI signals are explained in the *Timing Connections* section later in this chapter.
		Output	As an output, this is the TRIG1 (AI Start Trigger) signal. In posttrigger data acquisition sequences, a low-to-high transition indicates the initiation of the acquisition sequence. In pretrigger applications, a low-to-high transition indicates the initiation of the pretrigger conversions.
PFI1/TRIG2	DGND	Input	PFI1/Trigger 2—As an input, this is one of the PFIs.
		Output	As an output, this is the TRIG2 (AI Stop Trigger) signal. In pretrigger applications, a low-to-high transition indicates the initiation of the posttrigger conversions. TRIG2 is not used in posttrigger applications.
PFI2/CONVERT*	DGND	Input	PFI2/Convert—As an input, this is one of the PFIs.
		Output	As an output, this is the CONVERT* (AI Convert) signal. A high-to-low edge on CONVERT* indicates that an A/D conversion is occurring.
PFI3/GPCTR1_SOURCE	DGND	Input	PFI3/Counter 1 Source—As an input, this is one of the PFIs.
		Output	As an output, this is the GPCTR1_SOURCE signal. This signal reflects the actual source connected to the general-purpose counter 1.
PFI4/GPCTR1_GATE	DGND	Input	PFI4/Counter 1 Gate—As an input, this is one of the PFIs.
		Output	As an output, this is the GPCTR1_GATE signal. This signal reflects the actual gate signal connected to the general-purpose counter 1.
GPCTR1_OUT	DGND	Output	Counter 1 Output—This output is from the general-purpose counter 1 output.
PFI5/UPDATE*	DGND	Input	PFI5/Update—As an input, this is one of the PFIs.
		Output	As an output, this is the UPDATE* (AO Update) signal. A high-to-low edge on UPDATE* indicates that the analog output primary group is being updated for the 6035E.

Table 4-1. I/O Connector Signal Descriptions (Continued)

Signal Name	Reference	Direction	Description
PFI6/WFTRIG	DGND	Input	PFI6/Waveform Trigger—As an input, this is one of the PFIs.
		Output	As an output, this is the WFTRIG (AO Start Trigger) signal. In timed analog output sequences, a low-to-high transition indicates the initiation of the waveform generation.
PFI7/STARTSCAN	DGND	Input	PFI7/Start of Scan—As an input, this is one of the PFIs.
		Output	As an output, this is the STARTSCAN (AI Scan Start) signal. This pin pulses once at the start of each analog input scan in the interval scan. A low-to-high transition indicates the start of the scan.
PFI8/GPCTR0_SOURCE	DGND	Input	PFI8/Counter 0 Source—As an input, this is one of the PFIs.
		Output	As an output, this is the GPCTR0_SOURCE signal. This signal reflects the actual source connected to the general-purpose counter 0.
PFI9/GPCTR0_GATE	DGND	Input	PFI9/Counter 0 Gate—As an input, this is one of the PFIs.
		Output	As an output, this is the GPCTR0_GATE signal. This signal reflects the actual gate signal connected to the general-purpose counter 0.
GPCTR0_OUT	DGND	Output	Counter 0 Output—This output is from the general-purpose counter 0 output.
FREQ_OUT	DGND	Output	Frequency Output—This output is from the frequency generator output.

* Indicates that the signal is active low

[1] Not available on the 6034E

Digital I/O Signal Connections

The 6034E and 6035E both have digital I/O signals DIO<0..7> and DGND. DIO<0..7> are the signals making up the DIO port, and DGND is the ground reference signal for the DIO port. You can program all lines individually to be inputs or outputs. Figure 4-9 shows signal connections for three typical digital I/O applications.

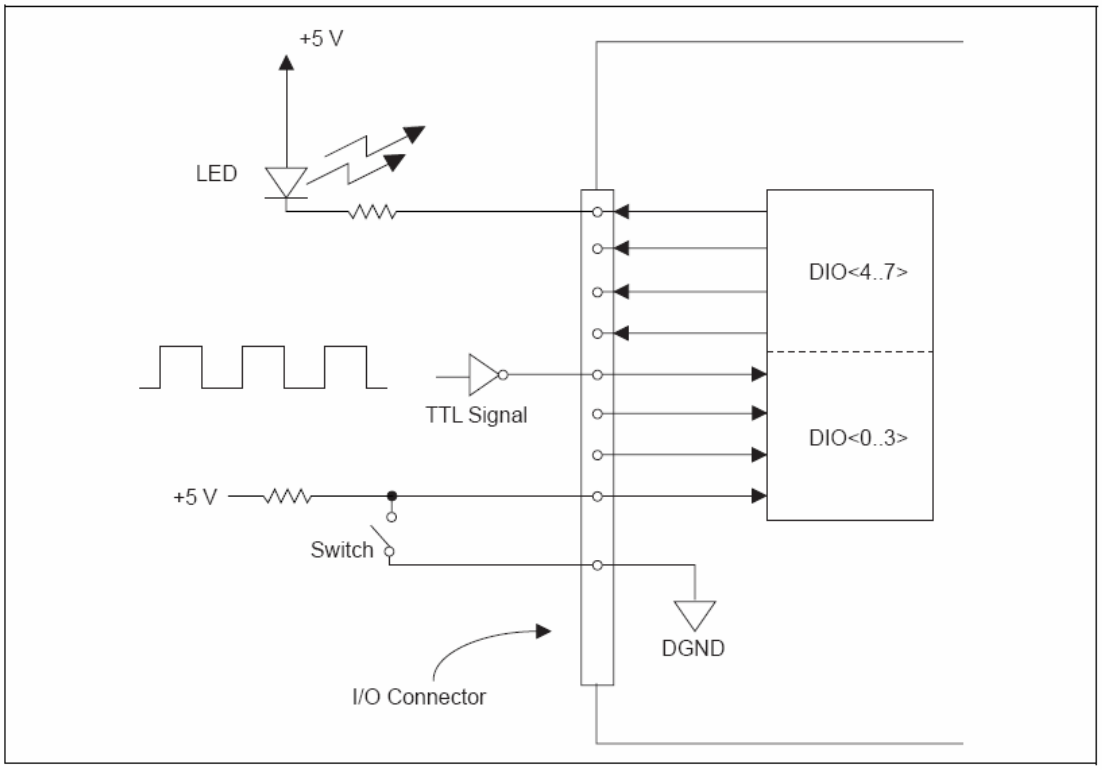


Figure 4-9. Digital I/O Connections

Figure 4-9 shows DIO<0..3> configured for digital input and DIO<4..7> configured for digital output. Digital input applications include receiving TTL signals and sensing external device states such as the state of the switch shown in the figure. Digital output applications include sending TTL signals and driving external devices such as the LED shown in the figure.

APPENDIX D

DAQ-BOARD PCI 6503 DATA SHEET

Digital I/O, 24 or 96 Lines, 5 V TTL/CMOS

NI 650x

- 24 or 96 digital input/output lines
- 5 V TTL/CMOS
- 2-wire handshaking capability
- Known power-up states
- NI-DAQ driver simplifies configuration and measurements

Models
- NI PCI-6503
- NI DAQCard-DIO-24
- NI PC-DIO-24
- NI PCI-DIO-96
- NI PXI-6508
- NI PC-DIO-96

Operating Systems
- Windows 2000/NT/XP
- Real-time performance with LabVIEW (see page 134)
- Others such as Linux and Mac OS X (see page 187)

Recommended Software
- LabVIEW
- LabWindows/CVI
- Measurement Studio

Other Compatible Software
- Visual Basic
- C/C++, C#

Driver Software (included)
- NI-DAQ 7

Family	Bus	Digital I/O Lines	Device Type	Logic Level	Isolation	Handshaking I/O	8255 Chipset	Change Notification	Pattern Matching
NI 6503	PCI PCMCIA ISA	24	Software timed	5 V TTL/CMOS	–	✓[1]	✓	–	✓
NI 6508	PCI PXI ISA	96 –	Software timed	5 V TTL/CMOS	– –	✓[1] ✓[1]	✓ ✓	– –	✓ ✓

[1]Handshaking supplied by the 8255; only one handshaking mode is available.

