United States Patent

Buhayar et al.

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[45] **Aug. 8, 1972**

[54] **APPARATUS FOR PRINTING CONTAINER SIDEWALLS**

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[21] Appl. No.: **19,136**

Related U.S. Application Data

[62] Division of Ser. No. 644,955, June 9, 1967, abandoned.

[52] **U.S. Cl.**.....**198/210,** 101/40

[51] **Int. Cl.**.....**B65g 29/00,** B41f 17/08

[58] **Field of Search**.....198/25, 33 AB, 33 AD, 211, 198/210; 101/38-40

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[57] **ABSTRACT**

Apparatus for printing indicia in a continuous operation on the side walls of containers such as cups having a generally circular cross-section and a cylindrical or frusto-conical shape, including a turret assembly for supporting the containers. The turret assembly consists of container-supporting mandrels mounted on a frame which rotates the mandrels through an orbital path having an object pickup section, an object rotate section, an object treatment section and an object removal section. The turret assembly further includes object rotate means to apply a rotational moment to the mandrells as they pass through the object rotate section.

11 Claims, 18 Drawing Figures

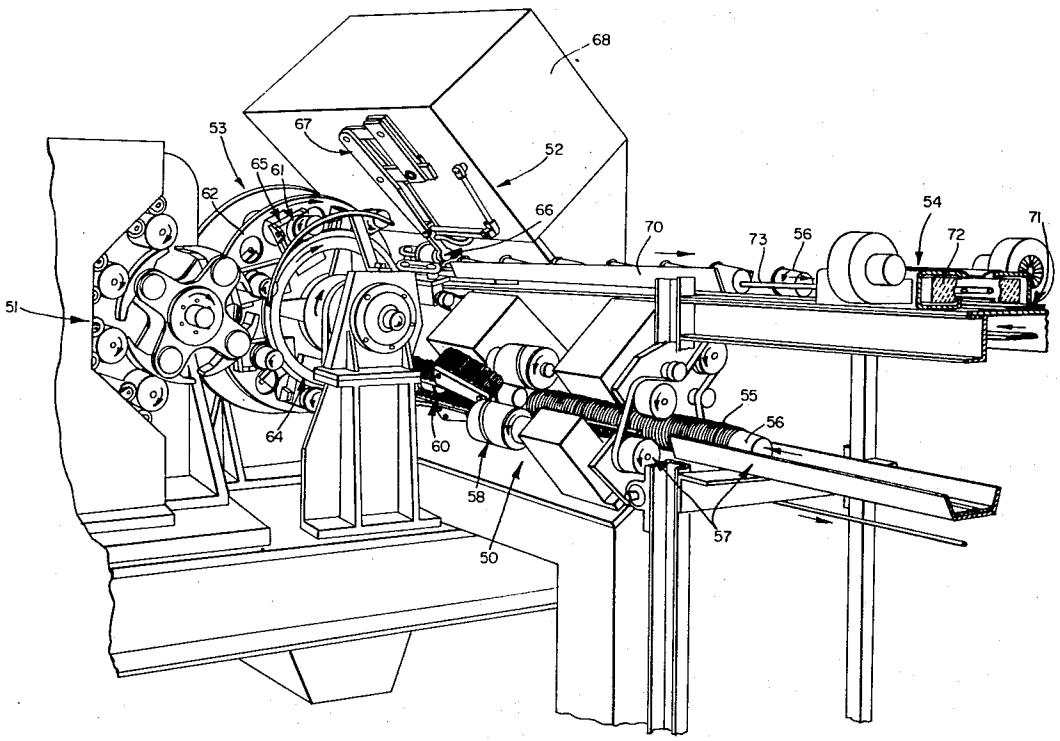
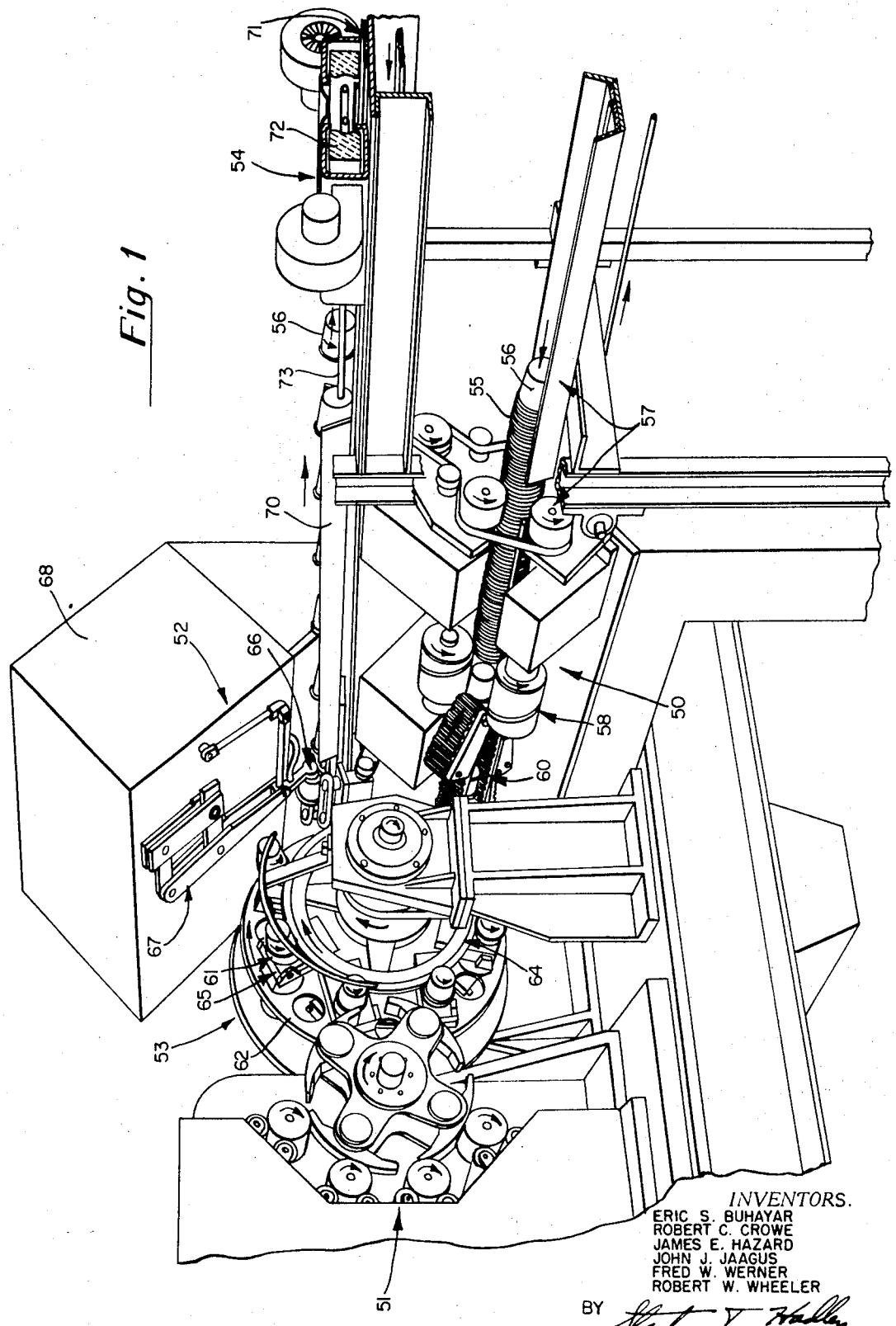


