United States Patent

[11] 3,561,618

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[21] Appl. No. **803,158**
[22] Filed **Feb. 28, 1969**
[45] Patented **Feb. 9, 1971**

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[54] **ARTICLE STORAGE AND TRANSFER ARRANGEMENT FOR PROGRAMMED MANIPULATORS**
6 Claims, 18 Drawing Figs.

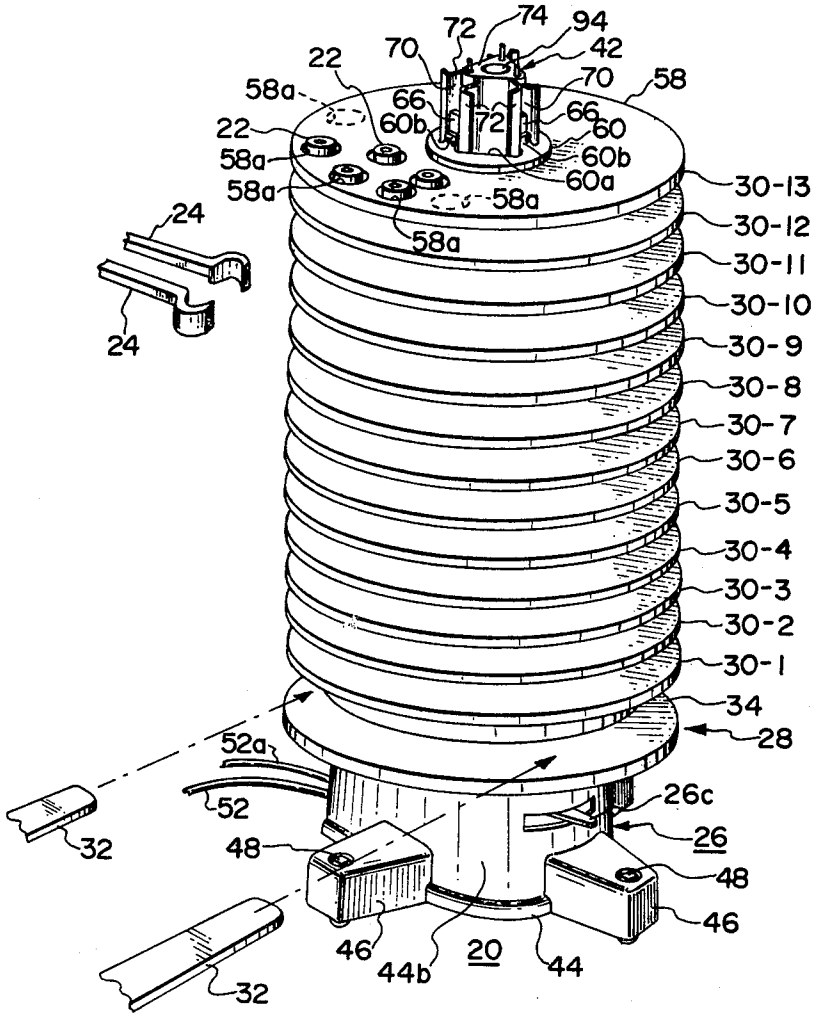
[52] **U.S. Cl.** **214/16.4,** 214/1
[51] **Int. Cl.** **B65g 1/00**
[50] **Field of Search** 214/16.4, 89, 1B2, 1B4, 1BS2, 1BS3

[56] **References Cited**
UNITED STATES PATENTS

3,250,208	5/1966	Rainbow	214/310X
3,261,131	7/1966	Loh et al.	214/89

Primary Examiner—Albert J. Makay
Attorney—Mason, Kolehmainen, Rathburn & Wyss

ABSTRACT: A series of programmed manipulators each having an article transfer arm are provided at different work stations to perform different work operations on a batch of articles. The articles are stored in and transferred between work stations in a magazine assembly which is capable of maintaining all of the parts in a predetermined orientation at each work station. Furthermore, the magazine assembly cooperates with the programmed manipulator at a particular work station to sequentially position each article in the batch to a predetermined position and with a predetermined orientation so that the article can be grasped by the manipulator, worked on, and redeposited in the magazine without human assistance.



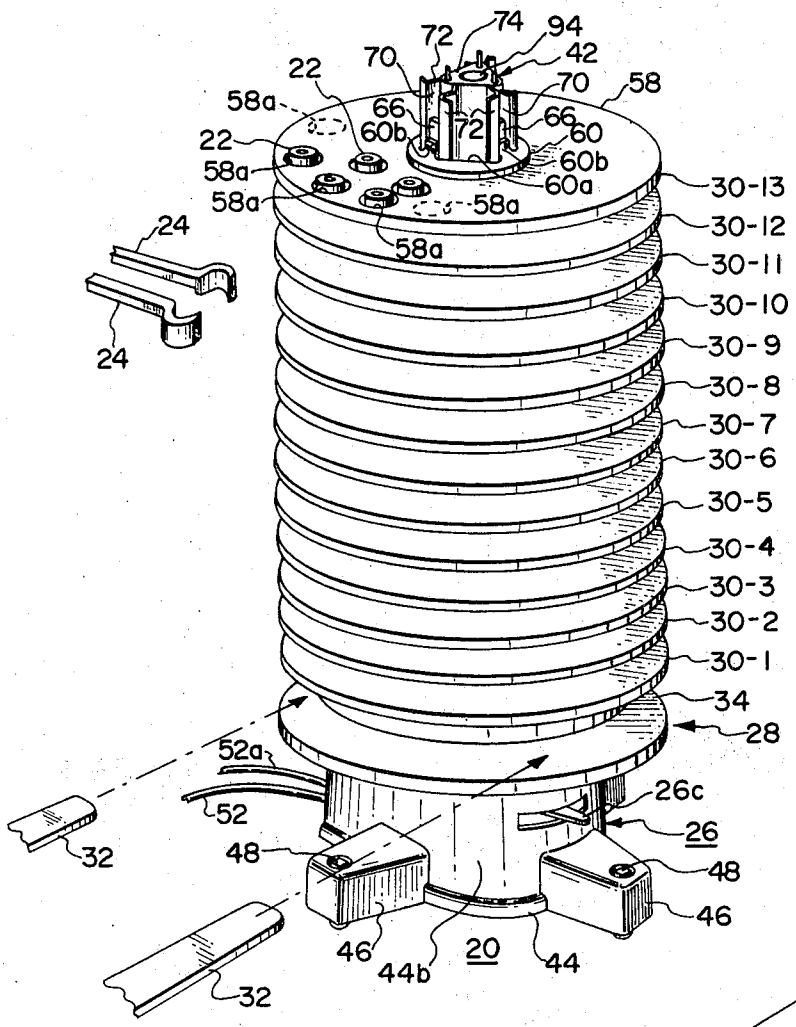


FIG. 1

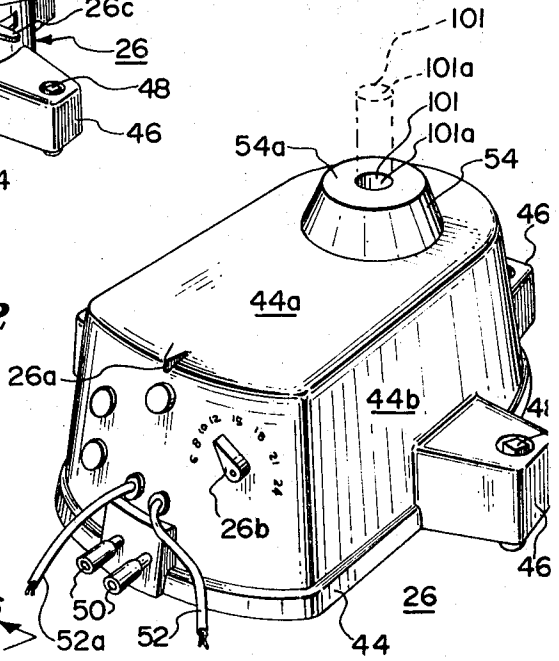
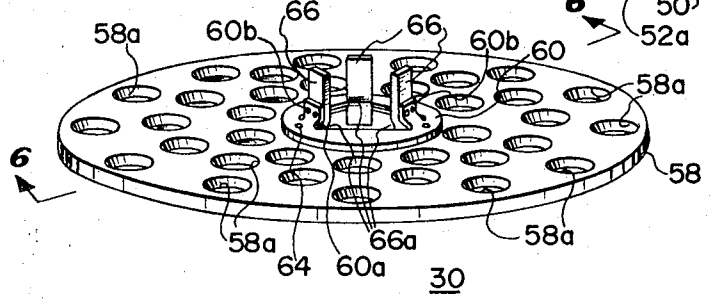