Table 1. NI 650x Specifications Overview (See page 385 for detailed specifications.)

Overview and Applications

NI 6503 devices are 24-bit parallel DIO interfaces for PCI, PCMCIA, and ISA. NI 6508 devices offer 96-bit parallel DIO interfaces for PCI, PXI, and ISA. All NI 650x devices are designed for 5 V TTL/CMOS I/O signals.

Hardware

82C55 Parallel Port Interfaces

NI 650x devices use 82C55 Parallel Port Interfaces (PPIs). NI 6503 devices contain one PPI, and the NI 6508 devices contain four. Each PPI controls 24 bits of DIO and has three 8-bit ports (A, B, and C). You can configure each port as either input or output. Ports A and B are always used for digital data I/O, while port C can be configured for digital data I/O, control, status, or handshake signals.

Digital I/O Power-Up State Selection

You can power up the PCI-6503, PC-DIO-24, PC-DIO-96, and PXI-6508 DIO lines in a user-defined state – either high or low. On these devices, each line is connected to a 100 kΩ resistor, and you can use a jumper to select whether the lines of the device power up in the high or low state. The DAQCard-DIO-24 and PCI-DIO-96 have 100 kΩ resistors that always pull high.

Digital I/O Connector

Digital connectors for the NI 650x devices are described in Table 2. The eight bits in Port A of each PPI are at xPA7 through xPA0 on the digital I/O connector where x represents which PPI is being used. Ports B and C are at xPB7 through xPB0 and xPC7 through xPC0, respectively. Each port is programmed to be input or output. Power from the computer I/O channel is also available on the DIO connector. See page 381 to learn more about connectivity solutions, including direct connectors, electromechanical relay devices, and other signal conditioning solutions.

Device	Connector
PCI-6503 PC-DIO-24	50-pin, shown in Figure 3
DAQCard-DIO-24	27-pin; cable adapts it to the 50-pin connector shown in Figure 3
NI 6508	100 pin; shown in Figure 2

Table 2. NI 650x Connector Overview

Fig. D.1 DAQ Board PCI- 6503 Data Sheet (Pages 162-164)

Digital I/O, 24 or 96 Lines, 5 V TTL/CMOS

Driver Software

With NI-DAQ driver software, you can interactively configure your devices, write custom programs, and easily perform digital I/O. You can also use messaging so when an input port matches or mismatches a user-defined pattern, NI-DAQ can perform another programmed operation. This process eliminates polling, decreases the load on the CPU and bus, and improves the efficiency of the system. NI-DAQ also provides numerous example programs for LabVIEW and other ADEs to quickly get you started with your application.

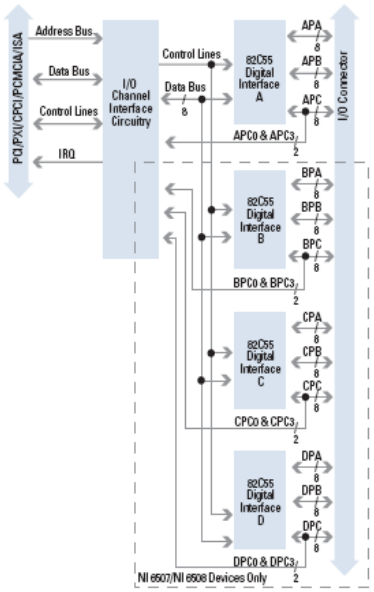


Figure 1. NI 650x Hardware Block Diagram

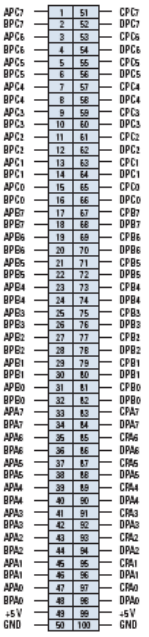


Figure 2. NI 6508 I/O Connector

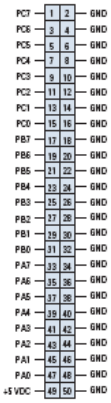


Figure 3. NI 6503 I/O Connector

Ordering Information

NI PCI-6503 777690-01
NI DAQCard-DIO-24 776912-01
NI PC-DIO-24 777368-01
NI PCI-DIO-96 777387-01
NI PXI-6508 777598-01
NI PC-DIO-96 777271-01

Includes NI-DAQ driver software

For information on extended warranty and value-added services, see page 20.

Recommended Configurations

Family	Device	Accessory	Cable
NI 6503	PCI-6503	CB-50LP (777101-01)	NB1 (180524-10)
	DAQCard-DIO-24	CB-50LP (777101-01)	PSH27-50F-D1 (776989-01)
	PC-DIO-24	CB-50LP (777101-01)	NB1 (180524-10)
NI 6508	PCI-DIO-96	SCB-100 (776990-01)	SH100-100-F (185095-02)
	PXI-6508	SCB-100 (776990-01)	SH100-100-F (185095-02)
	PC-DIO-96	CB-100kit (776455-02)	Included in kit

See page 382 for accessory and cable information.

BUY ONLINE!

Visit ni.com/info and enter pci6503, daqcarddio24, pcdio24, pcdio96, pxi6508, or pcdio96.

Digital I/O Connectivity and Signal Conditioning

Cables, Connector Blocks, and Signal Conditioning

Choose your Digital I/O cables, connector blocks, and signal conditioning in two easy steps.

Step 1. Choose your connector block and cable. (see digital I/O accessories section for details)

Device	Connector Block	Cables
PCI-6527, PXI-6527	CB-100 Kit SCB-100 CA-1000, CB-50, CB-50LP	Kit includes R1005050 cable SH100-100-F R1005050 (splits into two 50-pin connectors); with this cable, you can use two accessories from this group with one NI 6527 device
PCI-6503, PC-DIO-24	CA-1000, CB-50, CB-50LP	SH50-50 or NB1
DAQCard-DIO-24	CA-1000, CB-50, CB-50LP	PSH27-50F-D
PCI-DIO-96, PXI-6508	CB-100 Kit SCB-100 CA-1000, CB-50, CB-50LP	Kit includes R1005050 cable SH100-100-F NB5 (Splits into two 50-pin connectors); with this cable, you can use two accessories from this group with each device.
PC-DIO-96	CB-100 Kit SCB-100 CA-1000, CB-50, CB-50LP	Kit includes NB5 cable SH100-100-F NB5 (Splits into two 50-pin connectors); with this cable, you can use two accessories from this group with each device.

Step 2 (Optional). Choose your signal conditioning hardware and enclosures.

Device	SCXI Signal Conditioning System (Page 270)	SSR Series Modules (Page 349)	SC-206x Device (Page 349)	ER-8, ER-16 Electromechanical Relays (Page 349)	CA-1000 Custom Connectivity Enclosure (Page 351)
PCI-6527	–	–	–	–	✓
PXI-6527	–	–	–	–	✓
PCI-DIO-96	✓	✓	✓	✓	✓
PXI-6508	✓	✓	✓	✓	✓
PC-DIO-96	✓	✓	✓	✓	✓
PCI-6503	✓	✓	✓	✓	✓
PC-DIO-24	✓	✓	✓	✓	✓
DAQCard-DIO-24	✓	✓	✓	✓	✓

APPENDIX E

PIN DIAGRAM FOR PCI 6503

I/O Connector (PCI-6503)

The PCI-6503 has 50 pins that you can connect to 50-pin accessories with the NB1 cable.

PCI-6503 I/O Connector Pin Descriptions

Figure 3-4 shows the pin assignments for the PCI-6503 digital I/O connector using the NB1 ribbon cable.