Fig. 1



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Fig. 2

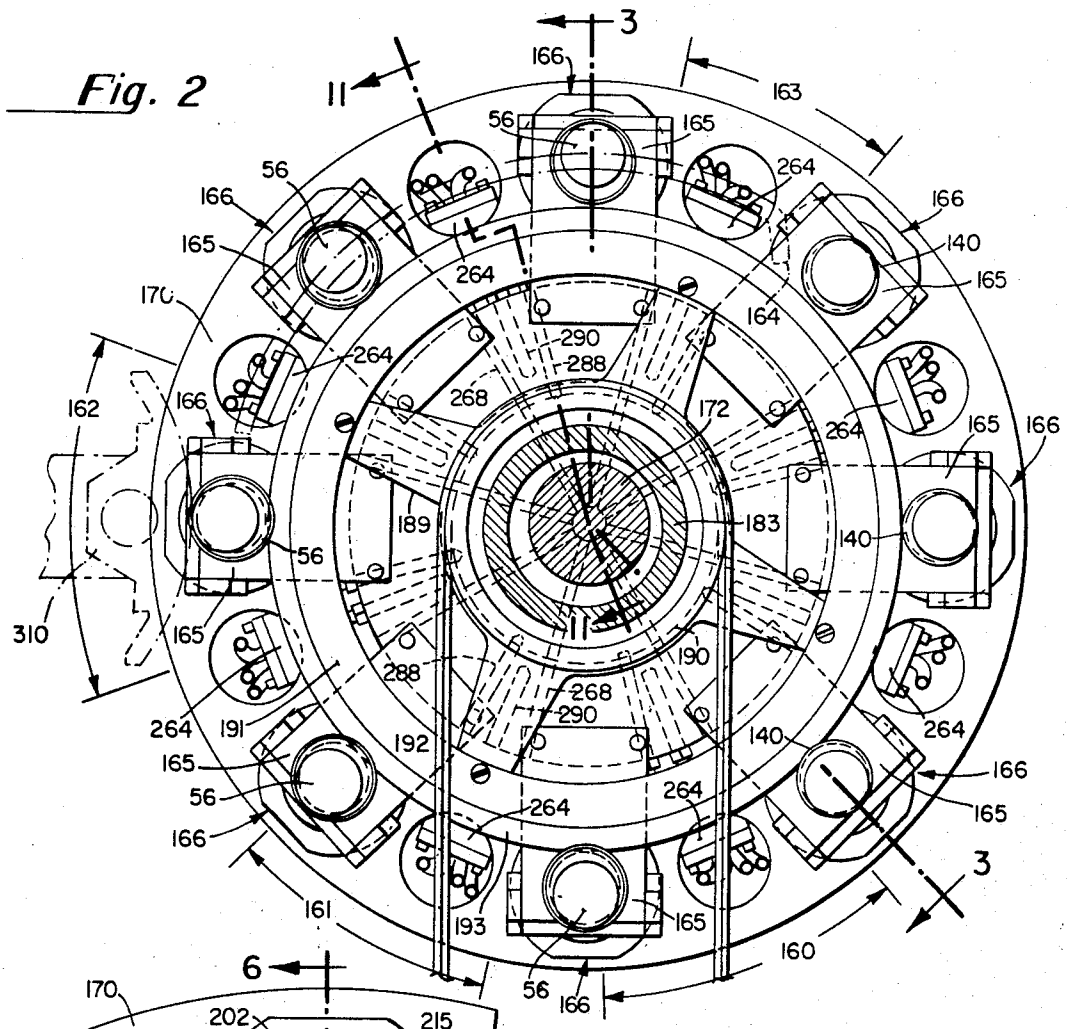
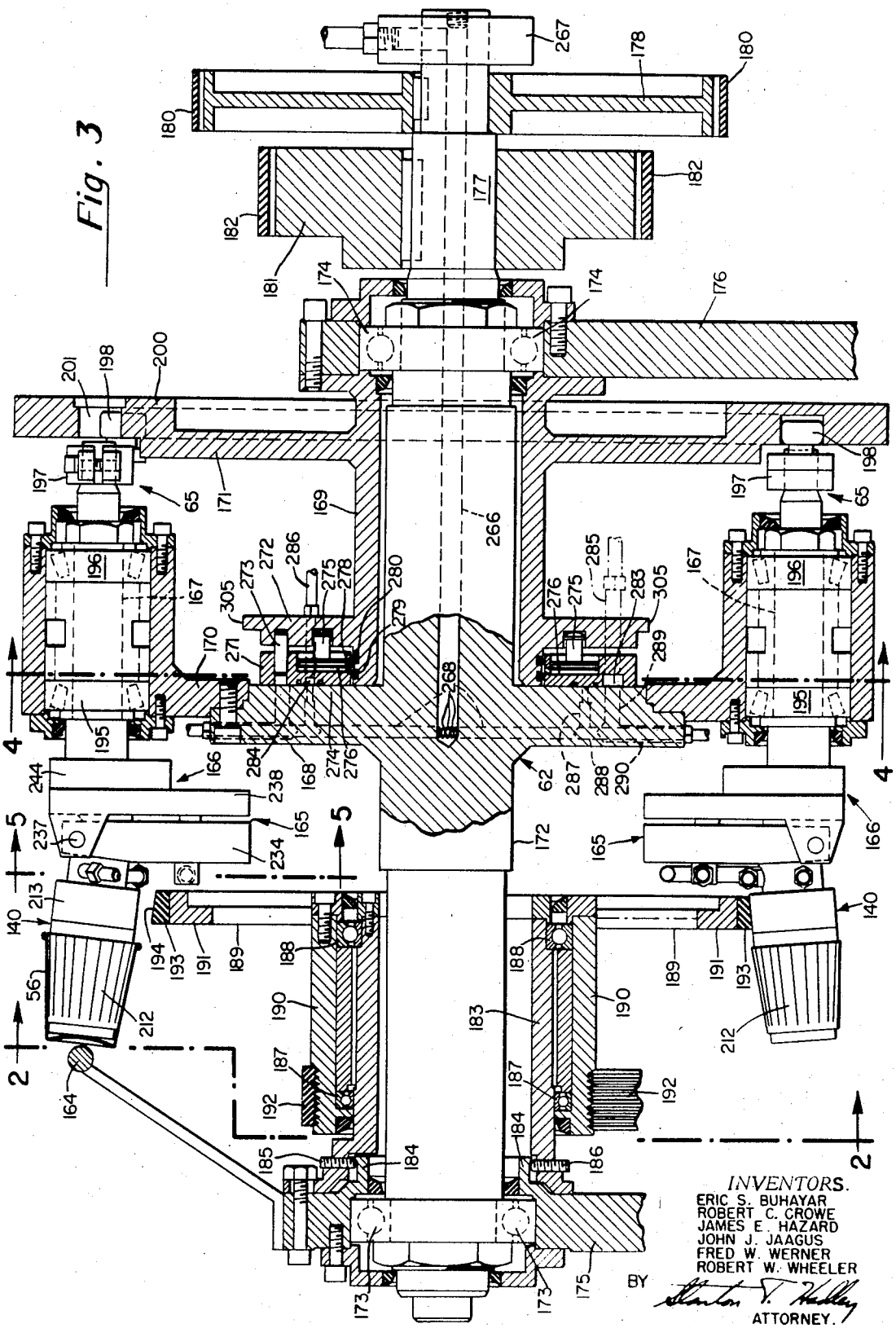