FIG. 2

FIG. 5



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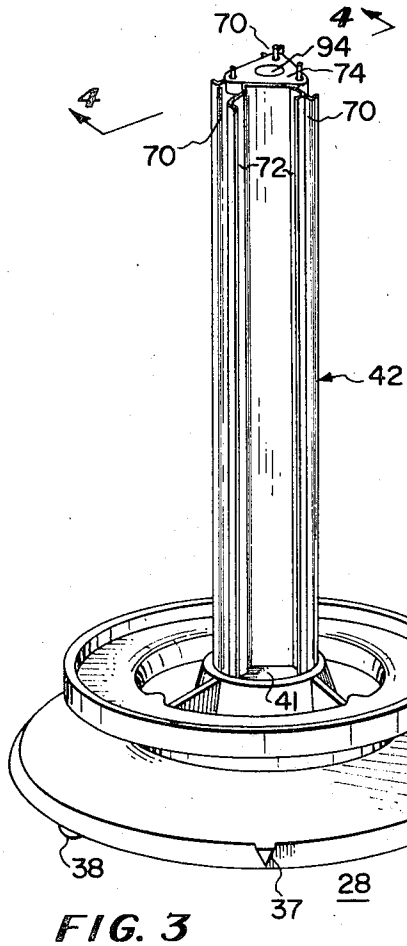


FIG. 3

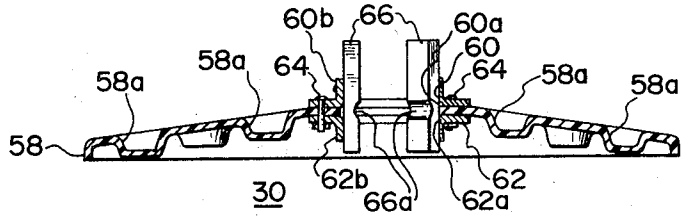


FIG. 6

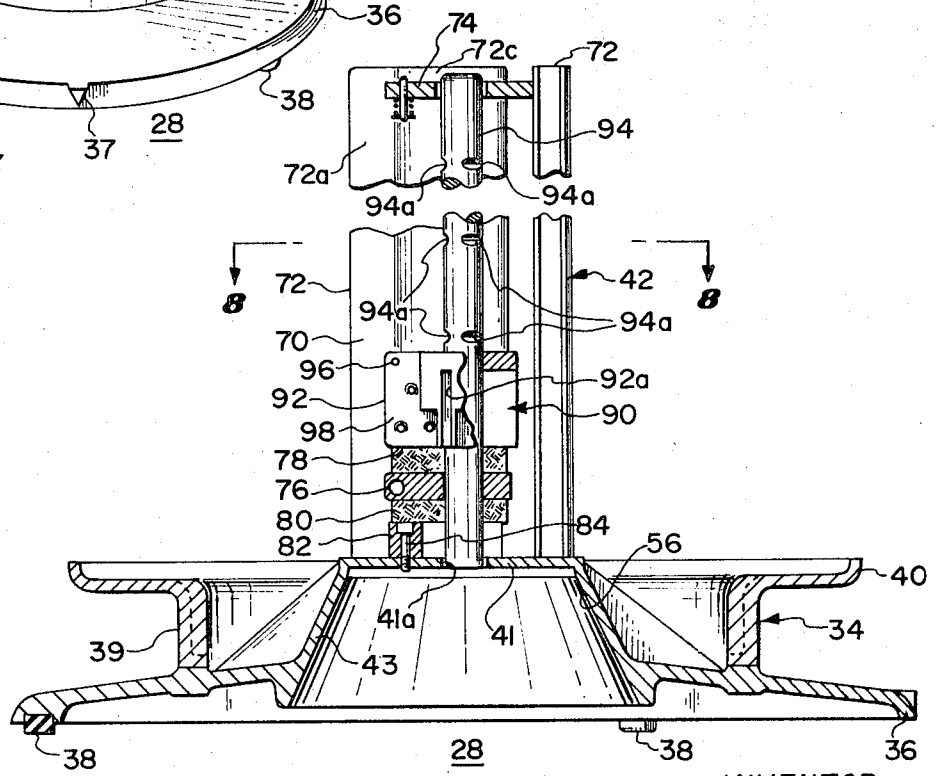


FIG. 4

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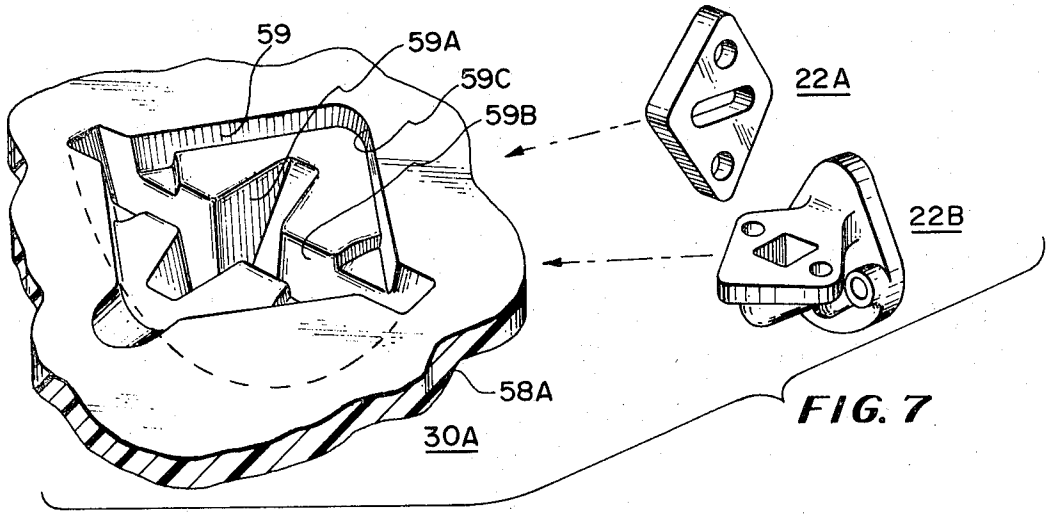


FIG. 7

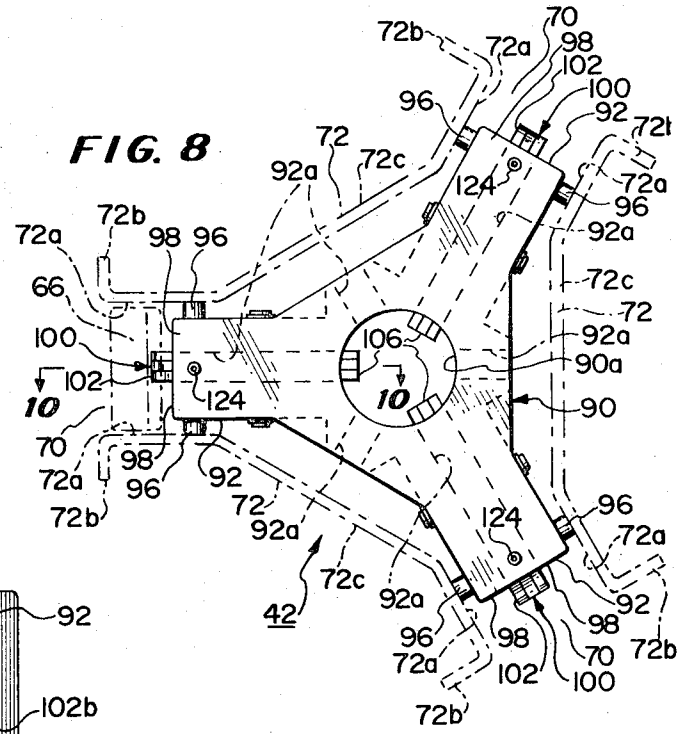


FIG. 8

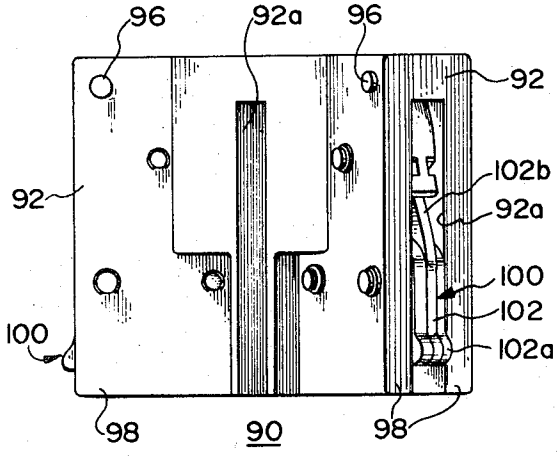


FIG. 9

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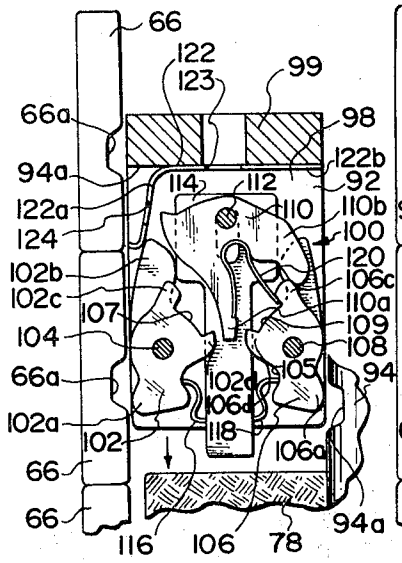