PC7	1	2	GND
PC6	3	4	GND
PC5	5	6	GND
PC4	7	8	GND
PC3	9	10	GND
PC2	11	12	GND
PC1	13	14	GND
PC0	15	16	GND
PB7	17	18	GND
PB6	19	20	GND
PB5	21	22	GND
PB4	23	24	GND
PB3	25	26	GND
PB2	27	28	GND
PB1	29	30	GND
PB0	31	32	GND
PA7	33	34	GND
PA6	35	36	GND
PA5	37	38	GND
PA4	39	40	GND
PA3	41	42	GND
PA2	43	44	GND
PA1	45	46	GND
PA0	47	48	GND
+5 V	49	50	GND

Figure 3-4. PCI-6503 I/O Connector Pin Assignments

Fig. E.1 Pin Diagram for PCI-6503 (Pages 166 & 167)

Table 3-2 describes the PCI-6503 signals.

Table 3-2. PCI-6503 Signal Descriptions

Pin	Signal Name	Alternate Port ID*	Description
1, 3, 5, 7, 9, 11, 13, 15	PC<7..0>	2	Port C—Bidirectional data lines for port C. PC7 is the MSB, PC0 the LSB.
17, 19, 21, 23, 25, 27, 29, 31	PB<7..0>	1	Port B—Bidirectional data lines for port B. PB7 is the MSB, PB0 the LSB.
33, 35, 37, 39, 41, 43, 45, 47	PA<7..0>	0	Port A—Bidirectional data lines for port B. PA7 is the MSB, PA0 the LSB.
49	+5 V	—	+5 Volts—This pin is fused for up to 1 A at +4.65 to 5.25 V.
All even-numbered pins	GND	—	Ground—These signals are connected to the computer ground reference.

*This document refers to the 82C55 ports as A, B, and C. NI-DAQ and LabVIEW documentation use numbers to identify ports. For example, this manual uses port A to refer to the first port of the 82C55A. NI-DAQ, LabWindows/CVI, LabVIEW, or other application software documentation, however, refer to this port as *0*. The Alternate Port ID column shows the correlation between the different port names.

APPENDIX F

PULL TYPE SOLENOID DATA SHEET

More About Linear Solenoids

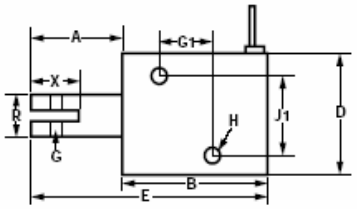
Pull Style

Push Style

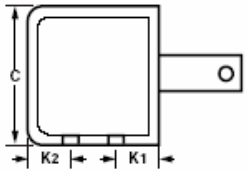
MCM Part No.	Input Voltage	Max. Stroke	Force, oz. @ ⅛" Stroke	Power Rating (Watts)	Coil Resistance (Ohms) 12V Model	24V Model	120 VAC Model
Pull Style—Intermittent Duty							
70155K1	DC	½"	20	11.5	12.5	50.1	____
70155K3	DC	½"	43	19.0	7.6	30.3	____
70155K5	DC	1"	120	38.0	3.8	15.2	____
70155K72	120 VAC	½"	14	22	____	____	232.1
70156K47	120 VAC	⅞"	24	40	____	____	85
70155K41	120 VAC	⅞"	45	60	____	____	32.2
Pull Style—Continuous Duty							
70155K2	DC	½"	11	5.0	28.8	115.0	____
70155K4	DC	½"	29	8.0	18.0	72.0	____
70155K6	DC	1"	76	11.0	13.1	52.4	____
70155K55	120 VAC	½"	12	8	____	____	400
70155K48	120 VAC	⅞"	12	12	____	____	200
70155K42	120 VAC	⅞"	14	10	____	____	133
Push Style—Intermittent Duty							
70155K11	DC	½"	42	19.0	7.6	30.3	____
70155K13	DC	1"	40	30.0	7.4	30.3	____
70155K65	120 VAC	½"	14	22	____	____	220
70155K61	120 VAC	⅞"	20	40	____	____	85
Push Style—Continuous Duty							
70155K12	DC	½"	16	8.0	18.0	72.0	____
70155K14	DC	1"	20	29.0	30.3	117.0	____
70155K66	120 VAC	½"	9	8	____	____	400
70155K62	120 VAC	⅞"	10	12	____	____	200

Pull Style

For part numbers 70155K1, 70155K2, 70155K55, and 70155K72.



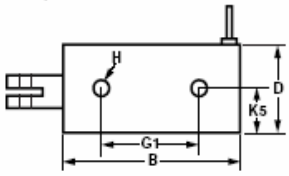
Side View



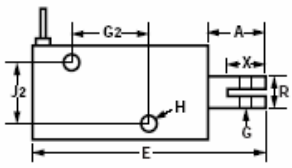
Top View

Retracted Rod Lg. (A)	Frame Lg. (B)	Frame Wd. (C)	Frame Ht. (D)	Overall Lg., Rod Retracted (E)	Rod Cutaway Depth (X)	Rod Hole Dia. (G)	Rod Dia. (R)	Mounting Hole Size (H)	Mounting Holes, Center-to-Center (G1)	Mounting Holes, Center-to-Center (J1)	Mounting Holes, Center-to-Frame Edge (K1)	Mounting Holes, Center-to-Frame Edge (K2)
.612"	1.13"	1.19"	.94"	1.74"	.41"	.096"	.31"	6-32	.406"	.625"	.41"	.31"

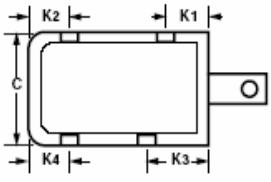
For part numbers 70155K3, 70155K4, 70155K47, and 70155K48.



Side View



Side View



Top View

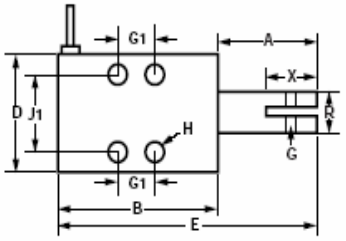
Retracted Rod Lg. (A)	Frame Lg. (B)	Frame Wd. (C)	Frame Ht. (D)	Overall Lg., Rod Retracted (E)	Rod Cutaway Depth (X)	Rod Hole Dia. (G)	Rod Dia. (R)	Mounting Hole Size (H)	Mounting Holes, Center-to-Center (G1)	Mounting Holes, Center-to-Center (G2)	Mounting Holes, Center-to-Center (J2)	Mounting Holes, Center-to-Frame Edge (K1)	Mounting Holes, Center-to-Frame Edge (K2)	Mounting Holes, Center-to-Frame Edge (K3)	Mounting Holes, Center-to-Frame Edge (K4)	Mounting Holes, Center-to-Frame Edge (K5)
.62"	1.846"	1.189"	.94"	2.466"	.41"	.096"	.31"	6-32	1"	.81"	.63"	.42"	.426"	.63"	.41"	.47"

McMASTER-CARR Copyright © 2004 McMaster-Carr Supply Company. All rights reserved. Document 70155KAC

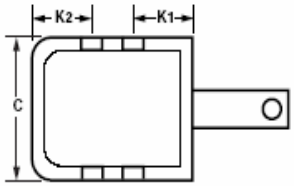
Fig. F.1 Solenoid Data Sheet (Pages 169-171)
70155K6 Linear Solenoid, Pull Type, Continuous, 1" Stroke, 76 oz Force

Pull Style *(Cont.)*

For part numbers 70155K5, 70155K6, 70155K41, and 70155K42.