Fig. 5

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Fig. 3



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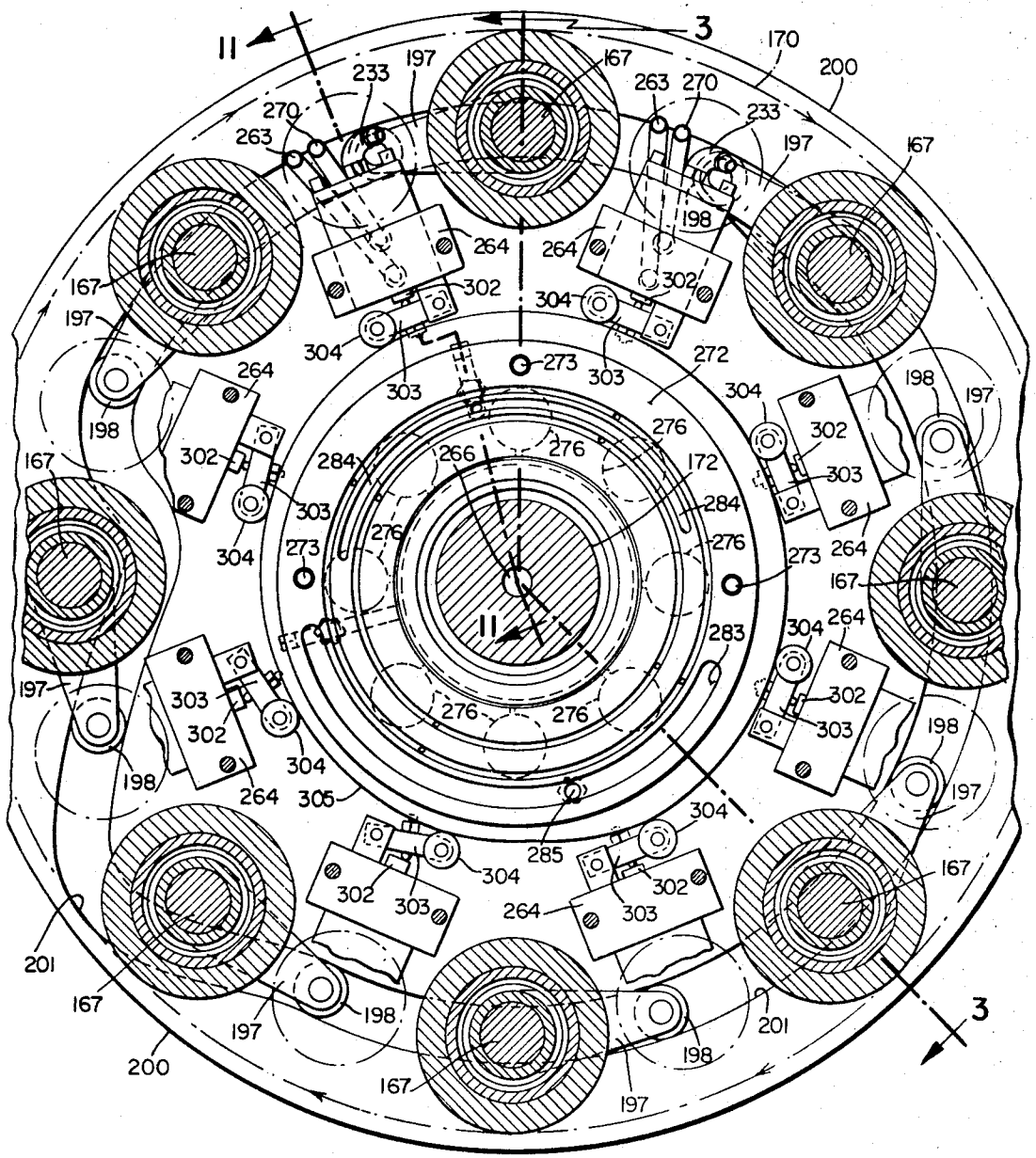