FIG. 10

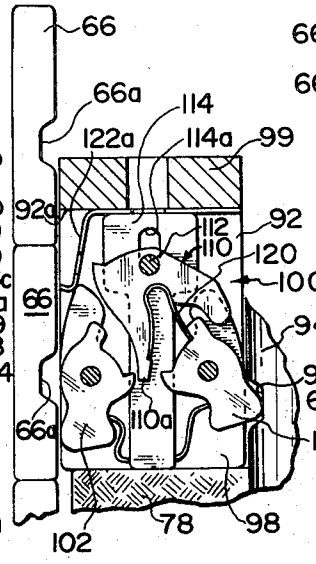


FIG. 11

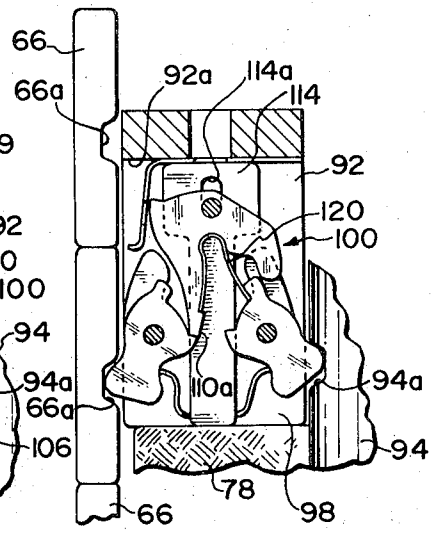


FIG. 12

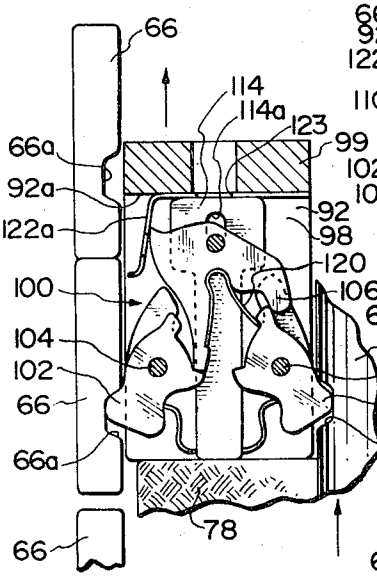


FIG. 13

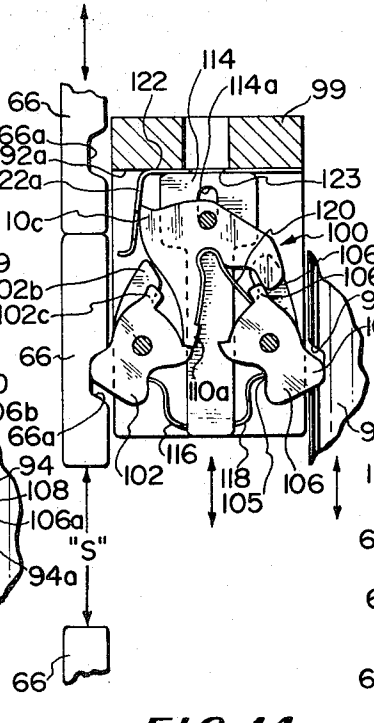


FIG. 14

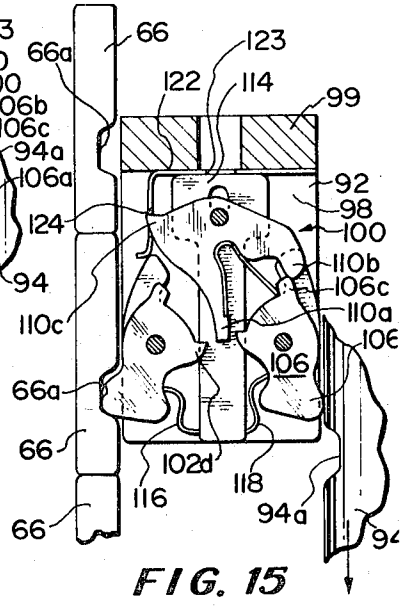


FIG. 15

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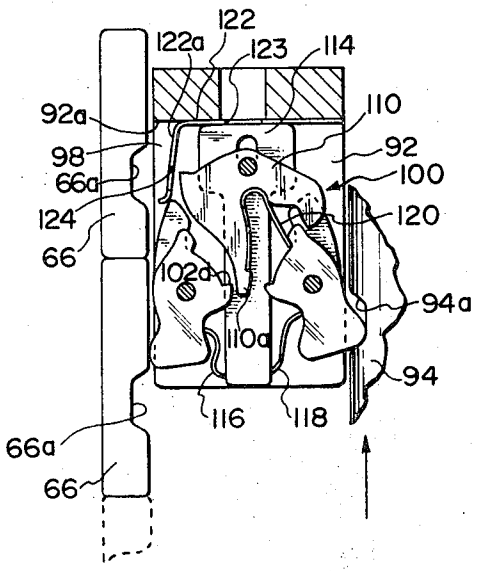


FIG. 16

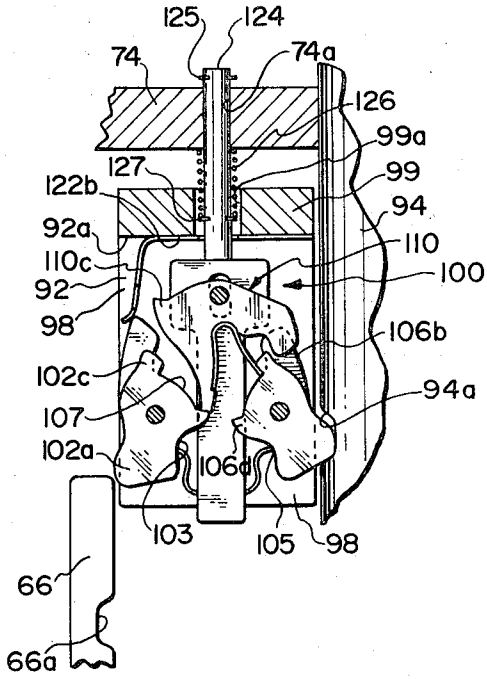


FIG. 17

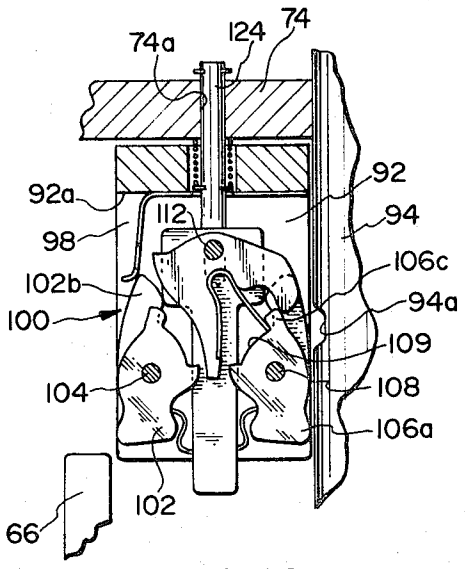


FIG. 18

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ARTICLE STORAGE AND TRANSFER ARRANGEMENT FOR PROGRAMMED MANIPULATORS

The present invention relates to acticle-handling systems and, more particularly, to an article storage and transfer arrangement for programmed manipulators.

Programmed article transfer apparatus or manipulators are being used in an increasing number of applications today to perform operations on a series of articles in accordance with a predetermined or programmed series of movements. Such programmed manipulators are provided with an article transfer are equipped to grasp an article of a particular size or shape and move the article sequentially to a series of positions at which various work operations may be performed on the article. The programmed manipulator usually includes an electromagnetic memory drum which stores a number of command signals for moving the transfer arm to different positions and along different axes during a work cycle. The manipulator may first be "taught" to perform a sequence of movements by recording appropriate signals on the memory drum, and is thereafter capable of repetitively performing the recorded sequence so that the same operations may be made on a large number of identical parts or articles. Programmed manipulators of this type are described, for example, in U.S. Pat. Nos. 2,988,237; 3,279,624; 3,283,918; 3,306,442; and 3,306,471.

In may instances different work operations must be performed on a batch of parts or articles at different work stations and a programmed manipulator is provided at each work station for automatic handling of the articles during the work operations at that particular work station. While the handling of the articles is accomplished by the manipulator in a completely automatic manner at any given work station, if the articles are simply dumped into a tote box and carried to the next work station the orientation of the articles within the box is completely random and an operator is required to align the articles to a predetermined orientation at the new work station so that the programmed manipulator at that station can grasp each article sequentially and perform the desired work operations thereon. Such an arrangement requires a large expenditure of labor in reorienting the articles at each new work station and detracts from the inherent labor-saving advantages of the manipulators themselves at each work station. Furthermore, the parts must be stored between operations, awaiting a machine to be set up for the next operation. Also, each operator must have readily at hand a continuing supply of parts to be worked and storage for the parts produced. A considerable amount of human attention and hand labor is thus required in present day arrangements for job lot or batch system operations where the production quantity is limited.