Side View

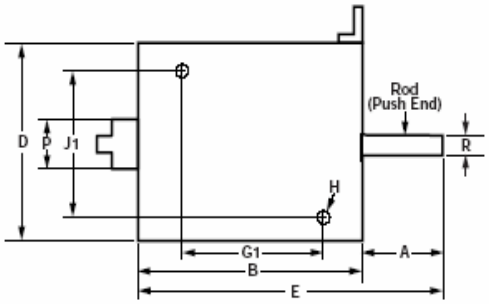


Top View

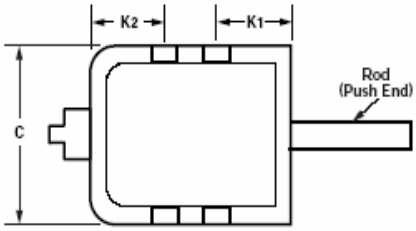
Retracted Rod Lg. (A)	Frame Lg. (B)	Frame Wd. (C)	Frame Ht. (D)	Overall Lg., Rod Retracted (E)	Rod Cutaway Depth (X)	Rod Hole Dia. (G)	Rod Dia. (R)	Mounting Hole Size (H)	Mounting Holes, Center-to-Center		Mounting Holes, Center-to-Frame Edge	
									(G1)	(J1)	(K1)	(K2)
1.165"	2"	1.63"	1.44"	3.165"	.69"	.128"	.437"	8-32	.5"	.936"	.87"	.63"

Push Style

For part numbers 70155K65 and 70155K66.



Side View



Top View

Extended Push End Lg. (A)	Frame Lg. (B)	Frame Wd. (C)	Frame Ht. (D)	Overall Lg., Push End Extended (E)	Rod (Push End) Dia. (R)	(P)	Mounting Hole Size (H)	Mounting Holes, Center-to-Center		Mounting Holes, Center-to-Frame Edge	
								(G1)	(J1)	(K1)	(K2)
.5"	1.13"	1.19"	.94"	1.63"	.093"	.31"	6-32	.406"	.625"	.32"	.41"

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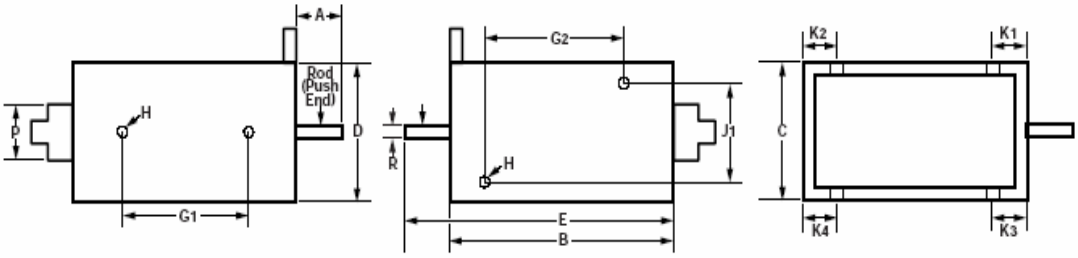
Push Style (Cont.)

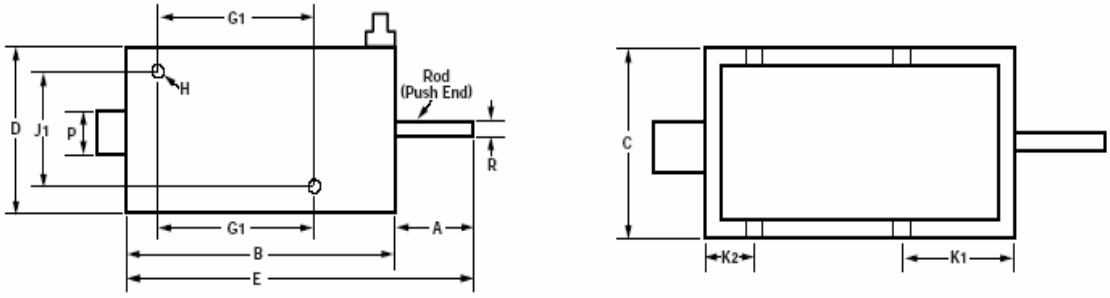
For part numbers 70155K11, 70155K12, 70155K61, and 70155K62.



Side View *Side View* *Top View*

Extended Push End Lg. (A)	Frame Lg. (B)	Frame Wd. (C)	Frame Ht. (D)	Overall Lg., Push End Extended (E)	Rod (Push End) Dia. (R)	(P)	Mounting Hole Size (H)	Mounting Holes, Center-to-Center			Mounting Holes, Center-to-Frame Edge			
								(G1)	(G2)	(J1)	(K1)	(K2)	(K3)	(K4)
1"	1.846"	1.19"	.94"	2.846"	.093"	.312"	6-32	1"	.812"	.631"	.404"	.63"	.42"	.42"

For part numbers 70155K13 and 70155K14.



Side View *Top View*

Extended Push End Lg. (A)	Frame Lg. (B)	Frame Wd. (C)	Frame Ht. (D)	Overall Lg., Push End Extended (E)	Rod (Push End) Dia. (R)	(P)	Mounting Hole Size (H)	Mounting Holes, Center-to-Center		Mounting Holes, Center-to-Frame Edge	
								(G1)	(J1)	(K1)	(K2)
1"	1.735"	1"	.84"	2.735"	.125"	.31"	8-32	.5"	.437"	.77"	.465"

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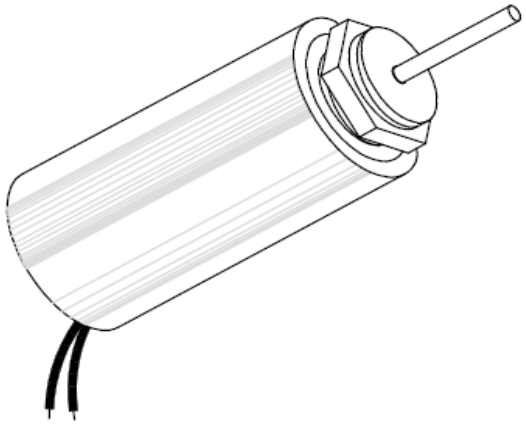
APPENDIX G

PUSH TYPE SOLENOID DATA SHEET

MAGNETIC SENSOR SYSTEMS

Push Type Tubular Solenoid



Series S-25-125-H

1 1/4" DIA X 2 1/2'

TOTAL WEIGHT: 11.2 OUNCES
PLUNGER WEIGHT: 1.5 OUNCES

duty cycle	1	1/2	1/4	1/10
maximum "ON" time, (Sec.)	∞	410	100	30
watts	11	22	44	110
approximate ampere turns	1410	2000	2820	4460

AWG number	resistance	volts DC	volts DC	volts DC	volts DC
20	0.97	3.2	4.5	6.3	10.0
21	1.38	4.0	5.6	7.9	12.5
22	2.49	5.1	7.2	10.2	16.1
23	3.49	6.2	8.8	12.5	19.7
24	6.06	8.1	11.5	16.2	25.5
25	9.89	10.3	14.5	20.5	32.4
26	16.6	13.0	18.4	25.9	41.0
27	24.5	16.1	22.8	32.2	50.9
28	36.9	20.4	28.9	40.8	64.5
29	61.8	25.5	36.1	51.0	80.6
30	93.3	31.5	44.6	62.9	99.5
31	144	40.3	57.1	80.6	127
32	210	49.4	70.0	98.7	156
33	357	63.5	90.0	127	201
34	553	82	116	164	259
35	993	105	149	210	332
36	1460	131	186	263	415
37	2406	160	227	320	506

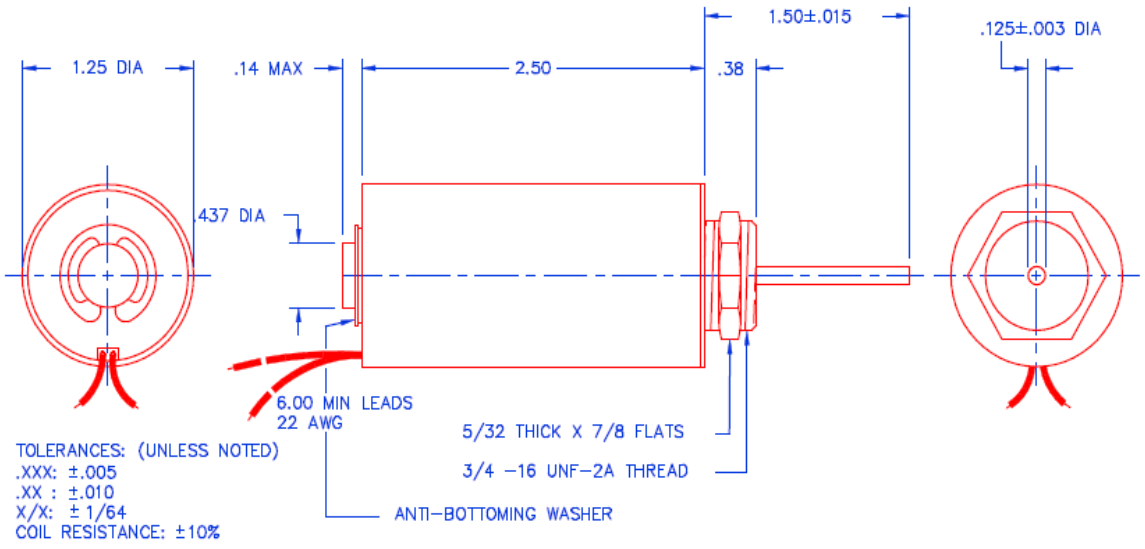
HEAT SINK: For proper heat dissipation, body of solenoid should be mounted on an equivalent of 6.0" x 6.0" x 1/8" aluminum plate in an unrestricted flow of air.

