June 15, 1965 H. D. MAYS ETAL 3,189,177

SORTER

Original Filed Dec. 21, 1959 7 Sheets-Sheet 1

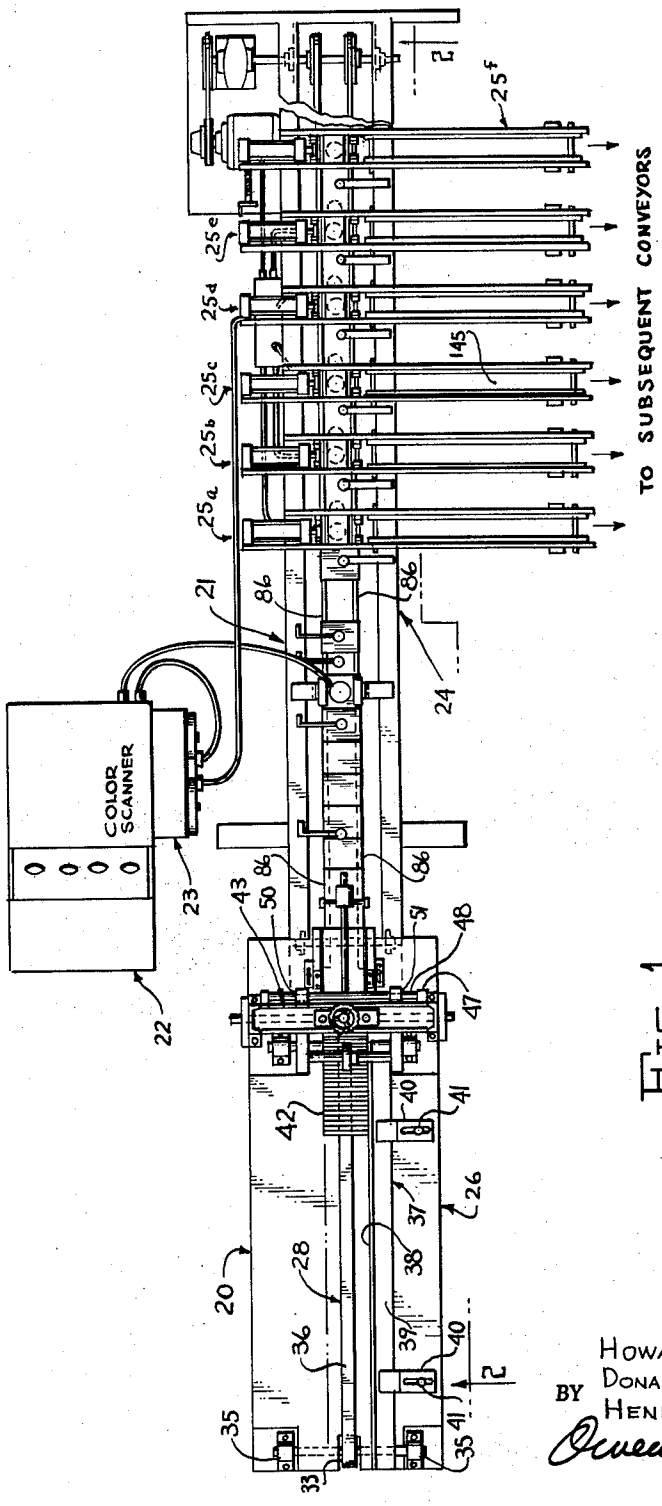


FIG. 1.

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SORTER

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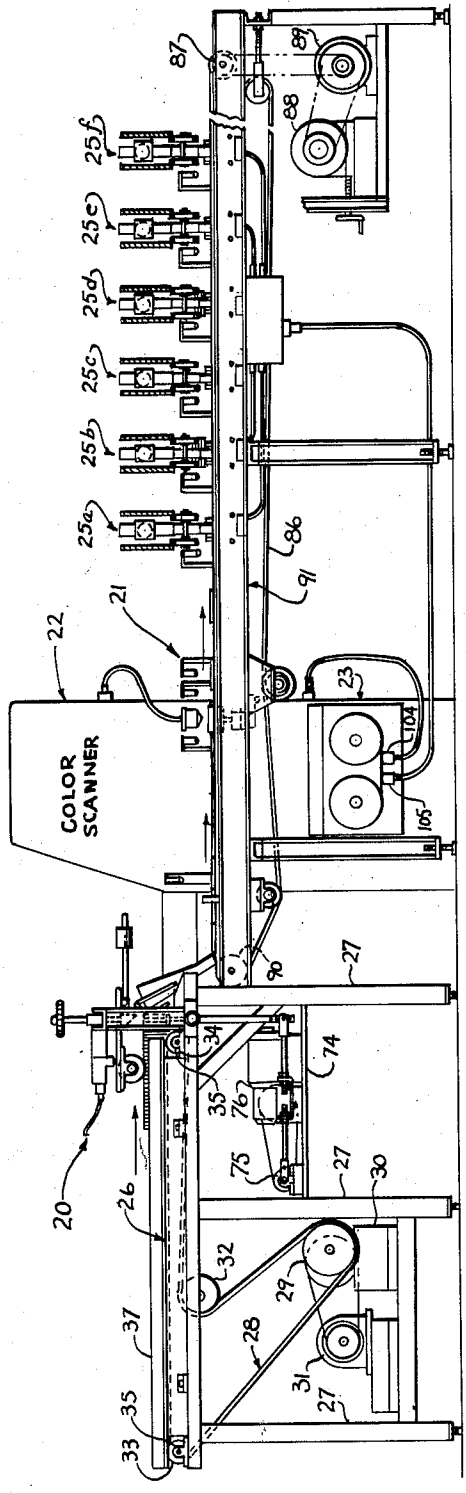


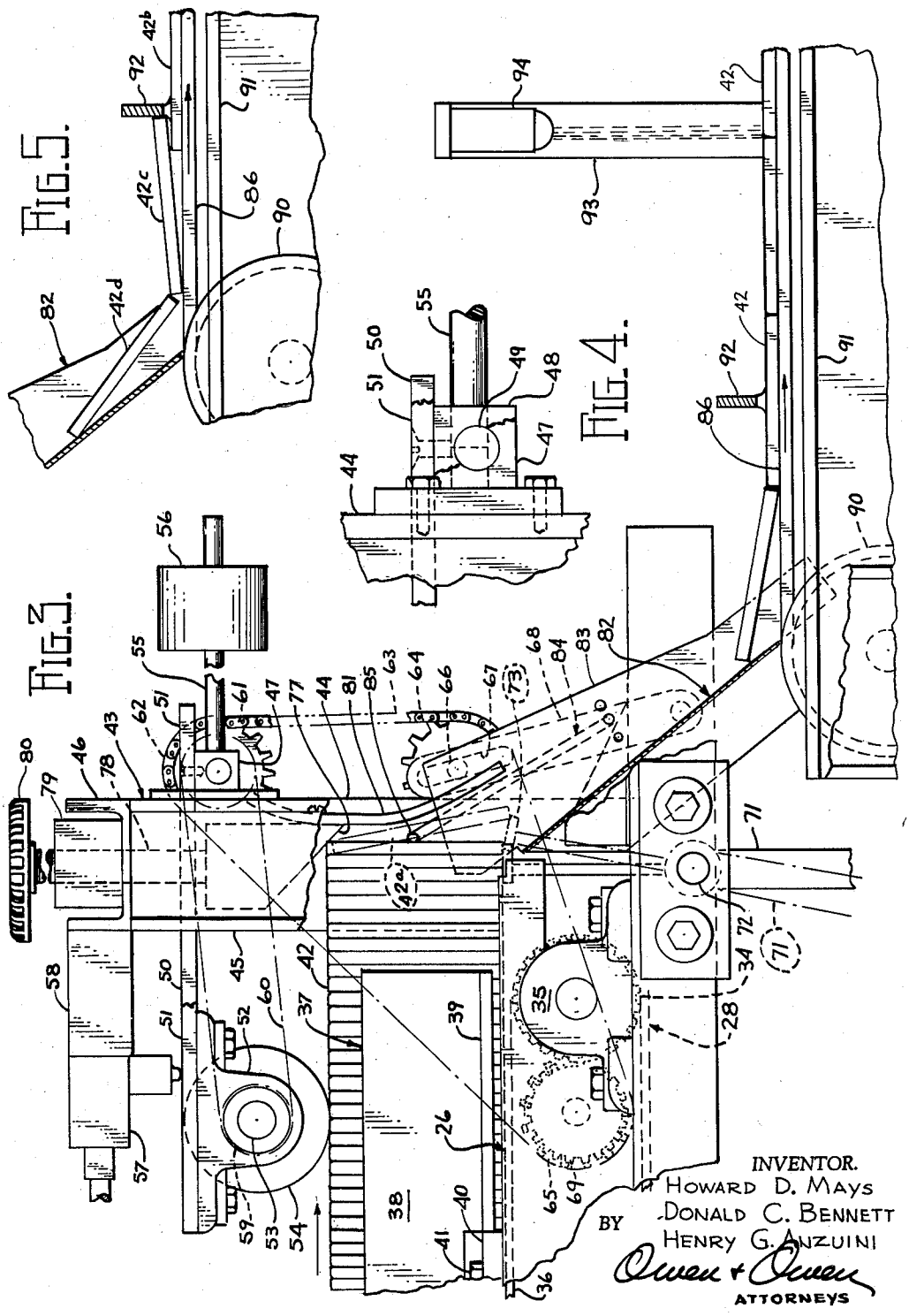
FIG. 2.