It is, therefore, an object of the present invention to provide a new and improved article storage and transfer arrangement which avoids the disadvantages of the prior arrangements described heretofore.

It is a further object of the invention to provide a new and improved article storage and transfer arrangement whereby a batch of articles may be sequentially fed to programmed manipulators at different work stations entirely automatically.

It is another object of the present invention to provide a new and improved articles storage and transfer arrangement wherein the articles are stored in a magazine assembly with predetermined orientation such that they may be sequentially presented to the transfer arm of the programmed manipulator with the correct orientation to be grasped thereby.

Another object of the present invention is to provide a new and improved magazine assembly which is operable in conjunction with the programmed transfer arm of a programmed manipulator and is adapted for sequentially orienting each part in the magazine into a predetermined position for handling by the arm.

Yet another object of the present invention is to prove provide a new and improved magazine assembly of the character described, which magazine is easily moved from one work station to another when fully loaded with a batch of parts.

Yet another object of the present invention is to provide a new and improved magazine assembly of the type and for the purpose described which magazines requires a minimum amount of human attention during operation thereof in conjunction with a programmed manipulator and requires a minimum of setup time in order to be readied for operation.

Yet another object of the present invention is to provide a new and improved magazine for the storage and transportation of a batch of parts or articles, which magazine operates in a highly efficient manner, occupies a minimum of floor space, and used used a minimum of volume at a work station.

Another object of the present invention is to provide a new and improved parts magazine of the character described, which magazine eliminates the need for and reduces wasteful material-handling functions normally attributed to work operations of a similar type.

In the aforementioned U.S. patents, there are described and shown programmed article transfer apparatus having a movable transfer arm with fingers or jaws on the end of the arm for grasping, holding, moving, and releasing workpieces or parts. The magazine assembly of the present invention is adapted for use in cooperation with a programmed manipulator of this general type and is especially well suited for use in situations where a number of operations are to be performed on the same part at different work stations.

The foregoing and other objects and advantages of the present invention are accomplished in an illustrated embodiment which comprises a new and improved workpiece or article storage magazine for holding a batch of parts and sequentially aligning each part in the batch into a predetermined position and orientation for handling by a programmed transfer arm. The magazine includes a tray carrier means having a vertical support column, and a plurality of trays, each adapted to hold a large number of parts in predetermined orientation, are mounted in a vertical, stacked array on the column for vertical, relative movement thereon. Index means is provided for supporting the carrier and rotating the trays to sequentially align each oriented part in a tray into a preselected position where it may be grasped by the arm of the a manipulator which a has been programmed to receive a part in said preselected position and with said predetermined orientation. Carriage means is mounted for vertical movement on the column of the tray carrier and is engageable with at least one tray in each pair of vertically adjacent trays in the stacked array for sequentially increasing the vertical spacing of the trays in each adjacent pair to provide access therebetween so that the arm of the manipulator may be moved between the spaced trays and may grasp one of the oriented parts from one of the trays, remove the part and perform operations thereon, and then return the part to the tray and deposit it therein with the same orientation. The tray carrier, when fully loaded with trays full of parts, is readily movable from one location to another and, preferably, a separate index means is permanently positioned at each work station. After a work operation has been completed on each part in the batch of parts contained in a tray carrier, the loaded carrier is then moved by a forklift truck or other means to the next work station in the system and is set down on the index means positioned at the station for the next sequence of operations. The three dimensional orientation of each part is thus maintained so that the programmed manipulator at the new station may grasp each article and perform additional work operations on it without requiring an attendant to load, unload, or orient the articles at each station.

For a better understanding of the present invention, reference should be had to the following detailed description taken in conjunction with the accompanying drawings, in which:

FIG. 1 is a perspective view of a new and improved magazine assembly loaded with a batch of parts and shown in position at a work station wherein a programmed article transfer arm is provided:

FIG. 2 is a perspective view of an indexing mechanism of the magazine assembly in accordance with the invention;

FIG. 3 is a perspective view of a tray carrier of the magazine assembly in accordance with the invention;

FIG. 4 is a vertical, cross-sectional view of the tray carrier taken substantially along line 4–4 of FIG. 3;

FIG. 5 is a perspective view of a single article-supporting tray, constructed in accordance with the invention adapted for use with the tray carrier of FIG. 3;

FIG. 6 is a cross-sectional view of the tray taken along line 6–6 of FIG. 5;

FIG. 7 is a fragmentary perspective view of a radial portion of a modified tray, constructed in accordance with the present invention and having especially shaped pockets or recesses therein for holding parts of different shapes in selected orientation;

FIG. 8 is a horizontal cross-sectional view through the center column structure of the tray carrier taken substantially along line 8–8 of FIG. 4;

FIG. 9 is a side elevational view of a carriage or crab mechanism mounted for vertical movement along the center column of the tray carrier for sequentially increasing the vertical space between each pair of adjacent trays mounted on the carrier; and

FIGS. 10 through 18 are frame fragmentary, vertical, sectional views taken substantially along line 10–10 of FIG. 8 illustrating a sequence of different operating positions of the crab mechanism as it is moved along the column of the tray carrier.

Referring now, more particularly, to the drawings, in FIG. 1 therein is illustrated a new and improved magazine assembly in accordance with the present invention an generally referred to be the reference numeral 20. The magazine assembly 20 is adapted to hold a batch or limited quantity of parts 22, 22A, 22B (FIGS. 1 and 7) and to sequentially position each individual part in the batch into a predetermined location and with a predetermined orientation relative to a work station at which is located apparatus on which a work operation on the parts is to be performed. Each part in the magazine 20 is grasped by the transfer arm of a programmed article-handling device or manipulator, which may be of the type described in any one of the above identified patents, and is removed from the magazine 20, presented to the work apparatus so that the desired operations may be performed thereon, and is then removed from the apparatus and returned to the magazine 20 by the manipulator arm in the same orientation as it was grasped. The programmed article-handling device or manipulator is preferably of the type having a programmable storage drum or other storage element in which may be stored a large number of desired sequential positions of the transfer arm of the manipulator in the various axes of movement thereof. The manipulator will sequentially move the transfer arm to a predetermined series of positions and with predetermined orientation in each position. The manipulator can also be programmed to seize and release articles at any desired position. Furthermore, the manipulator can be programmed to produce an external operate signal each time the transfer arm has completed its series of programmed movements. This signal is supplied to the magazine assembly 20 and controls the sequential orientation of parts stored within the magazine to the article-grasping position of the transfer arm, as will be described in more detail hereinafter. Programmed manipulators of this general type are described, for example, in the above-identified patents. The work transfer arm of the manipulator apparatus includes a pair of movable pickup jaws or fingers 24 for grasping and holding the parts 22, 22A, 22B, etc., and the arm and jaws are movable in several different axes to permit the part to be moved to and oriented in any desired position.

The magazine assemble 20 includes an indexing mechanism 26 (FIG. 2) which is normally bolted or permanently attached in a desired position at the work station, and the indexing mechanism is adapted to support a tray carrier 28 (FIGS. 3 and 4), on which tray carrier is mounted a plurality of annular part-supporting trays 30 (FIGS. 1, 5, and 6) arranged in a vertically stacked, concentric array. Each tray 30 is adapted to contain a selected number of parts or workpieces 22, 22A, 22B etc., and when the carrier 28 is fully loaded with a stack of part-containing trays thereon, the loaded unit is bodily movable from one work station to another with a forklift, other lifting device, or by hand. In FIG. 1, the tongue portions of a forklift vehicle are shown and indicated by the numerals 32, and the tongues are movable into a lifting position beneath the base of the tray carrier 28 for moving it from one indexing mechanism 26 to the next. More particularly, the movable tray carrier 28 includes a circular base 34, preferably formed of strong material, such as metal, and the base includes a lower flange 36 provided with an indexing mark 37 and having several circumferentially spaced-apart rubber feet 38 mounted on the outer rim for supporting the tray carrier from the floor or other surface when the carrier is not mounted on an indexing mechanism 26. The base 34 includes a cylindrical hollow body 39 and an upper flange 40 for contact with a lifting mechanism, such as the tongues 32 of a forklift vehicle (FIG. 1) used for transporting the loaded tray carrier from one place to another.

A vertical, centrally positioned, tray support column 42 extends upwardly from a horizontal circular wall 41 at the center of the base 34 and a stack of trays 30—1, 30—2, 30—3, etc. (FIG. 1) are removably mounted on the upstanding column 42. The circular wall 41 and lower flange 36 are connected by a frustoconically shaped wall 43 which forms a recess 56 for engagement with the indexing mechanism 26, as will be described more fully hereinafter.