6901 Woodley Avenue, Van Nuys, California 91406
Telephone: (818) 785-6244 Fax: (818) 785-5713
www.solenoidcity.com

Fig. G.1 Solenoid Data Sheet (Pages 173 & 174)
S-25-125H Linear Solenoid, Push Type, Continuous.

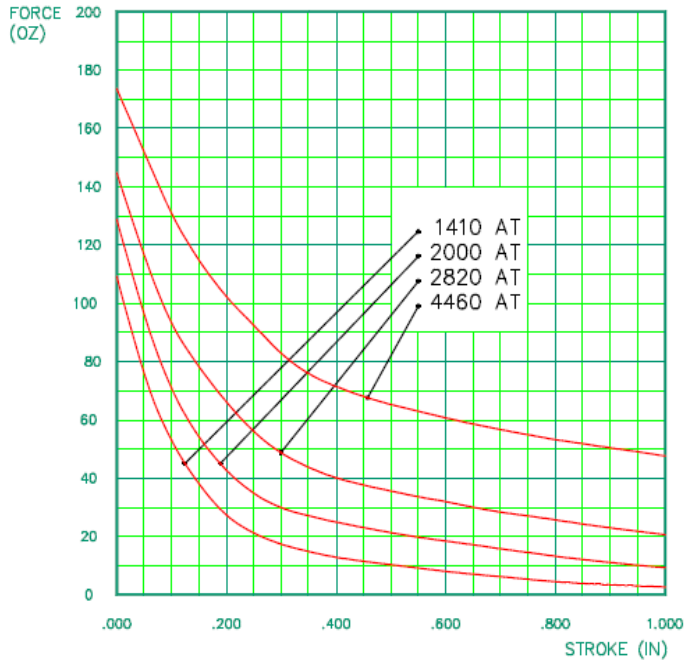
MAGNETIC SENSOR SYSTEMS

S-25-125-H MECHANICAL DIMENSIONS



SOLENOID SHOWN ENERGIZED

TYPICAL PUSH FORCE VERSUS STROKE



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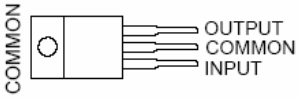
APPENDIX H

VOLTAGE REGULATOR DATA SHEET

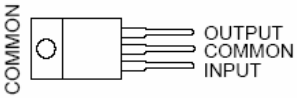
SLVS056J – MAY 1976 – REVISED MAY 2003

- 3-Terminal Regulators
- Output Current up to 1.5 A
- Internal Thermal-Overload Protection
- High Power-Dissipation Capability
- Internal Short-Circuit Current Limiting
- Output Transistor Safe-Area Compensation

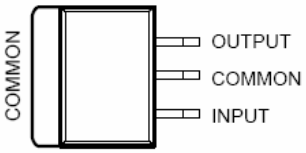
KC (TO-220) PACKAGE
(TOP VIEW)



KCS (TO-220) PACKAGE
(TOP VIEW)



KTE PACKAGE
(TOP VIEW)



description/ordering information

This series of fixed-voltage integrated-circuit voltage regulators is designed for a wide range of applications. These applications include on-card regulation for elimination of noise and distribution problems associated with single-point regulation. Each of these regulators can deliver up to 1.5 A of output current. The internal current-limiting and thermal-shutdown features of these regulators essentially make them immune to overload. In addition to use as fixed-voltage regulators, these devices can be used with external components to obtain adjustable output voltages and currents, and also can be used as the power-pass element in precision regulators.

ORDERING INFORMATION

T_J	$V_{O(NOM)}$ (V)	PACKAGE†		ORDERABLE PART NUMBER	TOP-SIDE MARKING
0°C to 125°C	5	POWER-FLEX (KTE)	Reel of 2000	μA7805CKTER	μA7805C
		TO-220 (KC)	Tube of 50	μA7805CKC	μA7805C
		TO-220, short shoulder (KCS)	Tube of 20	μA7805CKCS	
	8	POWER-FLEX (KTE)	Reel of 2000	μA7808CKTER	μA7808C
		TO-220 (KC)	Tube of 50	μA7808CKC	μA7808C
		TO-220, short shoulder (KCS)	Tube of 20	μA7808CKCS	
	10	POWER-FLEX (KTE)	Reel of 2000	μA7810CKTER	μA7810C
		TO-220 (KC)	Tube of 50	μA7810CKC	μA7810C
	12	POWER-FLEX (KTE)	Reel of 2000	μA7812CKTER	μA7812C
		TO-220 (KC)	Tube of 50	μA7812CKC	μA7812C
		TO-220, short shoulder (KCS)	Tube of 20	μA7812CKCS	
	15	POWER-FLEX (KTE)	Reel of 2000	μA7815CKTER	μA7815C
		TO-220 (KC)	Tube of 50	μA7815CKC	μA7815C
		TO-220, short shoulder (KCS)	Tube of 20	μA7815CKCS	
	24	POWER-FLEX (KTE)	Reel of 2000	μA7824CKTER	μA7824C
		TO-220 (KC)	Tube of 50	μA7824CKC	μA7824C

† Package drawings, standard packing quantities, thermal data, symbolization, and PCB design guidelines are available at www.ti.com/sc/package.

Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.

PRODUCTION DATA information is current as of publication date. Products conform to specifications per the terms of Texas Instruments standard warranty. Production processing does not necessarily include testing of all parameters.

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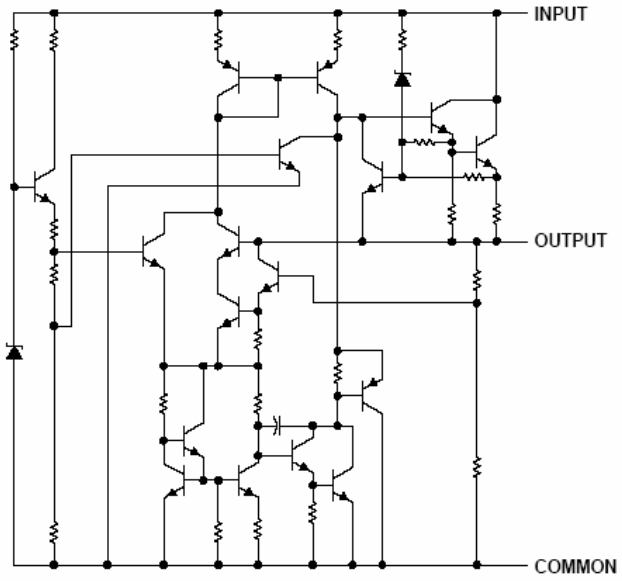
Fig. H.1 Voltage Regulator Data Sheet (Pages 176 & 177)

schematic



absolute maximum ratings over virtual junction temperature range (unless otherwise noted)†

Input voltage, V_I: μA7824C . . . . . 40 V
All others . . . . . 35 V
Operating virtual junction temperature, T_J . . . . . 150°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds . . . . . 260°C
Storage temperature range, T_{stg} . . . . . –65°C to 150°C

† Stresses beyond those listed under "absolute maximum ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under "recommended operating conditions" is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

package thermal data (see Note 1)

PACKAGE	BOARD	θ_{JC}	θ_{JA}
POWER-FLEX (KTE)	High K, JESD 51-5	3°C/W	23°C/W
TO-220 (KC/KCS)	High K, JESD 51-5	3°C/W	19°C/W

NOTE 1: Maximum power dissipation is a function of $T_J(max)$, θ_{JA}, and T_A. The maximum allowable power dissipation at any allowable ambient temperature is $P_D = (T_J(max) – T_A)/\theta_{JA}$. Operating at the absolute maximum T_J of 150°C can affect reliability.