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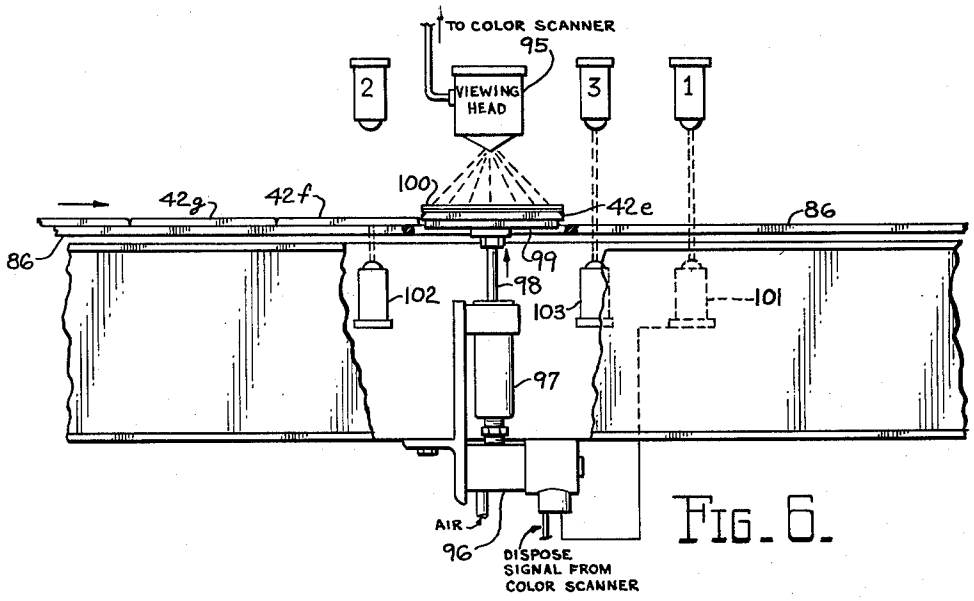


FIG. 6.

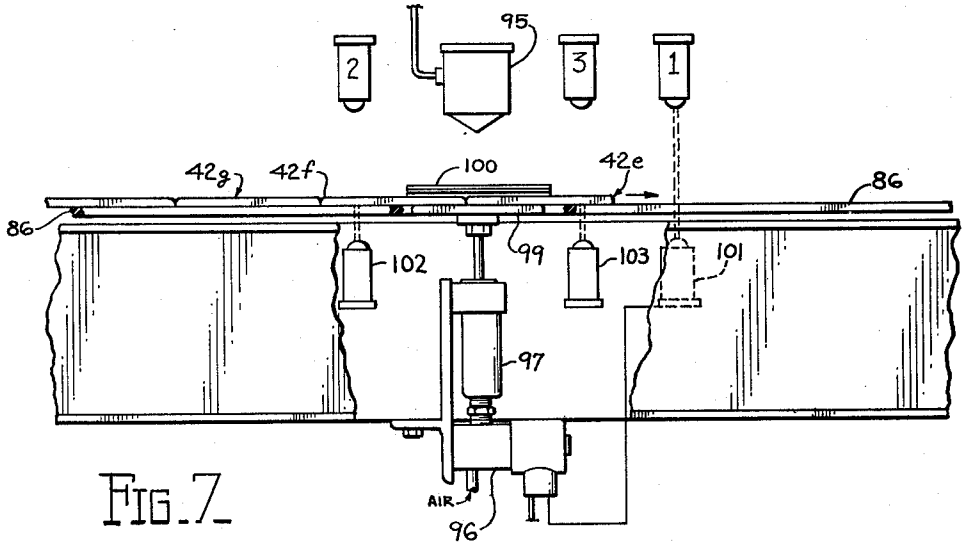


FIG. 7.

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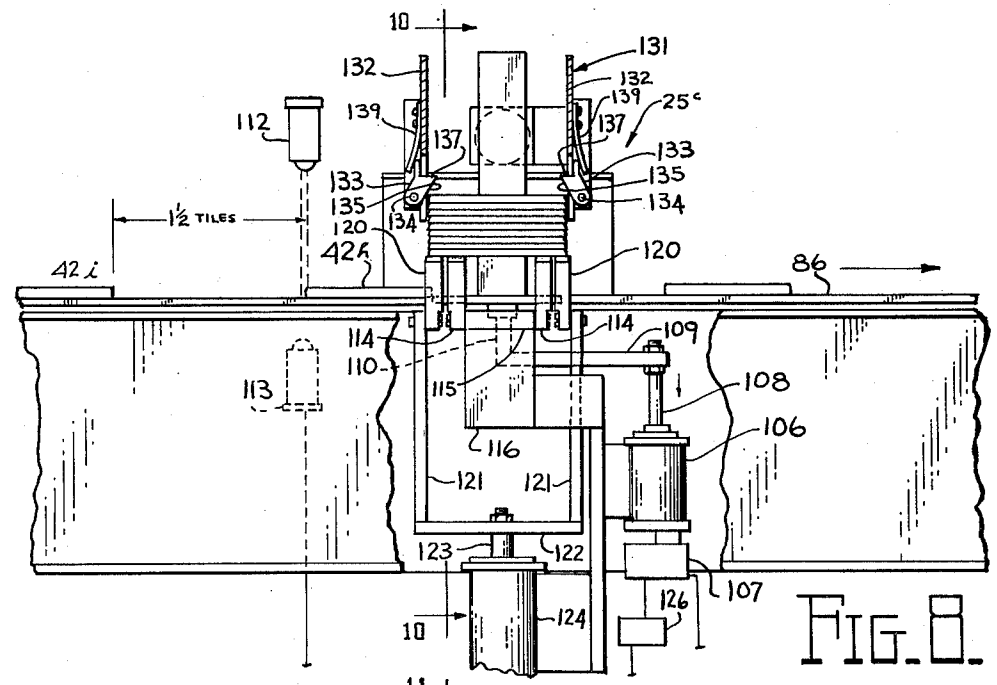


FIG. 8.

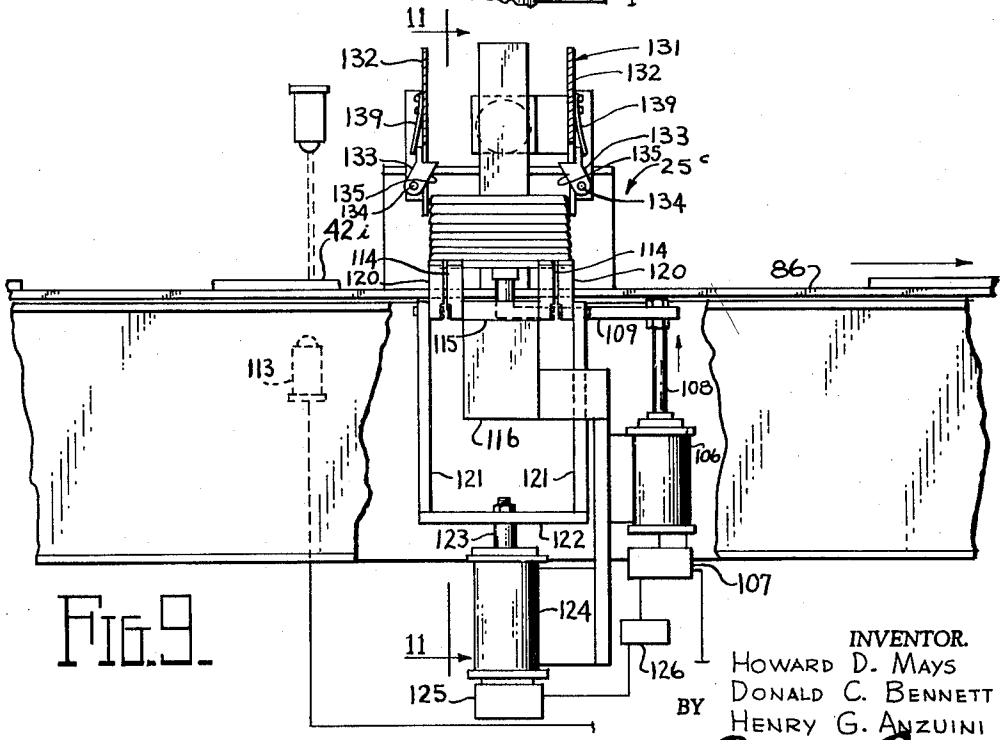


FIG. 9.