The indexing mechanism 26 includes a housing or enclosure 44 having a horizontal top wall 44*a*, a peripheral skirt or sidewall 44*b*, and a plurality of mounting feed 46 extend outwardly from the skirt, each foot being provided with an aperture therein to receive fastening means, such as a bolt or lag screw 48, for fixedly securing the mechanism to the floor or other surface in a desired position relative to a production machine, or the like, at a work station.

The indexing mechanism 26 is supplied with hydraulic power through a pair of hydraulic lines 50, one for hydraulic pressure in and one for return to sump, these lines being interconnected with the hydraulic system of the programmed manipulator with which the magazine assembly 20 is to be associated. Similarly, electric power for operating the indexing mechanism 26 is supplied through a cable 52 and external operate control signals from the associated programmed manipulator are supplied to the indexing mechanism 26 over a cable 52*a*. The external operate signal supplied by the associated manipulator may comprise either a continuous relay generated signal or a pulse-type signal, depending upon the internal circuitry of the manipulator, as will be readily understood by those skilled in the art. Both types of signals are available in manipulators commercially available at the present time. It will be understood that the associated manipulator may be programmed to generate an external operate signal at any desired time as required by the arrangement of parts on the trays 30. For example, if only one annular series of parts are positioned on a tray 30, the manipulator will develop an external operate signal after each cycle of movements associated with one part. On the other hand, if several parts are located along or near a radius extending outwardly from the center of the tray, the manipulator may be programmed to operate on all parts along this radius before it generates an external operate signal.

The indexing mechanism 26 includes a suitable electrical, geared brake motor which drives a frustoconical drum 54 mounted above the top wall 44*a* of the housing 44. The drum 54 is adapted to drivingly engage a tray carrier 28 and is adapted to seat in the similarly shaped recess 56 formed in the base 34 of the tray carrier. Accordingly, when the drive motor is energized it drives the drum 54 which in turn rotates the tray carrier and the drive motor is controlled by any suitable means, such, for example, as a series of cams associated with the drum 54, so that the drum 54 is rotated through a predetermined arc or angle in response to each external operate signal supplied from the associated manipulator, this predetermined angle being correlated with the spacing of the

parts in the trays **30** so that each part is sequentially moved to the programmed part-grasping position of the fingers **24** of the manipulator with the correct orientation to be grasped thereby.

In order to initially align a loaded tray carrier **28**, which is placed on the indexing mechanism **26**, the mechanism includes a marker projection **26***a* formed on the housing, which cooperates with the marker **37** on the tray carrier base **34** (FIG. 3) to provide a means for precise orientation of the trays **30** with respect to the associated manipulator. A manual control lever **26***c* is employed to energize the driving motor for the drum **54** independently of the programmed control thereof by the associate manipulator. Accordingly, after the tray carrier **28** is seated on the drum **54**, lever **26***c* is moved to rotate the carrier **28** until the markers **26***a* and **37** are aligned.

When a loaded tray carrier **28** is centered above the axis of rotation of drum **54** and then lowered in place thereon, the drum provides vertical support for the loaded carrier and stack of trays **30—1, 30—2, 30—3**, etc. mounted thereon and, additionally, is operable to rotate the tray carrier about its central vertical axis in a precise manner to sequentially align each part **22**, **22A**, **22B**, etc., carried in the trays to a pickup position on a selected radial plane ready for pickup by the jaws of fingers **24** of the transfer arm. Because the engaging frustoconical surfaces of the drum **54** and the tray carrier base **34** are relatively large, an excellent drive coupling is obtained with no slippage occurring even though the loaded carrier is held in place on the drum only by the force of gravity.

Each tray **30** includes an outer, shallow, frustoconically shaped, annular ring portion **58** (FIGS. **1**, **5**, **6**, and **7**) preferably formed of integrally molded, high-strength, impact-resistant plastic material, with a plurality if indentations or pockets **58***a* (FIG. 5) therein, one for each part to be carried. In the case of a symmetrical article such as the generally cylindrical parts or articles **22** shown in FIG. **1**, the pockets or indentations **58a** are slightly frustoconical in shape in order to readily accommodate the vertical insertion and withdrawal of the parts or articles from the pockets in the trays by the fingers **24**. Furthermore, the pockets or indentations **58***a* are shaped so that the part is held with the proper orientation so that it can be readily grasped by the fingers **24** of the associated programmed manipulator.

FIG. **7** illustrates a modified tray construction **30A** wherein the outer ring portion **58A** of the tray is formed with nonsymmetrical, specially shaped pockets **59** which are suitable for holding a pair or more of differently shaped articles, such as the different parts **22A** and **22B**. For this purpose, the pocket **59** includes a relatively deep groove **59A** for the part **22A** and a deep groove **59B** at right angles thereto for part **22B**, and a shallow indentation **59C** is provided to accommodate the horizontal flange portion on the part **22B**. Thus a single tray can be utilized for holding several differently shaped parts with the correct orientation on the tray for seizure by the fingers **24**, by proper design of the part-receiving pockets in the tray. When possible, the annular ring portion **58** of the trays are with upwardly projecting shaped indentations or pockets in the lower surfaces thereof in order to accommodate and fit over the upper portions of the parts or articles contained in the next lower tray in the stack. Thus, when a stack of trays is fully loaded with articles or parts in each tray, the parts themselves interlock the trays together in a nested fashion with each pair of vertically adjacent trays in the stack requiring a minimum vertical spacing therebetween to form a neat, compact bundle of minimum volume which is easy to handle bodily as a unit on the tray carrier **28**. Moreover, the parts or articles **22** are securely held in place by and between each pair of adjacent vertical stacked trays in the array or stack on the carrier. The diameter of the annular outer rings **58** or **58A** of the trays, the thickness of the material, and the shape of the article-receiving pockets **58***a* or **59** are determined by the type, number, weight, size, and shape of articles **22**, **22A**, **22B**, etc., which are to be carried in the trays and, depending upon these factors, the angular and radial spacing of the pockets in the trays is determined.

In order that the indexing mechanism **26** may accommodate trays having different outer diameters and holding different numbers of parts, in the index mechanism is provided with a selector switch **26***b*, which is adjustable to correspond with the number of articles carried in each tray, and the switch **26***b* is used to set up the desired amount of angular rotation of the drum **54** between the sequential handling of successive parts in the tray by the fingers **24** of the associated manipulator. In the event the parts are arranged in a plurality of circles of different radii, as shown in FIG. **5**, the parts in the innermost circle are preferably higher than those in the middle circle, and those in the middle circle are higher than those in the outer circle. This is readily accomplished by the shallow frustoconical shape of the outer ring member (FIG. **6**). Each time the indexing mechanism **26** received an external operate signal from the associated manipulator, the drum **54** rotates a precise angular amount equal to the angular distance between the succeeding parts to be handled. When the tray carrier **28** is loaded with a stack of trays **30**, each having a given number of parts therein, the switch **26***b* on the index mechanism **26** is set to the given number and the index mechanism provides the proper degree of rotation of the tray carrier each time a succeeding part or workpiece **22** is handled by the jaws **24** of the transfer arm. The frustoconical shape of the tray member **58** permits a pair or more of article-containing pockets **58***a* or **59** to be positioned on a common radial extending from the center of the tray and, accordingly, two or more parts positioned in radially spaced pockets on the common radial can be readily picked up and replaced by the jaws **24** without interference, because of the difference in height or level between the pockets closer to the center and the pockets outboard thereof. As the parts **22**, **22A**, **22B**, etc. in the trays **30**, **30A**, are picked up and replaced the pockets after a work operation has been cm completed on the part, the arm and jaws of or fingers **24** are moved radially toward and away from the column **42** between pairs of adjacent vertical trays in the stack. The jaws **24** open and close to grasp and release the articles, and the manipulator arm is movable in a vertical direction so that all of the articles in the stack of trays on the column can be handled in sequence. After the processing of each part or all of the parts on a common radial has been completed, the stack of trays is rotated a precise angular amount to align the next part or common radial into position on the same plane as the predetermined path or plane of horizontal and vertical movement of the arm and jaws **24**.

The outer diameter of the ring member **58**, **58A** of the trays **30**, **30A**, and the size, shape, location, and number of pockets therein, depends upon the size, shape, and weight of the parts or workpieces **22**, **22A**, **22B**, etc., which are to be carried on the trays and, as previously stated, preferably the tray rings are fabricated of integrally molded, high-strength, impact-resistant, plastic material.