APPENDIX I

RELAY DATA SHEET

D2n Relay V23105 AXICOM

2 pole telecom relay, non-polarized,
Through Hole Type (THT)

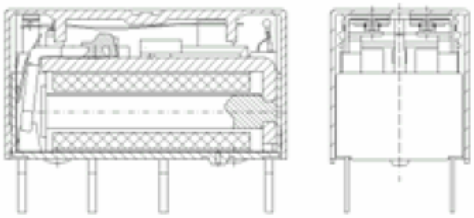
Relay types: non-latching with 1 coil

Features

- Standard DIL relay
- Dimensions 20.3 x 10.1 x 10.43 mm, 0.800 x 0.400 x 0.450 inch
- Switching and continous current 3 A
- 2 changeover contacts (2 form C / DPDT)
- Single contacts
- Immersion cleanable
- Four different coil sensitivities
  (150, 200, 400, > 500 mW)
- Surge voltage resistance meets FCC Part 68 requirement:
  1.5 kV (10 / 160 µsec) between coil and contacts

Typical applications

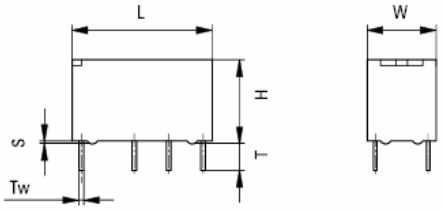
- Communications equipment
- Office equipment
- Measurement and control equipment
- Entertainment electronics
- Medical Equipment
- Consumer electronics



c UL us UL 508 File No. E 111441

Fig. I.1 Relay Data Sheet (Pages 179-182)

THT Version

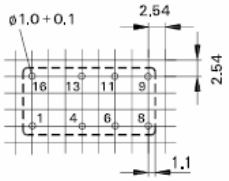


Dimensions

	THT V23105-A5xxx-A201	
	mm	inch
L	20.2 ± 0.1	0.795 ± 0.004
W	10.0 ± 0.1	0.394 ± 0.004
H	11.43 ± 0.2	0.450 - 0.008
T	3.5 ± 0.3	0.138 ± 0.012
Tw	0.72 - 0.2	0.028 - 0.008
S	0.3 ± 0.1	0.012 ± 0.004

Mounting hole layout

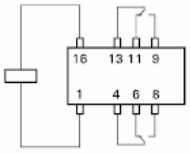
View onto the component side of the PCB
(top view)



Basic grid 2.54 mm

Terminal assignment

Relay - top view



Coil Data (values at 23°C)

Nominal voltage *U*nom	Operate/set voltage range Minimum voltage U_I	Operate/set voltage range Maximum voltage U_{II}	Release/ reset voltage Minimum	Nominal power consumption	Resistance	Coil number
Vdc	Vdc	Vdc	Vdc	mW	Ω / ± 10 %	
150 mW nominal power consumption						
5	4.0	13.0	0.25	150	167	001
6	4.8	15.6	0.30	150	240	002
9	7.2	23.4	0.45	150	540	006
12	9.6	31.2	0.60	150	960	003
24	19.2	59.5	1.20	165	3480	005
200 mW nominal power consumption						
3	2.1	6.7	0.15	200	45	308
5	3.5	11.2	0.25	200	125	301
6	4.2	13.5	0.30	200	180	302
9	6.3	20.3	0.45	200	405	306
12	8.4	27.0	0.60	200	720	303
24	16.8	54.1	1.20	200	2880	305
48	33.6	108.3	2.40	200	11520	307
400 mW nominal power consumption						
5	3.5	7.9	0.25	400	62	401
6	4.2	9.5	0.30	400	90	402
9	6.3	14.3	0.45	400	203	406
12	8.4	19.1	0.60	400	360	403
24	16.8	38.3	1.20	400	1440	405
48	33.6	76.6	2.40	400	5760	407
> 500 mW nominal power consumption						
5	3.5	6.3	0.25	695	36	501
6	4.2	8.9	0.30	515	70	502
9	6.3	12.5	0.45	580	140	506
12	8.4	17.8	0.60	515	280	503
24	16.8	34.4	1.20	550	1050	505
48	33.6	67.3	2.40	575	4000	507

U_I = Minimum voltage at 23° C after pre-energizing with nominal voltage without contact current

U_{II} = Maximum continous voltage at 23°

The operating voltage limits U_I and U_{II} depend on the temperature according to the formula:

$U_{I\,tamb}$ = $K_I \cdot U_{I\,23°C}$ and

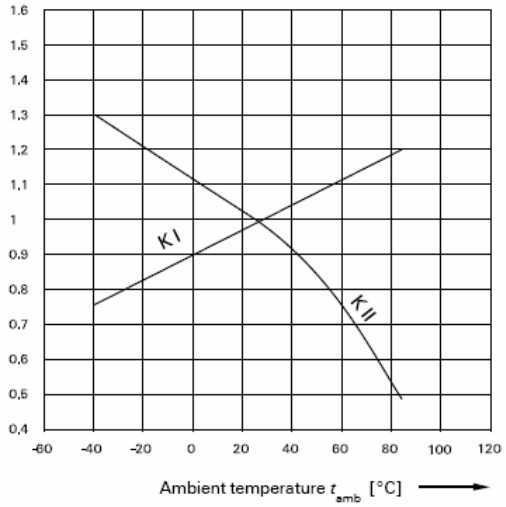
$U_{II\,tamb}$ = $K_{II} \cdot U_{II\,23°C}$

t_{amb} = Ambient temperature

$U_{I\,tamb}$ = Minimum voltage at ambient temperature, t_{amb}

$U_{II\,tamb}$ = Maximum voltage at ambient temperature, t_{amb}

k_I, k_{II} = Factors (dependent on temperature), see diagram



Coil versions, BT 47 type / specification T4563 C (current tested)

Nominal voltage Vdc	Operating current mA	Nominal power consumption mW	Resistance Ω / ± 10 %	British Telecom Code	Coil number
5	80	695	36	47 W / 5	475
10	32.5	500	200	47 W / 9	479
12	27	515	280	47 W / 6	476
24	14	550	1050	47 W / 7	477
48	7	575	4000	47 W / 8	478

Contact Data

Number of contacts and type	2 changeover contacts
Contact assembly	single contacts
Contact material	Silver-nickel, gold-covered
Limiting continuous current at max. ambient temperature	3 A
Maximum switching current	3 A
Maximum swichting voltage	220 Vdc 250 Vac
Maximum switching capacity	60 W, 125 VA
Thermoelectric potential	> 10 μV
Minimum switching voltage	100 μV
Initial contact resistance / measuring condition: 10 mA / 20 mV	< 100 mΩ
Electrical endurance at 230 Vac / 0.5 A	typ. 3.0 x 10^5 operations
at 6 Vdc / 0.1 A	typ. 2.0 x 10^6 operations
at 30 Vdc / 1 A	typ. 5.0 x 10^5 operations
at 30 Vdc / 2 A	typ. 1.0 x 10^5 operations
Mechanical endurance	typ. 15.0 x 10^6 operations
UL contact ratings	30 Vdc / 1.0 A 100 Vdc / 0.3 A 125 Vac / 0.5 A for 150 mW and 200 mW coil 125 Vac / 1.0 A for 400 mW and 500 mW coil