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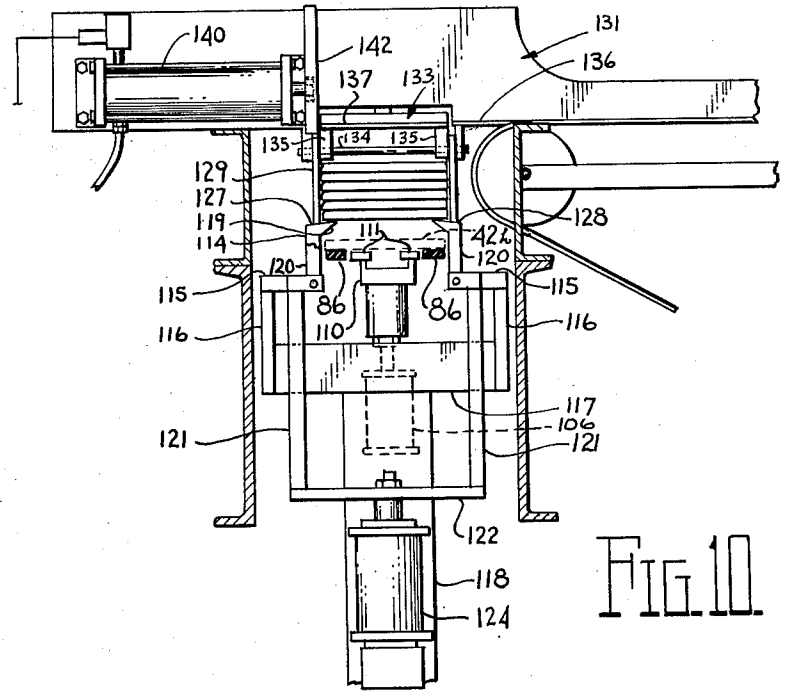


FIG. 10

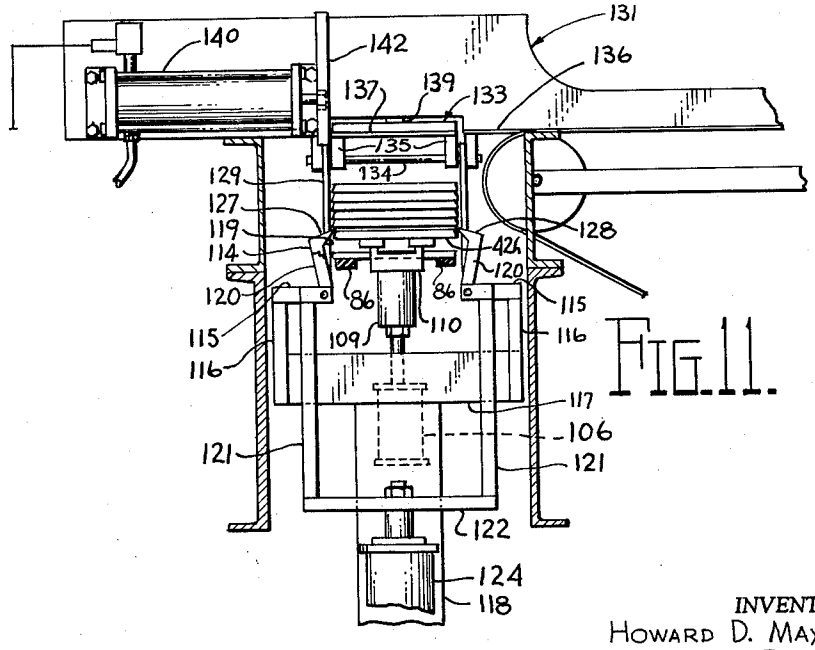


FIG. 11

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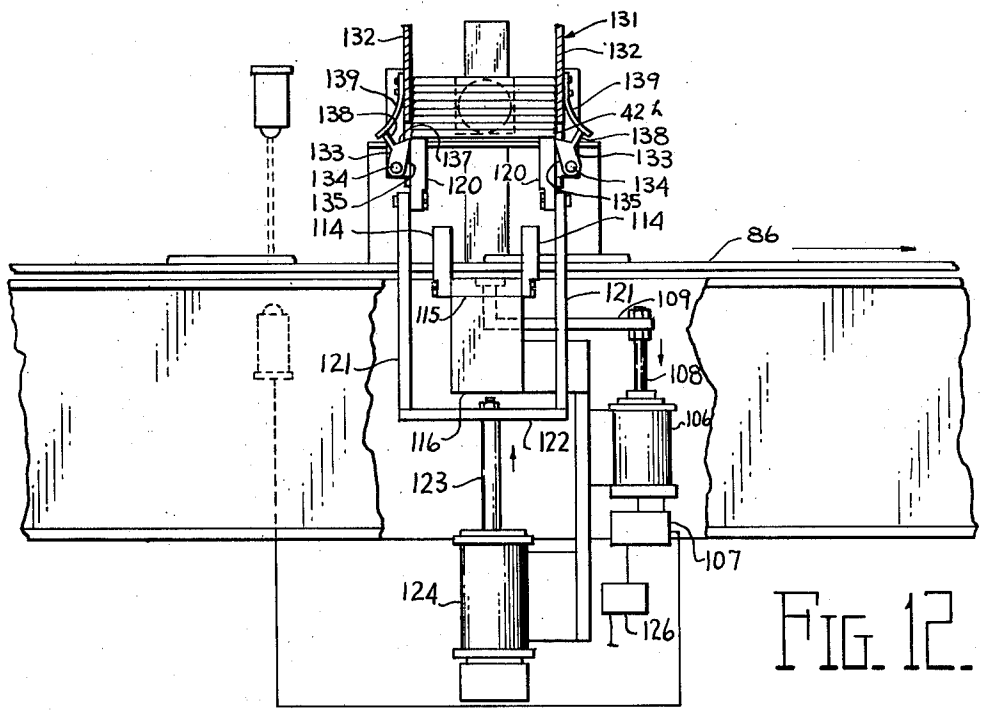


FIG. 12.

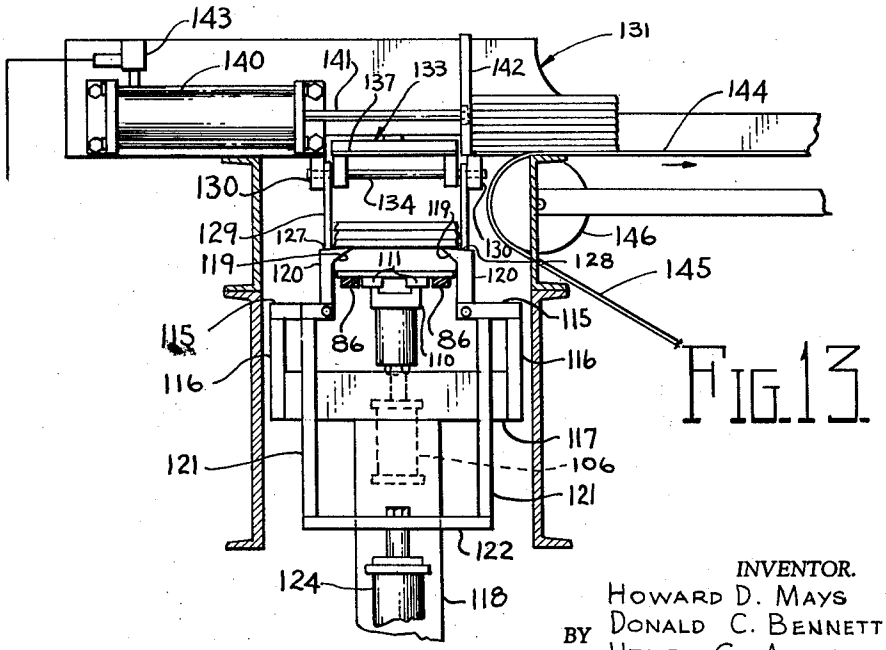


FIG. 13.

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United States Patent Office 3,189,177 Patented June 15, 1965

3,189,177

SORTER

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Continuation of application Ser. No. 860,879, Dec. 21, 1959. This application July 5, 1963, Ser. No. 294,215

4 Claims. (Cl. 209—74)

This application is a continuation of our application Serial No. 860,879, filed December 21, 1959, now abandoned.

This invention relates to sorters of the type in which a plurality of items having the same general description but differing from each other in detail are sequentially presented to a detail analyzer and are then sequentially moved away from the detail analyzer and sorted into groups according to the detail analyzed, sorting being accomplished by the coincidence of the arrival at a proper sorting station of each item and a signal resulting from the analysis of its detail.

For purposes of illustration in this application, the concepts underlying the instant invention will be presented with respect to a sorter specifically designed for the purpose of sorting ceramic tiles by color variations. It will be appreciated, of course, that this is but one of many embodiments of the underlying invention, which is not limited to use for sorting ceramic tiles nor to use for sorting like items on the basis of color variations.

Many sorting mechanisms operating in the general manner outlined in the introductory paragraph of this specification have been designed and employed in the past. They include, for example, punched card sorting machines where the detail analyzer consists of a mechanism for reading the holes in one or more columns of the card and for setting up signals which direct each respective card to a compartment for accumulation with cards bearing like apertures in these columns. Other sorting mechanisms of the same general type include weight sorting mechanisms wherein each successive article is weighed as it moves over a scale and is diverted into a suitable compartment with like articles in the same weight classification.

The sorting of massive items having high inertia presents many problems not present when light-weight tabulating cards or other similar light-weight items are handled, particularly when it is desired to handle the massive items at high speed. In the commercial production of many products, of which ceramic tile is a good example, it is necessary to sort literally millions of individual items one from the other in short periods of time.