Each tray is supported for vertical movement on the center column **42** of the tray carrier **28** and is keyed thereon against relative rotation and for this purpose each tray includes a centrally disposed pair of upper and lower hub members **60** and **62**, respectively, preferably formed of lightweight, strong material, such as aluminum or thin sheet steel. The upper and lower hubs are fastened together with bolts **64**, and the tray ring **58**, **58A** is sandwiched between the hubs (FIG. **6**). The hubs are provided with aligned, generally triangularly shaped openings **60***a* and **62***a*, respectively, in order to accommodate the general cross-sectional shape of the vertical column **42** of the tray carrier **28**. Each hub member is formed with a plurality of circumferentially spaced, vertical fingers **60***b* and **62***b*, respectively, and each pair of fingers **60***b* and **62***b* in vertical alignment support a separate tray guide block **66**. Each tray includes three equilaterally spaced guide blocks and the blocks serve as spacers between vertical adjacent trays in the stack. In addition, the guide blocks function to key the trays the structure of column **42** and to guide the vertical sliding movements of the trays in the stack.

Each guide block **66** includes a horizontal groove **66***a* on the inner face spaced about midway between the upper and

lower end for use in lifting or elevation of the trays on the column, and each trio of blocks on a tray is adapted to slide freely within a trio of equilaterally spaced, outwardly facing ways or tracks 70 (FIG. 8), formed between adjacent facing wall portions 72*a* of channel-shaped, vertical column members 72. As best shown in FIG. 8, each column 72 includes a pair of outer edge stiffening flanges 72*b* normal to the adjacent wall portions 72*a* and a single web portion 72*c* extends between the wall portions 72*a*. The web forms a portion or sidewall for the column on a side directly opposite each guideway or track 70. The columns 72 are connected to and supported at their lower end on the center wall 41 of the base 34 and the columns are held in upright parallel-spaced relation, as shown in FIG. 8, to form the generally triangular cross-sectional shaped vertical column structure 42.

The trio of guide blocks 66 on each tray 30 are slidable in the vertical ways 70 formed by the facing pairs of column wall portions 72a, and the trays are thus keyed by the guide blocks against relative rotation on the column structure. The channels 72 are connected at the upper end and are held at the desired spacing by an upper spacer 74 (FIG. 3), and a similarly shaped spacer 76 (FIG. 4) is provided adjacent the lower end of the column above the base wall 41. Resilient cushions 78 and 80 are mounted above and below the lower spacer 76, and beneath the cushion 80 is provided a trio of spacer blocks 82, each having its opposite ends fastened to the wall portion 72*a* of the columns. The blocks 82 are connected to the center wall 41 of the base 34 by bolts 84 and thus the column structure 42 is removably attached to the base 34 of the tray carrier 28.

The trio of columns 72 are attached to the upper spacer 74 and the spacing leg members 82 by suitable fastening means, such as cap leg or rivets (not shown) and the resulting hollow column structure 42 is relatively light and strong and readily adapted to support a vertical stack of trays 30—1, 30—2, 30—3, etc. The trays are adapted to slide freely on the column 42 while in vertically stacked relation thereon with the column structure extending upwardly through the triangular-shaped openings provided in the center members 60 and 62 of each tray.

Referring to FIG. 1, the upper tray 30—13 in the stack is spaced below the upper end of the column 42 and when the programmed transfer arm and jaws 24 begin to function to load and unload the parts from the trays, the spacing between one pair of trays in the stack is increased, beginning with the bottom pair of trays 30—1 and 30—2 and proceeding upwardly in sequence until only the parts in the upper tray 30—13 remain to be handled by the arm. The vertical spacing between each pair of vertically adjacent trays in the stack is normally maintained by end-to-end engagement of the guide blocks 66 on the respective trays in the pair, and when an increase in spacing to provide access by the transfer arm is provided, the upper tray of the pair and all of the trays in the stack thereabove are lifted upwardly on the column 42.

In accordance with the present invention, a tray carrier 28 with a full stack of trays thereon and each tray fully loaded with parts or workpieces is placed in position on an indexing mechanism 26 at a work station adjacent the pickup jaw or fingers 24 of a programmed transfer arm. The arm is programmed to grasp each part 22 and move the part from the tray carrier 28 of the magazine to a work station where a work operation is to be performed. After the work operation has been completed, the part is again grasped by the arm and is returned to its original position or pocket in a tray, and the process is repeated in sequence for every part contained in the magazine. Access to the parts in the lowest tray 30—1 in the stack is provided by lifting upwardly the lowest tray 30—2 and all those trays 30—3 through 30—13 in the stack thereabove and when ample spacing between the trays 30—1 and 30—2 is obtained the transfer arm and jaws 24 can move radially inwardly and outwardly between the spaced-apart trays to handle the individual parts in the tray 30—1. When all of the parts 22 in the tray 30—1 have been processed and returned to their original pockets in the tray, the spacing between the tray 30—1 and 30—2 is returned back to normal by lowering tray 30—2 and the rest of the trays in the stack thereabove. Tray 30—3 and trays 30—4 through 30—13 in the stack are then lifted to provide access to the parts in the tray 30—2. This sequence is repeated for each tray in the stack until the uppermost tray 30—13 is reached. The transfer arm of the associated manipulator is likewise programmed to grasp a part at a particular level corresponding to the tray which is then being made accessible to the arm.

In order to sequentially increase the vertical spacing between pairs of vertically adjacent trays in the stack on the tray carrier, a crab or carriage mechanism 90 (FIGS. 8 and 9) is mounted for sliding vertical movement within the column structure 42. Referring to FIG. 8, the crab mechanism 90 is Y-shaped in plan view and includes a trio of leg assemblies 92 which project radially outwardly in equilaterally spaced array relative to the vertical center axis of the column. Each leg assembly of the crab is adapted to slide between a pair of facing wall portions 72*a* of a pair of adjacent column member 72, and the outer end portions of the leg assemblies are guided between the facing wall portions which define the ways or tracks 70 by guide buttons 96. The trio of leg assemblies 92 of the crab 90 are all identical and, accordingly, only one will be described and referred to in FIGS. 10 through 18 of the drawings. The crab mechanism 90 is slidable vertically within the column structure 42 on a centrally disposed, vertical drive rod 94, which rod is also reciprocal in a vertical direction within the framework of the column structure. The rod 94 is reciprocated to actuate crab mechanism 90 to move in increments from a lower or rest position (FIG. 4) adjacent the cushion member 78 to a highest or uppermost position (FIG. 18) at the top of the column adjacent the upper spacer 74. When the crab reaches the uppermost position, it is released for free fall downwardly in the column structure to return to the lower or rest position of FIG. 4 ready to repeat the next tray-lifting sequence. The cushion members 78 and 80 absorb the shock of the falling crab and in addition the cushion members and spacer 76 being mounted on the lower end of the drive rod 94 act to initially lift the crab 90 from its rest position to the next higher lifting position to increase the spacing between trays 30—1 and 30—2 to provide access for the arm to handle the parts in the lowest tray 30—1.

The crab mechanism 90 is formed with a circular aperture or bore 90*a* at the center in order to accommodate the drive rod 94, and each of the leg assemblies 92 is provided with an enlarged downwardly facing slot or recess 92*a* in communication with the center bore. The slots 92*a* are open at the bottom and each is defined by a pair of opposite vertical sidewalls 98 joined by a top wall 99. Within each slot is mounted a lifting mechanism 100 for engaging the drive rod 94 and the guide blocks 66 of the trays for lifting the trays in the stack on the column 42 as described.

Each lifting mechanism 100 includes an outer, tray-engaging pawl 102 pivotally mounted on a pin 104, an inner rod-engaging pawl 106 pivotally mounted on a pin 108, an upper generally U-shaped latch member 110 pivotally mounted on a pin 112 and a T-shaped key member 114 disposed for relative vertical sliding movement on the pin 112 which projects through an elongated slot 114*a* formed in the head of the key member. The tray-lifting pawl 102 includes an outwardly projecting foot or toe portion 102*a* at the lower end, movable into and out of engagement with the horizontal grooves 66*a* on the inside faces of the guide blocks 66 of the trays 30, and the drive rod pawl member 106 includes an inwardly projecting foot or toe portion 106*a* at the lower end movable into and out of vertically spaced-apart, horizontal grooves 94*a* formed on the drive rod 94 at intervals equal to the normal spacing between adjacent trays. At each level a trio of grooves 94*a* are spaced equilaterally around the cylindrical outer surface of the drive rod to face the trio of leg assemblies 92 of the crab mechanism 90. The drive rod 94 is reciprocal vertically within the column structure 42 and is movable between a lower posi-

tion (FIG. 4) wherein the lower end of the drive rod **94** extends through an apertured **41***a* and is flush with the bottom surface of the center wall **41** of the tray carrier base **34** and an upper position wherein the lower end of the drive rod is raised by an amount determined by the normal vertical spacing between the trays in the stack. The rod **94** is movable up and down at the desired time by means of a hydraulic piston **101** (FIG. **2**) mounted in the indexing mechanism **26** and in coaxial alignment with the drum **54**. The piston **101** is movable from a first or lower position wherein the upper end surface **101***a* is flush with the upper surface **54***a* of the drum to an upper position as depicted in dotted lines (FIG. **2**) wherein the upper end surface is elevated by an amount determined by the normal vertical spacing between adjacent trays in the stack. Reciprocal movement of the piston **101** is in synchronism with the rotation of the drive drum **54** and is initiated by timely application and evacuation of hydraulic fluid supplied through the hydraulic line **50** to the underside of the piston.