APPENDIX J

SHAFT COLLAR DATA SHEET

Shaft Collars

McMASTER-CARR®

Part Number 6435K52

Type	One-Piece Clamp-On Shaft Collars
System of Measurement	Inch
Bore Size	5/16"
Outside Diameter	11/16"
Width	5/16"
Material	Black-Oxide Finish Alloy Steel
Alloy	Grade 12L14
Outside Diameter Tolerance	-.015" to +.015"
Width Tolerance	-.005" to +.005"
Bore Tolerance	-.001" to +.005"
Screw Size	4-40
Set/Cap Screw Material	Alloy Steel

Part Number 6435K12

Type	One-Piece Clamp-On Shaft Collars
System of Measurement	Inch
Bore Size	1/4"
Outside Diameter	11/16"
Width	5/16"
Material	Black-Oxide Finish Alloy Steel
Alloy	Grade 12L14
Outside Diameter Tolerance	-.015" to +.015"
Width Tolerance	-.005" to +.005"
Bore Tolerance	-.001" to +.005"
Screw Size	4-40
Set/Cap Screw Material	Alloy Steel

Black-Oxide Finish Alloy Steel and Plain Steel	Black finish, heat treated for strength and corrosion resistance.

Catalog Page: 1032

Fig. J.1 Shaft Collar Data Sheet

APPENDIX K

SOFTWARE CODE

(Written in VC++)

```
// This program takes the input information from a user and controls the solenoids
// accordingly.

#include <time.h>
#include <iostream.h>
#include <fstream.h>
#include <string.h>
#include "nidaqex.h"
#include "nidaq.h"

// Declaring all the Variables Used in the Program
i16 iStatus = 0;
i16 iRetVal = 0;
i16 iDevice = 1;
i16 iPort = 0;
i16 iLine = 6;
i16 iDir = 0;
i16 iState = 0;

i16 iStatus2 = 0;
i16 iRetVal2 = 0;
i16 iDevice2 = 2;
i16 iPort2 = 1;
i16 iDir2 = 0;
i16 iState2 = 0;

i16 iIgnoreWarning = 0;
int choise,delay=1;
int a[5],c[5],read,or,flag=0;
i16 i=0;

// Storing the Sequence 1 in Arrays b[] (Type of Silverware), and
// d[](Orientation)

int b[]={1,2,3,4,1,3,2,4,4,3,2,1,1,4,2,3,1,4,3,2,0,5,0,5,0},k;
int d[]={0,1,0,1,0,0,1,1,0,1,0,1,0,1,1,0,0,1,0,0,0,0,0,0,0};

void main(void)
{
  k=0;
  // Initializing arrays A[] & C[]
  for(i=0;i<4;i++)
  {
        a[i]=0;
        c[i]=0;
```

```
}
read=0;
while(1)
{
 // Configuring Digital I/O Ports of PCI 6035 E and reading Input
 // Signal from Optical Sensor

 iStatus = DIG_Line_Config(iDevice, iPort, iLine, iDir);
 iRetVal = NIDAQErrorHandler(iStatus,
                        "DIG_Line_Config",iIgnoreWarning);
 iStatus = DIG_In_Line(iDevice, iPort, iLine, &iState);
 iRetVal = NIDAQErrorHandler(iStatus, "DIG_In_Line",iIgnoreWarning);

 if((iState==0) && (flag==1))
 {
   printf(" The digital state on port %d line %d is %d\n", iPort,
         iLine, iState);

        // Configuring Digital Input Pins of PCI 6035 E and Sending the
        // Required signal as Output to DAQ PCI 6035 E
        iStatus = DIG_Line_Config(iDevice, iPort, 0, iDir);
        iStatus = DIG_Line_Config(iDevice, iPort, 1, iDir);
        iStatus = DIG_Line_Config(iDevice, iPort, 2, iDir);
        iStatus = DIG_Line_Config(iDevice, iPort, 3, iDir);
        iStatus = DIG_Line_Config(iDevice, iPort, 4, iDir);
        iStatus= DIG_Out_Prt(iDevice, iPort, a[0]);

        // Delay of 0.25 Seconds

   iRetVal2= NIDAQDelay(0.25);

         // Configuring Digital Input Pins of PCI 6503 and Sending the
        // Required signal as Output to DAQ PCI 6503

        iStatus2 = DIG_Prt_Config (iDevice2, iPort2, 0, iDir2);
   iStatus2= DIG_Out_Prt(iDevice, iPort, c[0]);

   printf("the choice %d -- %d: ",a[0],c[0]);

        read=b[k];
        or=d[k];
        k=k+1;

       // Calculations… Depending upon Silverware Type and Orientation
   if(or==1)
        {
```

```
                if(read==1)
                        c[2]=c[2]+1;
                if(read==2)
                        c[2]=c[2]+2;
                if(read==3)
                        c[1]=c[1]+4;
                if(read==4)
                        c[1]=c[1]+8;
        }

        if(or==2)
        {
                if(read==1)
                        c[2]=c[2]+0;
                if(read==2)
                        c[2]=c[2]+0;
                if(read==3)
                        c[1]=c[1]+0;
                if(read==4)
                        c[1]=c[1]+0;
        }

    if(read==1)
                a[2]=a[2]+1;
    if(read==2)
                a[2]=a[2]+2;
        if(read==3)
                a[1]=a[1]+4;
        if(read==4)
                a[1]=a[1]+8;
        for(i=0;i<4;i++)
        {
                a[i]=a[i+1];
                c[i]=c[i+1];
        }
        if(read==5)
                a[0]=a[0]+16;

        a[3]=0;
        c[3]=0;
        flag=2;
        }
        if(iState==1)
                flag=1;
  }
}
```

```
// This program gives the input information to Sorting and Orienting system
//Implementing Vision Based Identification and Inspection to actuate the Sorting
//and Orienting solenoids.

#include <stdio.h>
#include <conio.h>
#include <string.h>
#include <stdlib.h>
#include <process.h>
#include <time.h>
#include "nidaqex.h"
#include "nidaq.h"
#include "nitypes.h"
#include "ImgAn.h"

// Declaring all the Variables Used in the Program
i16 iStatus = 0;
i16 iStatus2 = 0;
i16 iRetVal = 0;
i16 iDevice = 1;
i16 iPort = 0;
i16 iLine = 6;
i16 iDir = 0;
i16 iState = 0;
i16 iIgnoreWarning = 0;
int choise,delay=1;

// Initializing arrays A[] & C[]
int a[]={0,0,0,0,0,0},flag=0;
i16 i=0,j=0;;
int b[]={0,0,0,0,0};
int c[]={1,2,3,4,1,3,2,4,4,3,2,1,1,4,2,3,0,5,0,5,0},k=0;

CMyImage * img1;
INTERFACE_ID int_id;
SESSION_ID ssn_id;
long sig_count=0;
long im_count;
char names[][20] = {"Unknown","Knife","Fork","Spoon","Soup Spoon"};
char direc[][10]={"NA","LEFT","RIGHT"};
Image * im;
Rect acqRect;

void errChk(IMG_ERR err);
void my_sleep( clock_t wait );
```

```
uInt32 service_routine(SESSION_ID sid, IMG_ERR err, uInt32 signal, void*
userdata);
void closing_routines();
void vam_main(int read, int or);

char path[1000];
FILE * mf;

void main()
{

FILE * fp;
char p_pt[1000];
acqRect.left=0;
acqRect.top=0;
acqRect.width=1024;
acqRect.height=500;
im_count=0;
im=imaqCreateImage(IMAQ_IMAGE_U8,5);
errChk(imgInterfaceOpen("img0",&int_id));
errChk(imgSessionOpen(int_id,&ssn_id));
printf("\nInterface & Session successfully opened !!");
errChk(imgSessionWaitSignalAsync(ssn_id,IMG_EXT_TRIG2,IMG_TRIG_PO
LAR_ACTIVEH, service_routine,NULL));

printf("\nTrigger configured !!\n\n");
mf = fopen("c:\\temp_im\\res.txt","w");
img1 = new CMyImage();
fp = fopen("proto.txt","r");
if (fp==NULL)
        {
        printf("\n\nError opening prototype files !!");
        closing_routines();
        getch();
        exit(0);
        }

fgets(p_pt,999,fp);
img1->Load_Proto(p_pt);
fclose(fp);
printf("\n Feed pieces ... \n\n");
char ch=1;

while(ch!=27)
        {
        if (kbhit()) ch=getch();
```

```
        }

closing_routines();
getch();
}

void closing_routines()
{
imaqDispose(im);
imgClose(int_id,TRUE);
delete img1;
fclose(mf);
}

uInt32 service_routine(SESSION_ID sid, IMG_ERR err, uInt32 signal, void*
userdata)
{
unsigned char * buff=NULL;
int res;

// Configuring Digital I/O Ports of PCI 6035 E
// Signal the output to DAQ PCI 6035 E (Lifting system)
iStatus = DIG_Prt_Config (1, 0, 0, 1);
iStatus= DIG_Out_Prt(1, 0, a[0]);

my_sleep((clock_t)(0.300 * (double)CLOCKS_PER_SEC));

// Configuring Digital I/O Ports of PCI 6503
// Code to signal the output to DAQ PCI 6503 (Orienting system)
iStatus2 = DIG_Prt_Config (2, 1, 0, 1);
iStatus2= DIG_Out_Prt(2, 1, b[0]);

sig_count++;

// actual image acquired .....
imaqSnap(sid,im,acqRect);

// copied to object ...
imaqDuplicate(img1->main_image,im);
res = img1->Process_Image();

// Sending the values to the Sorting and Orienting Program
vam_main(res,img1->ort);

fprintf(mf,"\nIMG%d  : %s : (%s) : %d",im_count,names[res],direc[img1-
>ort],res);
```

```
// store image ....
sprintf(path,"c:\\temp_im\\Image_%03d.bmp",im_count);
imaqWriteBMPFile(im,path,FALSE,NULL);
im_count++;
return(1);        // re-instate call back ...
}

void my_sleep( clock_t wait )
{
clock_t goal;
goal = wait + clock();
while( goal > clock() );
}

void errChk(IMG_ERR err)
{
if (err<0)
        {
        char err_msg[1000];
        imgShowError(err,err_msg);
        printf("\n\nERROR : %s",err_msg);
        getch();
        imgClose(int_id,TRUE);
        exit(0);
        }
}

//Sorting and Orienting Program Function
void vam_main(int read, int or)
{

        // Calculations… Depending upon Silverware Type and Orientation

        if(or==1)
                {
                        if(read==1)
                                b[2]=b[2]+1;
                        if(read==2)
                                b[2]=b[2]+2;
                        if(read==3)
                                b[1]=b[1]+4;
                        if(read==4)
                                b[1]=b[1]+8;
                }
```

```
        if(or==2)
                {
                        if(read==1)
                                b[2]=b[2]+0;
                        if(read==2)
                                b[2]=b[2]+0;
                        if(read==3)
                                b[1]=b[1]+0;
                        if(read==4)
                                b[1]=b[1]+0;
                }

        for(j=0;j<4;j++)
        b[j]=b[j+1];
        b[3]=0;

        k=k+1;
        if(read==1)
                a[2]=a[2]+1;
        if(read==2)
                a[2]=a[2]+2;
        if(read==3)
                a[1]=a[1]+4;
        if(read==4)
                a[1]=a[1]+8;
        for(i=0;i<4;i++)
                a[i]=a[i+1];
        if(read==5)
                a[0]=a[0]+16;
        a[3]=0;
        flag=2;
        if(a[0]== 2 || a[0] == 6 || a[0] == 10 || a[0] == 18)
        {
                iStatus = DIG_Line_Config(1,0, 1,1);
                iStatus= DIG_Out_Line(1, 0, 1, 1);
        }
        else
        {
                 iStatus = DIG_Line_Config(1,0, 1,1);
                iStatus= DIG_Out_Line(1, 0, 1, 0);
        }
}
```