Many sorting mechanisms of the general type herein discussed would be completely unsuitable for sorting massive items no matter what their sizes or shapes. In most of these sorting means, the items to be sorted are fed serially along a pathway. Each item is deflected from the pathway by a deflecting gate which swings across the pathway. The gate may relate to a particular station and open just as the item reaches the station or it may deflect the item from the common pathway into a by-path leading to a particular station. In either case each of the deflecting gates is subjected to repeated, heavy impacts. (Such impacts are, of course, insignificant with light-weight items such as tabulating cards, even when traveling at extremely high speeds.)

A second serious problem in the sorting of massive items arises from the relatively slow acceleration of gravity. In order to sort items which are deflected downwardly, as in the case of punched card tabulating sorters, the items must be driven against a deflector with sufficient

speed to be deflected by their impetus or the acceleration of gravity must be relied upon to move the items downwardly. With massive items, the first method is precluded by damage to the equipment, as mentioned. Even where the initial downward movement is a result of deflection, with the consequent repeated battering of the deflecting means if the item is massive, the acceleration of gravity is too slow to take a massive item out of the way quickly enough so that a second similar item could be deflected into the same compartment or pathway without striking and damaging the preceding item.

Another serious disadvantage arises in the sorting of items wherein the acceleration of gravity is involved, because after each of them is deflected into its correct compartment, and even where its momentum may be slowed down by some sort of shock absorbing means, a fall of even a short distance under the force of gravity results in a massive item striking the next preceding item with a sharp impact.

If a sorter for massive items deflects all the items into various paths or compartments in a common plane, without involving falling motion, the same problems still exist with respect to the deflecting means and to the impact of one item upon another.

However, even if the problems of impact and damage to the items being sorted and to deflector means are in some measure overcome, the inertia of the massive item presents another problem of considerable difficulty. Most items to be sorted, whether massive or not, have unequal dimensions in the three planes; very few items are cubical or spherical. In order for the items to be removed from a comon path they must be accelerated away from the path and the selector means by which they are so accelerated must be decelerated, stopped, and returned back out of the common path so that a succeeding item can move beyond the point of selection of the preceding item if desired. Where the items are massive, the time required for acceleration and deceleration of the item and the selecting means is longer than for light weight items so the time or space between successive items in the common path must be greater for the massive items.

It will be appreciated that the term "massive" is used herein not in an absolute sense but to indicate items of such weight relative to their physical strength or size that they are likely to damage equipment or to be damaged upon sudden acceleration, sudden deceleration or impact, or violent changes of direction of movement. Heavy frangible items such as tile, bricks, pottery or china, soft items such as fruits or vegetables, and many other things, cannot stand up under such treatment.

In short, the real problem involved, when massive items are to be sorted at high speed, is the problem of inertia and the resulting problems of acceleration and deceleration, momentum and impact.

It is, therefore, the primary object of the instant invention to provide a sorting mechanism for the high speed sorting of like items differing in detail wherein the items are fed serially along a common path, studied by a detail analyzer, again fed along a common path leading to a multiplicity of item-receiving means and items having like detail are all delivered into the receiving means for the items having this detail without raising the problem of impact.

It is another object of the instant invention to provide a sorter for similar massive items having a plurality of item-receiving stations located along a common path wherein the delivery of each item from the common path to its respective item-receiving station does not involve either the problem of deflection where the items are driven against a deflector means or the problem of impact, wherein the items may damage the mechanism or each other.

It is another object of the instant invention to provide

a sorter for handling massive items wherein the items are selected out of a common pathway by being moved out of the common pathway in the direction of least dimension of the items, thereby reducing the distance which a selected item must be moved and through which the selecting means must return so as to speed up the operation and permit the items to be more closely spaced along the common pathway for any given speed of operation.

It is yet another object of the instant invention to provide a sorter for massive items wherein all of the items have the same physical dimensions but differ from each other in detail, as by minute gradations of color, in which the items are serially fed to a detail analyzer or color scanner and are serially fed away from the color scanner along a common path leading to a series of individual color-receiving means and each item or tile is diverted into its particular receiving means by being moved in the direction of its least dimension a distance sufficient so that it is removed from the common high speed feeding means and initially deposited but a small distance therefrom, in a short space of time.

It is still another object of the instant invention to provide receiving station mechanism for a sorter for massive items wherein the items are all fed along a common path leading to the receiving station mechanism, and the receiving station mechanism is actuated by a signal corresponding to each item to be received therein in such a manner that the item is lifted vertically off of the common feeding means but a short distance and retained at this position; successive items intended for the receiving mechanism being similarly lifted vertically beneath preceding items; and upon the accumulation of a desired number of these items, the group of items being delivered, en masse, to mechanisms for handling the group as a unit.

Other and more specific objects and advantages of the invention will be better understood from the following specification and from the drawings, in which—

FIG. 1 is a greatly simplified plan view of a sorter embodying the invention as designed for the purpose of sorting ceramic tile on the basis of gradations in color;

FIG. 2 is a partially sectional view in elevation, taken along the line **2—2** of FIG. 1;

FIG. 3 is a fragmentary, greatly enlarged view of a storage magazine for the ceramic tile to be sorted and including mechanism for individually releasing tiles from the storage mechanism onto a common feeding means for carrying the tiles through a detail analyzer, in this embodiment of the invention a color scanner;

FIG. 4 is a fragmentary detailed view showing a portion of the mechanism illustrated in FIG. 3;

FIG. 5 is a fragmentary detailed view of a portion of the mechanism shown in FIG. 3 and illustrating means for preventing stacking of the tile being sorted at this point;

FIG. 6 is a fragmentary, diagrammatic view partly in elevation, of the detail analyzer portion of a sorter embodying the invention in one stage of a detail analyzing operation;

FIG. 7 is a view similar to FIG. 6, but at an intermediate stage;

FIG. 8 is a fragmentary view in elevation, with parts broken away and with parts in section, of an item-receiving station at one stage in its operation;

FIG. 9 is a view similar to FIG. 8 but showing the station at an intermediate position;

FIG. 10 is a transverse, sectional view, with parts broken away, taken along the line **10—10** of FIG. 8;

FIG. 11 is a view similar to FIG. 10, but taken along the line **11—11** of FIG. 9;

FIG. 12 is a view similar to FIGS. 8 and 9, but showing the mechanism at a still different stage in its operation and illustrating the stacking or accumulation of a number of items having like detail, in this case identical color, and

FIG. 13 is a view similar to FIGS. 10 and 11, but showing a different stage in the operation of the mechanism illustrated therein, namely, the removal of a group of like items from the receiving station while a successive group is being accumulated therein.

A sorter embodying the invention as illustrated in the drawings is shown as being embodied in an apparatus for the sorting of ceramic tiles of like size and physical characteristics, but of different colors. In the manufacture of ceramic tiles and of many other commercial items which are to be assembled in large numbers to cover areas, it is essential that the color of all of the items to be employed in a single installation shall be the same, at least to a degree such that the human eye cannot perceive any variations in the color. It has traditionally been the custom of all ceramic tile manufacturers to employ large numbers of persons who function as color sorters. These persons have working stations to which are brought bulk loads of tile of the same general color and it is the duty of such a person to differentiate tiles by the gradations of the base color and to assemble the tiles in standard numbers, for example one gross at a time, of the same gradation of the base color. This has been a costly and time-consuming operation requiring that each individual tile be handled by a color sorter and be manually placed with tiles of like color for subsequent packaging and shipping under color gradation code numbers. Unfortunately, without such color sorting, a tile installer has no way of knowing that all of the tiles in a single order will have the same color gradation. The differences in color are not readily perceptible until after an installation has been made, whereupon the person in whose home or building the installation has been placed, may be displeased by reason of the inadvertent variation in color of the mass of tile.

Within recent years, a sufficient physical understanding of the differences in color and a sufficient degree of electronic skill have been achieved so that it is now possible to scan items and to grade variations in a base color in but a very short time period, it also being possible to establish signals indicative of the particular gradation into which the item being scanned falls.

The embodiment of the instant invention disclosed in the drawings constitutes a sorter wherein the detail analysis is performed by a color scanner and in which the signals emanating from the color scanner are stored and delivered to sorting mechanism in time controlled sequence with the respective items which were scanned at the time of origination of each of the signals. Neither the color scanner per se nor the signal storage means per se constitutes a part of the instant invention except insofar as a sorter embodying the invention is designed to be operated in connection with and upon the basis of signals received either from some form of detail analyzer or as a result of human inspection of the items being sorted.

While a signal memory system is generally illustrated in the drawings, it will be appreciated that a memory system is but one way to provide for the simultaneous arrival of an item to be selected and a "sort signal" at a desired sorter station. Signals could equally well be impressed upon each of the items itself or upon the item conveying means adjacent the items to which the signals relate.

Although the illustrative embodiment of the invention employs a color scanner as a detail analyzer with respect to the colors of ceramic tiles, a sorter embodying the invention may, of course, function on the basis of signals determined by the weight, texture, size, magnetic response, electrical response, or any other detail, of like massive items, which can be detected in any manner or by any means and which can serve as a basis for the sorting signals.