When a loaded tray carrier **28** is placed on the drum **54** of the indexing mechanism **26**, the upper end surface **101***a* of the piston **101** is in direct contact with the lower end of the drive rod **94**. After the stack of trays has been initially indexed, as previously described, and the selector **26***b* has been set to correspond to the number of angular positions in which the trays **30** are to be positioned, hydraulic fluid is supplied to the lower end of the piston **101** which moves upwardly a selected amount causing a corresponding upward movement of the drive rod **94** in the column structure **42** of the tray carrier **28**. When hydraulic fluid is evacuated from the lower end of the piston **101**, the piston and drive rod are returned downwardly to the original lower or rest position (FIG. 4).

Referring to FIGS. **10** through **18**, the tray lift pawl **102** is biased in a clockwise direction about the pin **104** by a leaf-type bias spring **116**, the inner end of which engages the outside of the lower shank portion of the T-shaped key member **114** and the outer end of the spring engages a groove **103** on the inside surface of the pawl below the mounting pin. The drive rod pawl **106** is biased in a counterclockwise direction about the pin **108** by a similar leaf-type bias spring **118**, the inner end of which is engaged against the inside of the lower shank portion of the T-shaped key member **114** and the outer end of the spring is seated in a groove **105** on the inside surface of the pawl **106** below the pin **108**. Accordingly, the lower end portions of both pawls **102** and **106** are biased outwardly from the ends of the slot **92***a* in opposite directions and the foot projects projections **102***a* and **106***a*respectively, are urged outwardly into engagement in the grooves **66***a* of the guide blocks **66** on the trays **30** and the grooves **94***a* in the drive rod **94**, respectively.

Each pawl **102** and **106** is formed of three thin sheet members laminated together and having a central lamina with an enlarged, upwardly projecting finger. The enlarged upper finger on the tray lift pawl **102** is designated as **102***b* and the enlarged upper finger on the drive rod pawl **106** is designated as **106***b*. The outside pair of laminas of the respective pawls **102** and **106** are shaped differently from their respective center or middle lamina and, as best shown in FIG. **10**, each outside lamina of the pawl **102** includes a pair of short, spaced-apart, upwardly projecting lugs **102***c* and **102***d*, which lugs form the end walls of an upwardly facing slot or groove **107** for receiving the lower end of the left-hand leg **110***a* of the U-shaped latch member **110**. The outside laminas on the drive rod engaging pawl **106** are a shaped differently from the center or middle lamina thereof and are formed with a pair of short, spaced-apart, upwardly projecting lugs **106***c* and **106***d* which define the end walls of an upwardly facing recess **109** for receiving the lower end of the right-hand leg of a downwardly extending U-shaped spring member **120** mounted on the latch member **110** below the pin **112** between the left-hand and right-hand legs **110***a* and **110***b*. In addition to the depending legs **110** *a* and **110***b*, the latch member **110** is formed with a toothlike projection **110** *c* on the left-hand upper corner, which tooth is adapted to engage a downwardly depending vertical leg **122***a* of an L-shaped, leaf-type biasing spring **122**. The bias spring **122** includes a horizontal leg **122***b* seated against the lower surface of the top wall **99** of the crab mechanism leg **92**. The top wall **99** is formed with an aperture or bore **99***a* arranged in coaxial alignment with the longitudinal vertical center axis of the shank of the T-Shaped key member **114**. The horizontal leg **122***b* of the L-shaped spring **122** is formed with an opening **123** therein in line with the opening **99***a* in the wall **99**, and the downwardly depending leg **122***a* of the spring is provided with an opening **124** adapted to receive the tooth projection **110***c* on the U-shaped latch member **110**, as best shown in FIG. **15**.

Referring specifically to FIG. **10**, in this view the tray-lifting mechanism **100** is illustrated during a free-falling condition as it falls downwardly at the end of a cycle from the upper end of the column **42** toward the resilient cushion member **78** on the lower spacer **76**. The T-shaped key member **114** is in a lower or downward position on the lift mechanism and the pin **112** is at the upper end of the slot **114***a* in the head portion. In this position, the head portion of the key member is wedged directly between the upwardly projecting fingers **102***b* and **106***b* of the tray lift pawl **102** and drive rod engaging pawl **106**, respectively. When the head of the key member is wedged between the fingers **102***b* and **106***b*, the foot projections **102***a* and **106***a* of the respective pawl members are retracted inwardly from the opposite ends of the slot **92***a* and no longer engage the spacer block grooves **66***a* and the drive rod grooves **94***a*. When this occurs, the crab mechanism **90** is then free to fall downwardly on the rod **94** within the column structure **42** without interference until the crab strikes the resilient cushion **78** on the lower spacer **76**.

When the crab **90** contacts the cushion **78**, the T-shaped key member **114** is forced upwardly from its lower position occupied during the free fall to an upper position wherein the pin **112** is at the bottom end of the slot **114***a*. In this position, the head of the key member **114** is no longer wedged between the fingers **102***b* and **106***b* of the respective pawl members (FIG. **11**) and the bias springs **116** and **118** act on the pawls **102** and **106** urging the foot projections **102***a* and **106***a* outwardly. As shown in FIG. **11** the foot projection **106***a* extends outwardly into engagement in the first or lowest level groove **94***a* in the drive rod **94** but the foot projection **102***a* is spaced below the groove **66***a* in the guide block on the second tray **30—2** in the stack. When pressurized hydraulic fluid is supplied to the lower end of the piston **101** in the indexing mechanism **26**, the drive rod **94** begins rising upwardly toward the position shown in FIG. **12**, lifting the crab **90** upwardly because of the engagement between the pawl **106** and groove **94***a* in the drive rod **94**, and when the foot projection **102***a* of the tray lift pawl **102** has been lifted enough to be level or even with the groove **66***a* in the guide block on the second tray **30—2** in the stack, the bias spring **116** is then effective to seat the foot projection **102***a* in the groove. With the foot projections **102***a* and **106***a* both seated in the grooves **66***a* and **94***a* (FIG. **12**), further upward travel of the rod **94** toward the positions of FIGS. **13** and **14** results in lifting of the tray **30—2** plus all of the trays **30—3** through **30—13** in the stack. The amount of uplift depends on the length of stroke of the piston **101** in the index mechanism **26** which is set up to provide the clearance or access space S (FIG. **14**) which is needed between adjacent pairs of trays in the stack for handling of the parts **22** by the transfer arm jaws or fingers **24**.

During the lifting operation FIGS. **12**, **13** and **14**), the U-shaped spring **120** is operable to bias the U-shaped latch member **110** in a clockwise direction on the pin **112** and the left-hand leg **110***a*of the latch moves into the recess **107** between the lugs **102***c* and **102***d* on the pawl **102**. When this occurs, the lower end of the leg **110***a* is in locking contact against the lug **102***d* and the pawl **102** is locked against rotation and is capable of supporting a relatively heavy load including the entire stack of loaded trays **30—2** through **30—13** which are mounted on the tray carrier, When the drive rod **94** reaches an upper position at the end of the upward stroke of

the piston 101, as shown in FIG. 14, full or maximum separation S between the trays 30—1 and 30—2 in the stack is achieved, and this increased spacing permits ready access to the parts 22 in the lower tray 30—1 by the programmed transfer apparatus and jaws or fingers 24 thereof.

During a lifting operation on the tray 30—2 in the stack, the drive rod engaging pawls 106 of the crab mechanism 90 are locked in engagement within the lowest set of grooves 94*a* on the drive rod and rotation of the pawls on the pin 108 is prevented by engagement of the right-hand legs 110*b* of the latch members 110 and the right-hand legs of the U-shaped latch springs 120 on opposite sides of the lugs 106*c* (FIGS. 12, 13 and 14).