APPENDIX L

DATA FILE

Sequence 1		Sequence 2	
Type	**Orientation**	**Type**	**Orientation**
Knife	Left	Fork	Left
Fork	Right	Soupspoon	Left
Spoon	Left	Knife	Left
Soupspoon	Right	Spoon	Right
Knife	Left	Fork	Right
Spoon	Left	Knife	Right
Fork	Right	Spoon	Left
Soupspoon	Right	Soupspoon	Right
Soupspoon	Left	Spoon	Left
Spoon	Right	Knife	Right
Fork	Left	Fork	Left
Knife	Right	Soupspoon	Right
Knife	Left	Fork	Right
Soupspoon	Right	Soupspoon	Left
Fork	Right	Spoon	Left
Spoon	Left	Knife	Right
Knife	Left	Soupspoon	Left
Soupspoon	Right	Knife	Left
Spoon	Left	Spoon	Left
Fork	Left	Fork	Left
Unclean		Unclean	
Unidentified		Unclean	
Unclean		Unidentified	
Unidentified		Unidentified	
Unclean		Unclean	

Table L.1 Sequence 1, and Sequence 2

VITA

Ravi Vamshidhar Peddi

Candidate for the Degree of

Master of Science

Thesis: SILVERWARE SORTING AND ORIENTING SYSTEM

Major Field: Mechanical Engineering

Biographical:

Personal Data: Born in Karimnagar, Andhra Pradesh, India, on July 22nd 1981, the son of Ravi Kumar P.N. and Sujatha P.R.

Education: Received Bachelor of Technology Degree in Mechanical Engineering from Jawaharlal Nehru Technological University in April 2004. Completed the requirements for the Master of Science Degree at Oklahoma State University in May 2005.

Experience: Graduate Research Assistant, Department of Mechanical and Aerospace Engineering, Oklahoma State University from January 2004 to December 2004. Graduate Research Assistant, Department of Nutritional Science Department, Oklahoma State University, from August 2003 to May 2004. Project Head, Jagadhambha Industries Private Limited, from November 2001 to April 2002.

Name: Ravi Vamshidhar. Peddi Date of Degree: May, 2005

Institution: Oklahoma State University Location: Stillwater, Oklahoma

Title of Study: SILVERWARE SORTING AND ORIENTING SYSTEM

Pages in Study: 195 Candidate for the Degree of Master of Science

Major field of Study: Mechanical Engineering

Scope and Method of Study: This study investigates the sorting and orientation of silverware in commercial dishwashing applications. The purpose of this research was to investigate means to effectively sort and orient mixed silverware, piece by piece. The challenge was to efficiently lift silverware pieces off a magnetic conveyor, accurately sort them, and orient them into their respective collection bins. It was desired to have high accuracy, repeatability and reliability while operating at speeds to process at least 30 pieces per minute of mixed clean and unclean knives, spoons, forks and soupspoons. The method of study was primarily experimental.

Findings and Conclusions: An efficient, accurate and reliable mechanism for sorting and orienting silverware has been designed, developed and tested. Lifting mechanisms powered by solenoids has been successfully incorporated to lift silverware off magnetic conveying blocks. An orienting mechanism powered by solenoids has also been incorporated to place differently oriented silverware in different collection bins. Suitable DAQ boards were used in the system to interface with the computer. Software was developed for a PC to interface with an existing machine vision identification and inspection system, and send and receive controlling signals to the various components, employing a specially constructed power supply. Experimental results demonstrate that the accuracy of sorting of the Silverware Sorting and Orienting Machine in a stand-alone mode was 98.20%; accuracy in orienting the silverware was 100% at processing rates up to 55 pieces/min. In co-ordination with the vision-based identification and inspection system at a processing rate of 45 pieces/min, the accuracy of sorting was 98.00%; accuracy in orienting the silverware was 100%.

ADVISER'S APPROVAL: Dr. Lawrence L. Hoberock