Passing now to the particular sorting apparatus disclosed in the drawings, FIGURE 1 is a plan view on a small scale and showing little detail, of an entire apparatus for the sorting of ceramic tile upon the basis of shades or gradations of a single base color. The apparatus may be

generally divided into several major sections. These include a feeding magazine, generally indicated at 20, a scanning station, generally indicated at 21, auxiliary detail analysis equipment, in this case a color scanner 22, and a signal storage and delivery means 23. The sorter proper comprises, among other parts, a high speed conveyor, generally indicated at 24, and a plurality of individual stations, generally indicated in FIGURE 1 by the reference numbers 25*a*, 25*b*, 25*c*, 25*d*, 25*e* and 25*f*.

Each of the individual stations 25*a*–25*f* is identical with each of the others and each of them is intended to select a single color and to accumulate and deliver ceramic tiles of the same color, shade or description. Each of them is thus electrically or electronically connected to the signal storage device 23 in such manner that it is actuated at a time appropriate for diverting tiles intended to be selected by that particular station 25*a*–25*f*. In further descriptions in this specification, therefore, only one of the individual sorter stations 25*a*–25*f* will be described in detail and that description will suffice for the description of all of the stations 25*a*–25*f*.

In FIGURE 1 it will be observed that adjacent to the outboard ends of the stations 25*a*–25*f* (the bottom thereof in FIG. 1), there appears the legend "to subsequent conveyors." These subsequent conveyors do not in any sense constitute part of the instant invention and, of course, are merely conveying means for delivering the groups of tiles of like color, shade or description to machinery or operators for packaging under appropriate control numbers.

Tile magazine

The tile magazine 20 is illustrated in detail in FIGS. 3 and 4. It comprises, among other parts, a main table 26 (see also FIGS. 1 and 2) supported above floor level by a plurality of legs 27. A feeding belt 28 runs around a drive pulley 29 which is driven from a gear box 30 powered by a motor 31, and around an idler pulley 32 and span pulleys 33 and 34. The span pulleys 33 and 34 are mounted in pillow blocks 35 at the left and right sides (FIG. 2) of the table 26 with a top span 36 of the belt 28 extending horizontally across the table 26 from end to end and at a level just slightly above the level of the table 26. A longitudinally extending guide 37 extends along, parallel to and spaced from, the span 36 of the belt 28, having a vertical wall 38 and a horizontal arm 39, the guide 37 being adjustably positionable relative to the belt span 36 by slotted brackets 40 through which bolts 41 extend and are threaded into the table 26. The guide 37 permits an operator to stack groups of individual tiles 42 on the table 26 and belt span 36 in orderly array. It is to be noted that the tiles 42 are stacked against the guide 37 on edge.

In the embodiment of the invention disclosed in the drawings and to be described herein, the entire apparatus is illustrated as designed for the sorting of square ceramic tiles approximately four inches square and one-half inch thick. It will be appreciated, of course, that apparatus embodying the invention may be made in different physical sizes not only for the handling of ceramic tiles of other than 4 x 4 sizes or other than square shape, but also for the handling of other massive items having quite different proportions and shapes.

At the right end of the table 26 there is erected a bridge which extends across above the table 26 and above the right end of the belt span 36. The bridge 43 comprises a pair of uprights 44 and 45 erected from the table 26 and a cross-arm 46. A bearing block 47 (FIGS. 3 and 4) is secured to each of the uprights 44 and 45 serving as pivotal supports for a transversely extending square bar 48 having circular tenons 49 at its ends. Two rearwardly extending parallel bars 50 and 51 are rigidly attached to thhe square bar 48 and extend rearwardly through the bridge 43, parallel to and above the belt span 36 (see also FIG. 1). At their rear ends each of the bars 50 and 51 dependingly supports a pillow block 52, the two pillow blocks 52 serving to journal a cross-shaft 53. A roller 54 is secured on the shaft 53 and rolls in surface contact with the top edges of the array of tiles 42. A counterweight strut 55 is set into the square bar 48 and extends horizontally forwardly beyond the table 26 having a counterweight 56 threaded on its end. One of the bars 50 or 51 bears against the actuating plunger of a microswitch 57 which is mounted on the end of an arm 58 extending rearwardly from the bridge 43. As long as there are tiles 42 in the area beneath the roller 54, the bar 50 or 51 is held up in contact with the plunger of the microswitch 57, holding the circuit to the drive motor 31 closed, so that the belt 28 runs continuously. Sliding contact of the belt span 36 with the bottom edges of the tiles 42 continuously urges the tiles 42 against each other and toward the right end of the table 26.

The roller 54 is driven in the direction indicated by the arrow thereon through a drive chain mechanism comprising a circuit 59 secured on the shaft 53 and engaged with a chain 60 which is also engaged with a sprocket 61 rotatably journaled on one of the end tenons of the bar 48. The sprocket 61 is pinned to a second sprocket 62 also journaled on the tenon of the bar 48, the sprocket 62 being engaged with a drive chain 63 which extends around an idler sprocket 64 and a drive sprocket 65. The idler sprocket 64 is journaled on a pin 66 mounted in a slot 67 in an arm 68 for tensioning the chain 63. The sprocket 65 is carried by a short stub shaft (not shown) on which is also pinned a drive gear 69 which is, in turn, engaged with a similar gear 70 secured to the shaft upon which the right span pulley 34 is mounted. Because the belt 28 is driven, this rotates the span pulley 34 and through the gears 70 and 69 turns the sprockets 65, 64 and 62 and, in turn, drives the chain 60 and the roller 54. The gear reduction is such that the surface of the roller 54 turns at approximately the same lineal speed as the lineal speed of the upper span 36 of the feeding belt 28 and also urges the tiles toward the end of the table 26.

Mechanism for discharging individual tiles 42 from the right end of the array of tiles on the table 26 comprises a rocking arm 71 shown in FIG. 3 in a solid line position where no tile is being discharged and in a broken line position where a tile is being discharged from the array. The arm 71 is pivoted on a shaft 72 and has a pad 73 at its upper end. The pad 73 fits in beneath the most advanced one of the tiles 42 at a level of the table 26 when the arm 71 is in its solid line position. At the lower end of the arm 71 it is yoked to an adjustable connecting rod 74 (FIG. 2 driven by a crank 75 which is powered from a motor 76 mounted beneath the table 26.

The upper edge of the foremost one of the tiles 42 (FIG. 3) is stopped against a rear face of a vertically adjustable wedge 77. The wedge 77 is carried on the lower end of an adjustment screw 78 extending through a block 79 on the cross arm 46 of the bridge 43. A hand knob 80 is secured to the upper end of the screw 78 for vertical adjustment of the position of the wedge 77 and extends downwardly across the face of the foremost one of the tiles 42 being spaced horizontally therefrom a distance somewhat greater than the thickness of an individual tile. The lower end of the guide 81 extends downwardly between the side walls of a chute 82 having side walls 83 which extend upwardly above the level of the table 26 on each side of the array of tiles 42. An inverted U-shaped bail is pivoted at the lower ends of its arms in the side walls 83 of the chute 82 and its cross-arm 85 lies against the forward face of the foremost one of the tiles 42.

Each time that the arm 71 reciprocates the lower edge of the foremost one of the tiles 42 (for example, that tile shown in broken lines in FIG. 3 and indicated by reference number 42*a*) is swung outwardly, withdrawing

its upper edge from behind the wedge **77** until it engages the guide **81** and slides off the edge of the pad **73**. The tile **42***a* then falls, striking the bottom of the chute **82** and sliding downwardly therethrough as a successive tile **42** moves up into discharge position against the inclined face of the wedge **77** and on the pad **73**.

Sorter conveyor and feed control

A twin belt conveyor is utilized for carrying the tiles from the magazine and feeder **20** through the scanning station **21** and to the respective one of the sorter stations **25***a*–**25***f*. This sorter conveyor comprises a pair of parallel belts **86** (FIG. 1), the top spans of which run horizontally and parallel to each other the full length of the remaining portions of the apparatus disclosed in the drawings. The belts **86** are illustrated as having a "V belt" configuration with their wider surfaces uppermost but may also be circular in cross section and are spaced from each other transversely such a distance that the edges of the tiles ride on the belts. This leaves an open space between the belts through which various mechanisms in the stations **25***a*–**25***f* may be raised and lowered. The two belts **86** are driven by a pair of drive pulleys **87** (FIG. 2) located at the far end of the machine and driven in turn from a motor **88** through a gear box **89**. The belts **86** run continuously during the operation of the machine and at a constant high speed. The opposite ends of the top spans of the belts **86** are engaged with a pair of idler pulleys **90** (see also FIGS. 3 and 5) which are spaced just below the lower end of the chute **82** from the magazine **20**. The belt pulleys **87** and **90** are supported at opposite ends of a long conveyor table, generally indicated at **91**, and suitable idler pulleys are journaled beneath the table **91** to carry the return span of the belts **86**.