Continued hydraulic pressure on the piston 101 maintains the expanded spacing S between the trays 30—1 and 30—2 while the parts 22 in the lower tray 30—1 are being processed and after the programmed transfer arm has completed the processing of all of the parts 22, the hydraulic pressure beneath the piston 101 is reduced and the fluid is permitted to drain out so that the drive rod 94 and piston return on a downward stroke toward the original starting positions (FIG. 15). As this occurs, the stack of trays including trays 30—2 through 30—13 is lowered on the column 42 and the vertical spacing S between the trays 30—1 and 30—2 is returned to a normal or minimum value. During the lowering operation time, the foot projections 102*a* on the lift pawls 01 102 are continuously maintained in engagement with grooves 66*a* in the guide blocks 66 on the tray 30—2. When the guide blocks 66 on the trays 30—1 and 30—2 are again in end-to-end contact, as shown in FIG. 15, the stack of trays 30—2 through 30—13 is no longer supported by the crab 90 but instead is supported by the guide blocks 66 of the lowest tray 30—1. Upon further downward movement of the guide of the drive rod 94, the crab 90 becomes supported by the guide blocks 66 on the tray 30—2 instead of vice versa and the drive rod pawls 106 pivot in a clockwise direction from the position of FIG. 14 to that of FIG. 15. As this occurs, the U-shaped latch member 110 is pivoted in a counterclockwise direction because of the engagement of the lug 106*c* between the right-hand leg 110*b* of the U-shaped latch member and the right-hand leg of the spring 120. The left-hand leg 110*a* of the latch member is moved out of engagement with the lug 102*d* unlatching the pawl 102; however, the weight of the crab mechanism 90 and the spring 116 are sufficient to maintain engagement of the foot projection 102*a* in the groove 66*a* of the guide block 66 on the tray 30—2. Accordingly, the crab mechanism 90 is retained at the level of the tray 30—2 and does not return to its original starting point or lowest level as does the drive rod 94 which continues downwardly as shown in FIG. 15. With the crab mechanism 90 thus retained at the level of the tray 30—2, when the drive rod 94 is returned to its initial or lowest level, the second level of grooves 94*a* on the drive rod are in horizontal alignment with the foot projection 106*a* on the drive rod pawls 106, and the pawls are pivoted in a counterclockwise direction by the bias springs 118 until the projections 106*a* are moved outwardly into engagement with the second level of grooves 94*a* on the drive rod.

On the next cycle of operation, the rod 94 begins an upward stroke and carries the crab mechanism 90 upwardly (FIG. 16) from the level of the second tray 30—2 to the level of the tray 30—3. Because of the leg 110*a* is no longer latching the pawl 102, the pawl is pivoted from the position of FIG. 15 to that of FIG. 16 as the upward stroke of the drive rod 94 proceeds. When the foot projections 102*a* of the pawl 102 are elevated enough to align horizontally with the grooves 66*a* in the guide blocks of the tray 30—3 at the next level, the springs 116 bias the pawls 102 in a clockwise direction to establish lifting engagement (FIG. 12) between the foot projections 102*a* and the tray 30—3. As the drive rod 94 continues on the upward stroke (FIGS. 13 and 14) the tray 30—3 and the stack of trays 30—4 through 30—13 thereabove are lifted until the end of the upward stroke of the rod 94. At the end of the upward stroke, the vertical spacing S between the trays 30—2 and 30—3 is attained and access to the parts 22 in the tray 30—2 by the programmed transfer arm and jaws 24 is provided.

The sequence of the operation just described and illustrated in FIGS. 10 through 16 is repeated in sequence for each higher level tray in the stack until the crab mechanism 90 reaches the highest or last tray 30—13. When this occurs, as shown in FIG. 17, and the drive rod 94 begins to rise on the next upward lifting stroke, the crab mechanism 90 is carried upwardly toward the top spacer member 74 (FIG. 18). Each leg of the upper spacer 74 is provided with an aperture 74*a* aligned with an aperture 99*a* in the top wall 99 of the respective legs 92 of the crab mechanism. A release pin 124 is mounted for vertical sliding movement in each aperture or bore 74*a* and is provided with a lockwasher 125 adjacent the upper end for preventing the pin from dropping downwardly from the spacer. Each pin is biased downwardly by a coiled compression spring 126 between the lower surface of the spacer 74 and a lower retaining washer 127 carried on a lower portion of the pin. As the crab mechanism 90 is moved upwardly from the position illustrated in FIG. 17 towards the position of FIG. 18, the release pins 124 begin to project downwardly into the bores 99*a* of the crab mechanism until the lower end of the pins contact the enlarged head portions of the respective T-shaped, key members 114. When this occurs, the head of each T-shaped key member is forced downwardly to a lower position, as shown in FIGS. 10 and 18, wherein the pin 112 is at the top of the slot 114*a* and the head is wedged directly between the upwardly extending fingers 102*b* and 106*b* on the center laminas of each pair of pawls 102 and 106. When this condition occurs, the lower foot projections 102*a* and 106*a* on the pawls are retracted inwardly so that no engagement with the grooves 66*a* in the guide blocks 66 or drive rod grooves 94*a* can occur. This retraction then permits the crab mechanism 90 to free a fall downwardly along the column structure 42 from the position at the top of the column (FIGS. 17 and 18) to the lower position, as shown in FIGS. 10 and 11, wherein the crab mechanism finally comes to rest on the resilient cushioning member 78. The cushion member 78 is supported on the lower spacer 76, which in turn in as attached to the drive rod 94 and the lower cushion member 80 between the spacer 76 and spacing legs 82, helps to absorb the shock of the falling crab mechanism 90. With the crab mechanism 90 in the lower position, as shown in FIGS. 4 and 11, the sequence of tray lifting is ready to be repeated, and usually the previous tray carrier 28 is then moved to another indexing mechanism 26 at another work station where a different work operation is to be performed on the parts 22.

The magazine assembly 20 described is capable of storing with predetermined orientation a batch of separate parts contained in a stack of trays mounted on a movable tray carrier. When a loaded tray carrier 28 is mounted on an indexing unit 26 and connected to the associated programmed workpiece transfer apparatus, the vertical spacing between each pair of vertical adjacent trays is increased above the normal spacing so that the transfer apparatus has access for movement between the trays for handling the parts or article 22 contained in the lower tray of the pair. After all of the parts have been processed, the spacing is returned to a normal value, and the spacing between the next pair of trays upwardly in the stack is increased and the cycle is repeated for each pair of trays in the whole stack. The loaded tray carrier 28 is readily movable to different indexing mechanism 26 or to storage locations, and because of the nested arrangement of the parts in the stacked trays, a relatively large number of parts can be contained in a minimum of space and are protected from outside damage.

While but a single embodiment of the present invention has been here specifically disclosed, it will be apparent that many variations may be made therein, all within the scope and spirit of the invention.

I claim:

1. A workpiece storage magazine for storing and sequentially positioning a plurality of individual workpieces adjacent

a work station with predetermined orientation with respect thereto, comprising: tray carrier means including a vertical support column. A plurality of trays for holding said workpieces in predetermined orientation, said trays positioned in a vertically stacked array on said column for relative vertical movement thereon, indexing means for supporting said carrier and rotating said trays to sequentially align successive workpieces therein into a selected rotative position relative to said work station, and crab means mounted for vertical movement on said column engageable with at least one of a pair of adjacent trays in said stacked array for increasing the vertical spacing therebetween, thereby providing access between said spaced trays for pickup of said workpieces.

2. An article storage arrangement for transferring a number of articles between different work stations while maintaining a predetermined orientation of the articles with respect to said work stations, comprising: tray carrier means including a vertical support column, a plurality of trays for holding said articles in predetermined orientation, said trays positioned in vertically stacked array on said column for relative vertical movement thereon, indexing means for supporting said carrier and rotating the same to sequentially align successive articles in said trays in a position for pickup, and carriage means mounted for vertical movement on said column engageable with at least one of a pair of adjacent trays in said stacked array for moving the same vertically away from the other tray of said pair, thereby providing access to the articles for pickup.

3, A workpiece storage and positioning device for holding a plurality of separate workpieces for pickup by a workpiece transfer arm, comprising a stack of workpiece-supporting trays arranged for vertical movement on a support column, each tray including means for holding a plurality of workpieces at circumferentially locations radially outward of said column, indexing means for rotating said trays to move successive workpieces into alignment with said transfer arm for pickup thereby, and means movable along said column for increasing the distance between pairs of adjacent trays in said stack to permit access to the workpieces contained on in one of said trays of said pair by said transfer arm.

4. A workpiece storage and positioning device for holding a plurality of separate workpieces for pickup by a workpiece transfer arm, comprising a plurality of workpiece-supporting trays arranged in moveable vertically stacked relation on a support column, each tray including means for holding a plurality of workpieces at circumferentially spaced locations radially outward of said column, indexing means for rotating said trays to move successive workpieces into alignment with said transfer arm for pickup thereby, and means movable along said column for pickup thereby, and means movable along said column for spreading pairs of adjacent trays apart to permit access to the workpieces contained in one of said trays of said pair by said transfer arm.

5. In combination, a plurality of article-supporting trays arranged in a stacked array on a vertical support column, pickup means movable toward and away from said column for sequentially engaging articles contained in said trays one at a time, means for rotating said stack of trays to align successive articles in the path of movement of said pickup means, and carriage means mounted on said column movable to engage at least one of said trays for increasing the spacing between said one tray and an adjacent tray in said stack, thereby permitting access to the articles in said adjacent tray by said pickup means extended between said one tray and said adjacent tray.

6. In combination, a plurality of article-supporting trays arranged in a stacked array on a vertical support column, pickup means movable toward and away from said column for sequentially removing articles contained in said trays, means for rotating said stack of trays to align successive articles in the path of movement of said pickup means, and carriage means mounted on a said column movable to engage at least one of said trays for moving the same away from an adjacent tray in said stack, thereby permitting access to the articles in said adjacent tray by said pickup means extended between said one tray and the adjacent trays.