At the near end of the table **91** and just to the right of the idler pulleys **90** for the belts **86**, there is positioned an overhead bridge **92**, the under edge of which is placed above the upper surface of the belts **86** a distance equal to less than two thicknesses of the tiles being handled. As each of the tiles falls down the chute **82** and onto the belts **86**, it is picked up and carried along by the belts **86**. If, by chance, the functioning of the remaining portions of the machine is slowed down slightly, or if it operates at a rate of speed which is slightly less than the speed of delivery from the magazine **20**, it may be that a preceding tile has not yet been moved away from the chute **82** when a successive tile comes down the chute **82**. Such a condition is illustrated in FIG. 5 where a tile **42***b* is shown as just being moved beneath the bridge **92** and a succeeding tile **42***c* has come down the chute **82** and partially overlies the tile **42***b*. As the belts **86** move the tile **42***b*, the bridge **92** scrapes the tile **42***c* off of the top of the tile **42***d*. Any succeeding tile is also held back until the way is cleared.

Just beyond the location of the bridge **92** and erected upon a post **93** (FIG. 3) there is located a downwardly pointed feed control eye **94**. The feed control eye **94** controls the motor **76** of the feeder **20** to shut off the feeder when an accumulated supply (say, 5) of tiles **42** extends in edge-to-edge contact all the way back on the belts **86** to the position of the eye **94**. Because the belts **86** are constantly running, all of the tiles **42** in the accumulated group are urged forwardly against each other and against that tile waiting to enter the scanning station **21** (as will be described below) which eliminates edge impacts on the belts **86** and also results in thrusting each tile into the scanning station with a minimum of lost time between release of a previous tile and insertion of a subsequent tile.

Scanning station

At a several tile distance beyond the feed control eye **94**, there is located the scanning station **21**, which is illustrated in detail in FIGS. 6 and 7. In the embodiment of the invention disclosed in the drawings wherein ceramic tiles are to be sorted by color gradation, the color scanner **22** is shown as functioning as the detail analyzer. While, as mentioned, the color scanner **22** does not in itself constitute a part of the instant invention, its peculiarities and requirements are provided for in the sorter of the particular modification of invention which is illustrated. One of the peculiarities of a color scanner capable of differentiating, for example, between the wave lengths of, say, nine shades of a single color, is that its scanning head should not be allowed to scan an area having a light reflective wave length very different from the wave lengths of the colors of the tile being scanned at any one time. In other words, it is necessary at the scanning station **21** to provide that the tiles being sorted shall be in edge-to-edge contact as they move into and through the scanning station. In addition, the items being scanned should all be positioned during scanning with their colored, observed, surfaces at the same distance from the scanner head. Means must also be provided to sequence the color scanner so that it will analyze the shade of each tile and establish a signal which will later arrive at one of the sorter stations **25***a*–**25***f* in time for selecting the particular tile in question.

With a massive item, it is simpler to lift each item off of the feeding conveyor to a fixed viewing position and then to lower it back onto the conveyor rather than moving it by power both to the fixed position and back to the conveyor. It is for this reason that the 4¼" x 4¼" x ⅜" or ½" tiles are fed horizontally on the conveyor belts **86** rather than being erected on one edge.

The controls of the scanning station comprise, therefore, several electric eyes related to each other and coupled together in the circuit. In the embodiment of the invention shown in the drawings, three such eyes are employed. They are numbered **1**, **2** and **3**, respectively, in FIGURES 6 and 7. Photo cell **1** may be referred to as a "clamp actuator"; photo cell **2** as a protective device to prevent the removal of a tile from beneath the scanning or viewing head of the color scanner; and photo cell **3** as a sequencing device. In other words, photo cell **2** is a circuit breaker and unless its beam is interrupted, the color sequencing cell **3** cannot function to cause a color scan. Photo cell **3** determines when the trailing edge of a just previously scanned tile has left the scanning station and signals to the color scanner to sequence a subsequent scan.

As the tiles **42** are fed along by the belts **86**, each of them, for example the tile **42***e* in FIG. 6, reaches the scanning position immediately beneath a viewing head **95** of the color scanner **22**. In a manner to be described immediately below, the three photo cells have at this point so set the circuits that when the tile **42***e* reaches this position, a signal is received by an electrically controlled air valve **96** which feeds air to an air cylinder **97** positioned beneath the scanning station and having a piston rod **98** on the upper end of which there is mounted a table **99**. The table **99** is vertically movable between the two belts **86**. When the air cylinder **97** is actuated, it thrusts the rod **98** and table **99** upwardly, lifting the tile **42***e* upwardly about a half tile thickness and against the under side of a pair of lips **100** which overlie the edges of the tiles and the belts **86**. There are two lips **100**, one located at each side of the machine and each of the lips **100** extends longitudinally along, parallel to and above the line of movement of the side edges of the tiles **42** on the belts **86**. The under surfaces of the lips **100** preferably should be cushioned with a thin layer of rubber, for example a soft strip about 1/16" thick, against which pressure in the cylinder **97** clamps each successive tile **42** while it is being scanned. The lips **100** extend inwardly over the edges of the tile only a small distance so that they do not extend into the margins of the area being viewed by the color scanner viewing head **95**.

After a particular tile is scanned and the color scanner has set up the proper signal in the memory unit **23**, it

originates a "dispose signal" which actuates the electrically controlled valve 96 to reverse air in the cylinder 97, pulling its piston rod 98 downwardly. This lowers the just scanned tile 42*e* onto the belts 86 which immediately move it out of the scanning station. Because the just scanned tile 42*e* was elevated into clamped scanning position a vertical distance less than its thickness, its trailing edge has been functioning as a stop for the front edge of the succeeding tile, i.e., the tile 42*f* in FIG. 6. As the tile 42*e* moves out of the scanning station, tile 42*f* moves in, still remaining in edge to edge contact because both are on the belts 86.

As the tile 42*e* leaves the scanning station 21, it interrupts the beam to electric eye 3. Interruption of this beam of electric eye 3 has no effect upon the action of the color scanner. As the tile 42e continues to move, its leading edge interrupts the beam to photo cell 1. This is a narrow beam of light and, when interrupted, originates the signal to the air valve 96 to actuate the clamp for clamping the successive tile 42*f* into position. The beam of photo cell 1 is positioned one tile length beyond the scanning position wherein successive tiles are clamped against the lips 100.

At this point, with the leading edge of tile 42*e* having just interrupted the beam to photo cell 1, and the succeeding tile 42*f* having been clamped in scanning position, the scaner is still not sequenced until the trailing edge of the tile 42*e* passes beyond the beam from photo cell 3. This signals to the color scanner that the preceding tile has left the scanning station and a scanning sequence is originated.

At the same time, of course, succeeding ones of the tiles have been moved along by the constantly moving belts 86 into edge to edge contact. As the succeeding tile 42*f* moves into scanning position, the second succeeding tile 42*g*, moves up with the tile 42*f*. The edge to edge continuity of the tiles 42*f* and 42*g* and succeesive tiles keeps the beam to the photo cell 2 broken and because it is broken, keeps the circuit under the control of photo cells 1 and 3, operative. Were this edge to edge contact to be broken, so that the beam of light for the photo cell 2 appears to that cell, it would mean that for some reason no tile was following the tile being moved into scanning position. Were the scanner to be allowed to sequence under these conditions, it would inevitably result in there being a break or space between succeesive tiles and the viewing head of the scanner being exposed to light of radically different wave lengths, would upset its operation. Each of the photo cells 1, 2 and 3 has a light beam source 101, 102, 103, respectively, the light beam sources being located beneath and between the belts 86 in line with their respective photo cells 1, 2 or 3.

Signal storage

Each of the individual stations 25*a*–25*f* is independently controlled and independently connected to the signal storage unit 23. In the embodiment of the invention illustrated in the drawings, the storage unit 23 shown as being a magnetic tape device having two banks of heads 104 and 105. As an illustration of the type of signal storage operation necessary to control a sorter embodying the invention, a wide magnetic tape having parallel tracks thereon corresponding in number to the number of stations 25*a*–25*f* (and classifications of sorting) is mounted to run at a constant speed on suitable drums. The input bank 104 in the embodiment of the invention would have six closely adjacent magnetic impulse heads, one corresponding to each of the six stations 25*a*–25*f*. Similarly, the output bank 105 would have six magnetic reading heads spaced laterally across the tape and each corresponding to one of the input heads in the bank 104 and to the corresponding one of the stations 25*a*–25*f*.

Assuming, for example, that the tile 42*e*, shown in scanning position in FIG. 6, has a color shade such that it should be diverted into, stored by and discharged from the station 25*c*, the following sequence of events must occur. When the tile 42*e* is scanned in the position illustrated in FIG. 6, the color scanner 22 delivers a signal to that one of the heads in the input bank 104 corresponding to the station 25*c*. The speed of movement of the scanner memory tape in the magnetic tape device 23 must be related to the speed of lineal movement of the belts 86 in such phase that the signal impressed upon the tape by the input head 104 will arrive at the aligned one of the output heads in the output bank 105 just preceding the arrival of the tile 42*e* at its station 25*c*.

By the time the tile 42*e* arrives at the station 25*c*, of course, the next succeeding tile 42*f* may have already arrived at the station 25*a* to which its color shade may determine it to be directed. This situation is even more apparent if the first of a pair of successive tiles has a color such that it should be diverted into station 25*f* and the second has a color such that it should be diverted into station 25*a*. Because the stations 25*a*–25*f* are in a straight line series and because it requires considerably more time to get from the scanning station to the more remote ones of the sorter stations 25*a*–25*f*, it follows that the distances between the input heads in the bank 104 and the corresponding output heads in the bank 105 are not uniform, but that the heads for the nearer ones of the sorter stations, for example, the station 25*a*, must be closer to each other than the heads for the remote sorter stations, such as the station 25*f*. The key to the control resides in substantial identity of two periods of time: (1) the period of time required to move the tile from the scanning position of FIG. 6 to that sorter station to which it is intended to go, and (2) the time required to move a signal placed upon the magnetic tape at the time of scanning from the input head in the bank 104 to the reading head in the bank 105.

Sorter stations

Each of the sorter stations 25*a*–25*f* is intended to divert, store and deliver tiles all of which fall within one of the selected groups of detail which is analyzed by the detail analyzer, in this case the color scanner 22, and thus, in the embodiment of the invention shown in the drawings, to divert, store and deliver tiles all of a single one of the several shades of a base color by which the tiles are being sorted. While six of the stations 25*a*–25*f* are shown in FIGS. 1 and 2, it will be appreciated that the number of stations in any particular device is determined by the number of gradations of sorting which the particular embodiment of the invention is designed to accomplish. If, for example, sorting is by color and the color scanner is capable of sorting nine gradations, then there would be, of course, nine stations. On the other hand, if the sorting is on the basis of some other detail, for example, weight, and if it is desired to sort items weighing between, say, four and five pounds on the basis of ounces, there would, of course, have to be sixteen stations, one for each of the ounce classifications. Because each of the stations 25*a*–25*f* is identical in construction and functions identically, only one will be described in this portion of the specification and the description of that one is intended for all six.

In general, that one of the sorter stations 25*a*–25*f* to which a particular item is intended to be delivered, or by which a particular item is to be selected and/or stored, will be called the "indicated sorter station" and such item, a "selected item."

For purposes of illustration the sorter station 25*c* will be selected and it is shown in detail in FIGURES 8–13, inclusive. Each sorter station has an elevator and a stacker. The stacker functions to lift each individual tile for that station off of the conveyor belts 86 upwardly a distance sufficient so that it is above the upper surface of succeeding tiles which might be intended to move past the particular station to more remote sorter stations. The elevator functions to (1) accumulate and store a stack of tiles one on top of the other, and (2) to elevate the

stack to an upper position where it is held and then laterally discharged from the sorter station to a sorter station conveyor and then to subsequent conveyors which may lead to packing stations.

Each of the stackers comprises an air cylinder **106** (FIG. 8) controlled by an electrical valve **107** to which a circuit leading from the signal storage mechanism **23** is connected. The air cylinder **106** has a piston rod **108** which carries a horizontally extending arm **109** having an upturned finger **110** which protrudes upwardly between the belts **86**. As can best be seen in FIGS. 10 and 11, the finger **110** is bifurcated, terminating in a pair of pads **111** which actually make contact with the under surface of a tile to be stacked.

When a completed "sort signal" is received at the electrical valve **107**, the cylinder **106** is energized to thrust its rod **108** upwardly and through the arm **109**, finger **110** and pads **111** to engage and lift a tile vertically off of the belts **86**. The actuation of the electrical valve **107**, and thus the stacker cylinder **106**, is determined not only by the signal from the signal storage mechanism **23**, but also by an overcontrol which originates from a photo cell **112** toward which a beam of light from a lamp **113** is directed. The far edge of the beam of light from the lamp **113** (right edge FIGS. 8 and 9) is spaced one tile length from the position which a tile is to occupy when it is lifted by the stacker mechanism. In FIG. 8, a tile **42***h* is shown in position where its trailing edge has just passed the far edge of the beam of light from the lamp **113**. The photo cell **112** is so connected into the signal control circuit that when its beam is interrupted it pre-conditions the control circuit for actuation at the time its beam is re-established.

The signal storage mechanism **23** and its connections into the same control circuit are so designed that a "sort" signal is impressed into the circuit at a time closely approximating the time of arrival of the particular tile at its particular sorting station. In the case of the tile **42***h*, for example, the signal for energizing the stacker valve **107** would be read from the magnetic tape at such time that the circuit would be pre-conditioned or enabled prior to arrival of the tile **42***h* at the position indicated in FIG. 8. Immediately upon passage by the tile **42***h* of the far edge of the light beam to the photo cell **112**, the "sort" signal would be completed to actuate the sorter station. The delay between the time of completion of the "sort" signal and the functioning of the stacker cylinder **106** to actually lift the tile **42***h* off of the belts **86**, is such that the tile **42***h* moves on the belts **86** from the position shown in FIG. 8 to the precise position at which it is to be lifted from the belts **86** by the time it is engaged by the stacker pads **111**.

In fact, it is preferable that the stacker cylinder **106** should be actuated just before the tile reaches the precise position for lifting in order that friction between the top surfaces of the pads **111** and the bottom of the tile **42***h* being stacked will overcome the momentum of the tile **42***h* and bring it to a stop in proper position for lifting. It has been found that because of the substantial uniformity in weight and surface characteristics of the tiles **42** and because of the constant speed of the belts **86**, the inertia of each tile to be stacked can be overcome with close enough control so that each successive tile stops with its edges located within a very small fraction of an inch, say 1/64 or less, of the edges, of preceding and subsequent tiles.

The stacker mechanism comprises a pair of stacker dogs **114**. The stacker dogs **114** are pivoted at their lower ends on a support block **115** and there are two sets of stacker dogs **114**, one at each side of the pathway of the belts **86**. The two support blocks **115** extend inwardly toward each other from the upper ends of vertical plates **116** which are secured to opposite ends of a cross-bar **117** erected on a main support bar **118**. The stacker dogs **114** do not move up and down vertically (see FIG. 12), but reciprocate pivotally on their pivot points in the blocks **115**. Each of the stacker dogs **114** (see FIG. 10) has an inwardly turned angular surface **119** so that movement of a tile upwardly, for example the tile **42***h*, cams the stacker dogs **114** laterally outwardly. This action is illustrated in FIG. 11 where the stacker is shown as elevating the tile **42***h* from its position on the belts **86** (indicated in broken lines) to a position (indicated in solid lines) which is almost at the top of the stroke of the stacker cylinder **105**. As can be seen in FIG. 11, the upper lateral edges of the tile **42***h* are moved against the lower angular surfaces **119** of the dogs **114**, camming the dogs **114** outwardly so that the tile **42***h* can move up between the dogs **114**.

By feeding the tiles horizontally, with their least dimension of 3/8" or 1/2" extending vertically, the action of the stacker cylinder **106** lifts them off of the belts in the direction of their least dimension. The distance of movement of a tile to get it out of the way of succeeding tiles and the time necessary to select a tile, by extending the stacker pads **111** upwardly between the belts **86** and returning the pads **111** to a level below the belts is, therefore, shorter than that which would be required if the tiles were moved laterally. If the tiles were on edge at the time of selection, the shortest distance and least time would be required to divert the tiles horizontally; again, in the direction of their least dimension.

The elevator mechanism also comprises a pair of dogs **120**, there being one elevator dog **120** adjacent each of the stacker dogs **114**. The elevator dogs **120** are each individually pivoted at the upper end of an elevator strut **121** and the two struts **121** at each side of the elevator mechanism are connected to a cross-plate **122**, the plate **122** in turn being secured on the upper end of a piston rod **123** on an elevator cylinder **124**.

Referring again to FIG. 11, the elevator dogs **120** are identical in configuration with the stacker dogs **114** and are similarly cammed outwardly by the lifting of the tile **42***h* upwardly off the belts **86** by the stacker mechanism. Immediately after the instant of movement illustrated in FIG. 11, the vertical movement of the stacker pads **111** terminates, with the tile **42***h* lifted above the horizontal levels of upper ends **127** of the stacker dogs **114**, and upper ends **128** of the elevator dogs **120**. All of the stacker dogs **114** and elevator dogs **120** are urged inwardly toward the position illustrated in FIG. 10 by leaf springs or other means not shown in the drawings, so that as soon as a tile such as the tile **42***h* is lifted above the apices of the surfaces **119** and **127** the dogs **114** and **120** are snapped inwardly beneath the edges of the tile **42***h* which has just been lifted. During the last increment of vertical movement of the tile **42***h*, the stacker also lifts previously stacked tiles to accommodate the stacked tile **42***h* on top of the upper ends **127** and **128** of the stacker dogs **114** and elevator dogs **120**, respectively.

The timing of the detail analyzer, in this case the color scanner **22** and its associated controls, is such that subsequent tiles flowing along the belts **86** are spaced from each other such a distance that sufficient time between tiles exists for the stacker mechanism to lift a tile upwardly in the manner just described and to return to its lower position (FIGS. 8 and 10) with the stacker finger **110** and its pads **111** again below the level of the upper surface of the belts **86**, before a subsequent tile reaches the position of the tile **42***h* in FIG. 8. This spacing, indicated at about one and one-half tile lengths in FIG. 8, is necessary because two successive tiles, for example the tile **42***h* and a subsequent tile **42***i*, might both be intended for the same sorting magazine and in order that the stacker finger pads **111** are below the belts **86** when the next tile moves thereover.

The stacker cylinder **106** and the elevator cylinder **124** are both single impulse cylinders. In other words, a single impulse to their respective electrical valves **107** and **125** causes them to go through a complete reciprocation

to move from their lower positions to their upper positions and to immediately return to their lower positions.

After a selected number of successive tiles has been stacked by the operations just described, a counter **126** reaches its pre-set position and an impulse is delivered to the elevator valve **125** to energize the elevator cylinder **124**. At this point, of course, there are a number of tiles resting on the flat upper surfaces **127** and **128** of the stacker dogs **114** and elevator dogs **120**. A vertically extending chute is erected above the stacker position, having side walls **129** but no end walls. The side walls **129** depend from ears **130** which are supported by a transversly extending trough **131** having a pair of spaced vertical side walls **132**.

A support dog **133** is pinned or otherwise secured on each of two transversely extending shafts **134** which are pivotally mounted in the ears **130**. The shafts **134** extend transversely of the length of the belts **86** and the support dogs **133** protrude inwardly (left and right in FIGS. 8, 9 and 12) within the space delineated by the side walls **132** of the trough **131**. Each of the support dogs **133** has a pair of inwardly angled inner edges **135** which are in line to be engaged by the upper front and back edges of the uppermost one of the tiles in the stack of tiles now supported on the upper faces **127** and **128** of the stacker dogs **114** and elevator dogs **120**, respectively.

When the elevator cylinder **124** is energized, its piston rod **123** is extended to the position in FIG. 12, lifting the entire stack of tiles upwardly to a level above the level of a partial bottom **136** (FIG. 10) of the trough **131**. This raises the bottom face of the lowermost tile *42h* above the level of continuous lips **137** on the support dogs **133**. The movement of the stack of tiles upwardly has, of course, cammed the support dogs **133** outwardly to the position shown in FIG. 12. Each of the dogs **133** has a cross bar **138** on its upper end which bears against a leaf spring **139** as the dog **133** is swung outwardly, the leaf spring **139** acting to restore the dog **133** to the position shown, for example, in FIG. 8. When the stack of tiles reaches the position shown in FIG. 12, the springs **139** snap the support dogs **133** back into the position shown in FIG. 8 but, at this time, with a stack of tiles resting upon the lips **137**. When the elevator cylinder **124** retracts, lowering the elevator mechanism and the elevator dogs **120** to the lower position shown in FIG. 8, the stack of tiles is left behind on the support dogs **133**.

In summary, each tile which is intended to be sorted into the particular sorter station is lifted off of the feeding belts **86** by the action of the stacker. Frictional resistance between the stacker pads **111** and the under surface of the tile overcomes the inertia of the tile and stops the tile in position for vertical insertion upwardly into the stack of tiles and the stacker pads **111** lift the tile upwardly until it is caught and held by the stacker dogs **114** and elevator dogs **120**. When a selected number of tiles have been thus lifted into position, with each successive tile engaging beneath the preceding tiles in the stack and in turn being supported on the elevator dogs **120**, the elevator mechanism is energized to elevate the entire stack of tiles upwardly a distance such that they pass and are deposited upon the support dogs **133**. Because the elevator dogs **120** are mounted on the struts **121** which are outboard of the belts **86**, the elevator mechanism can move at a speed slower than the stacker mechanism while tiles continue to pass through the particular station and/or to be stacked on the stacker dogs **114**.

After the stack of tiles is elevated up to the position shown in FIG. 12 and the support dogs **133** have snapped inwardly beneath the edges of the tiles, the next step is to discharge the recently elevated stack of tiles from the position on the support dogs **133** and onto the conveyor of the sorter station which leads to subsequent conveyors for packaging and subsequent handling of the tiles. At the side of each of the troughs **131** there is mounted a horizontal air cylinder **140** (FIGS. 10, 11 and 13) having a horizontally extending piston rod **141** on the end of which there is secured a vertical pusher plate **142**. When the elevator mechanism returns to its lower position after having elevated a stack of tiles upwardly to the position shown in FIG. 12, an impulse is delivered to a control valve **143** for the cylinder **140** and its piston rod **141** is extended so that the pusher plate **142** slides the stack of tiles off of the support dogs **133** across the partial bottom **136** of the trough **131** and onto an upper span **144** of a sorter station belt **145**. The belt **145** (driven by means not shown) passes around an idler pulley **146** located just beneath the partial bottom **136** of the trough **131**, being driven in the direction indicated by the arrow in FIG. 13, so that the stack of tiles pushed over by the pusher plate **142** is carried away by the belt **145**. After pushing the stack of tiles to the position shown in FIG. 13, the cylinder **140** reverses and retracts the pusher **142** back to the position shown in FIGS. 10 and 11 ready for a subsequent stack of tiles to be elevated onto the support dogs **133**.

It will be appreciated that tiles which are not intended for the particular sorter station in this case *25c*, may be removed from the belts **86** either by preceding sorter stations *25a–25b* or they may pass through the mechanism of the particular sorter station *25c* moving farther along to one of the subsequent sorter stations *25d–25f*.

If one or more tiles is accumulated on the stacker dogs **114** while the elevator mechanism is in its upper position, the elevator dogs are cammed outwardly by their angular under surface (similar to the faces **119** of the stacker dogs **114**) as the elevator dogs **120** are moved down to their lower position.

Having described our invention, we claim:

1. In a sorter for items subject to damage upon impact with other objects, said sorter having an item detail analyzer and detail signal storage and delivery means associated with said detail analyzer, the improvement comprising, in combination, a pair of laterally spaced, parallel and horizontally extending item conveyor belts for moving items sequentially along a path to and from said analyzer with said items resting on said belts, means for driving said belts continuously at constant speed and a plurality of sorter stations located sequentially along said path, each of said sorter stations comprising a stacker having an item lifter reciprocable through the space between said belts between a lower position beneath and not obstructing said path and an upper position located above said path a distance greater than the vertical thickness of said items, means responsive to a signal corresponding to an item to be selected at such sorter station for actuating said lifter, two sets of catch means mounted above said path a distance greater than the vertical thickness of said items and engageable beneath the edges of an item lifted thereto by said lifter, said catch means of each set being normally laterally spaced from each other less than the corresponding lateral dimension of said item and separable by entry of an item therebetween, means for urging each of said sets of catch means into normal position, an elevator mechanism including means for mounting one of said sets of catch means, means for lifting said elevator catch means and a stack of items thereon upwardly from the other of said sets of catch means, and for returning said elevator catch means to lower position with said other set of catch means, a third set of catch means located in a third position above said first two sets for retaining said stack of items at such third position, and means actuated by the accumulation of a predetermined number of items in a stack on said elevator catch means for actuating said elevator lifting means.

2. A sorter according to claim **1** in which each of said sorter stations has a horizontal station conveyor at the level of the elevated position of the elevator catch means for carrying elevated groups of items away from said station.

3. In a sorter for items subject to damage upon impact

with other objects, said sorter consisting of single item detail analyzer, a horizontally extending item conveyor for moving items sequentially along a path to, through and from said analyzer with said items resting on said conveyor means, detail signal storage and delivery means associated with said analyzer and a plurality of sorter stations located sequentially, along said path, the improvement consisting of a sorter station comprising a stacker having item contacting means reciprocable between a lower position beneath and not obstructing said path and an upper position located above said path a distance greater than the vertical thickness of said items, catch means mounted above said path and aligned with said stacker at the upper position thereof for receiving and retaining items lifted thereto by said stacker, said catch means comprising dogs mounted at opposite sides of the paths of the edges of said items and normally separated from each other a distance less than the width of said items, means actuated by movement of an item upwardly to a level above said dogs for separating said dogs for passage of an item therebetween, means urging said dogs toward each other, said stacker being actuated upon arrival of a corresponding item at said sorter station by a signal delivered to such station at such time from said storage means for actuating said stacker at the time of arrival of a corresponding item at said sorter station.

4. A sorter for massive items having thicknesses less than their widths and lengths, said sorter consisting of a single item detail analyzer, an item conveyor for moving items sequentially along a path to and from said analyzer, means adjacent said analyzer for moving each item in the direction of its least dimension a distance sufficient to break feeding contact between said conveyor and said item for retaining said item in detail analyzing position, detail signal establishing, storing and delivering means associated with said analyzer, and a plurality of sorter stations located sequentially along said path, each of said sorter stations comprising a stacker having an item contacting means reciprocable across the path of said items on said conveyor between a first position located at one side of and not obstructing said path and a second position at the opposite side of said path a distance greater than the least dimension of an item, means for reciprocating said contacting means from first to second position and return in response to a signal corresponding to an item to be selected thereby, an item holder located at said second position and displaceable by passage of an item to said second position for retaining such item in said second position after return of said item contacting means to first position, means urging said holder to item holding position, means responsive to the movement of an item on said contacting means to second position for displacing said item holder, means at said second position for accumulating a predetermined number of items at said second position and for delivering such predetermined number of items as a group to a third position, and means at said third position for discharging said group from said sorter station.

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