Fig. 4

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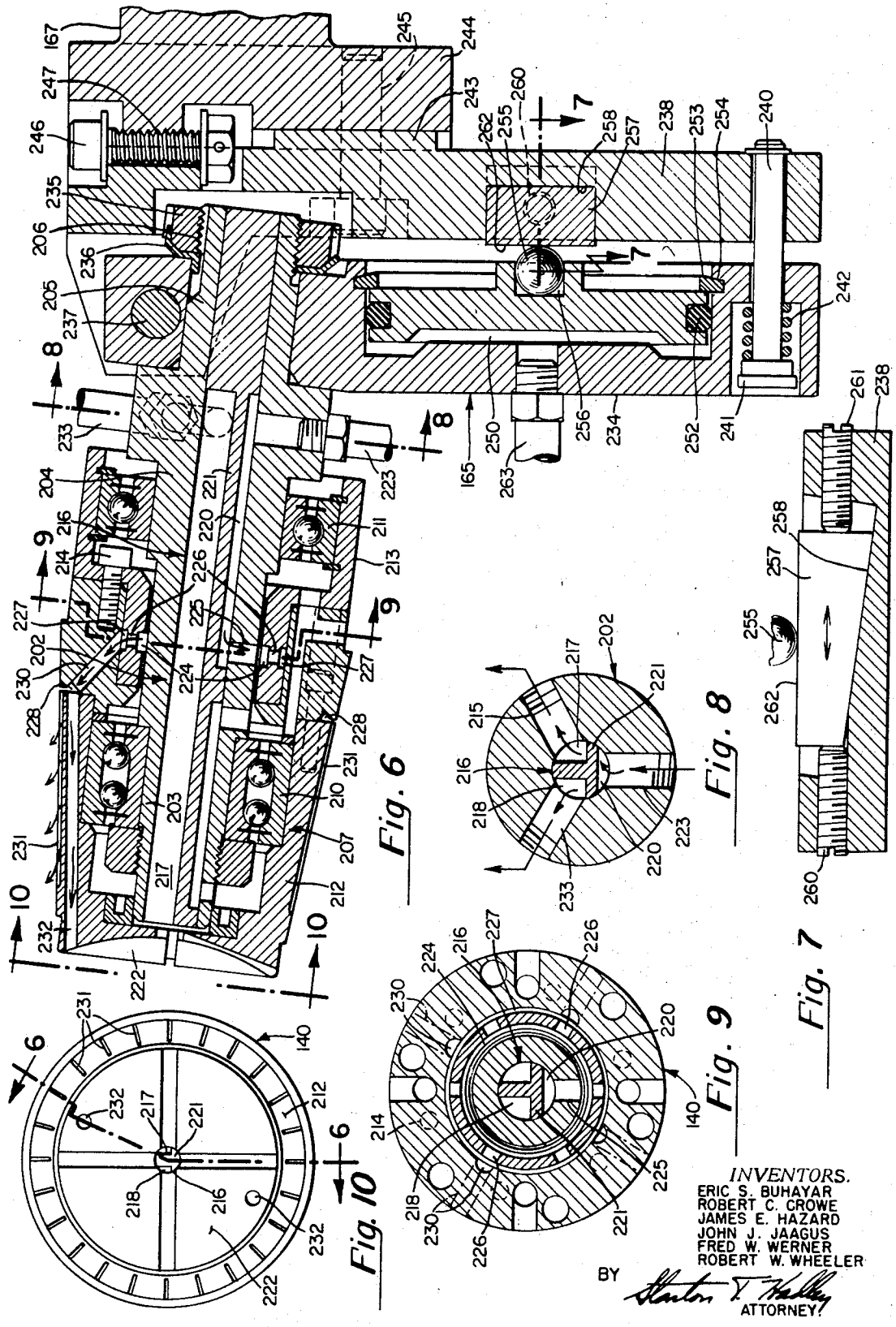


Fig. 6

Fig. 8

Fig. 7

Fig. 9

Fig. 10

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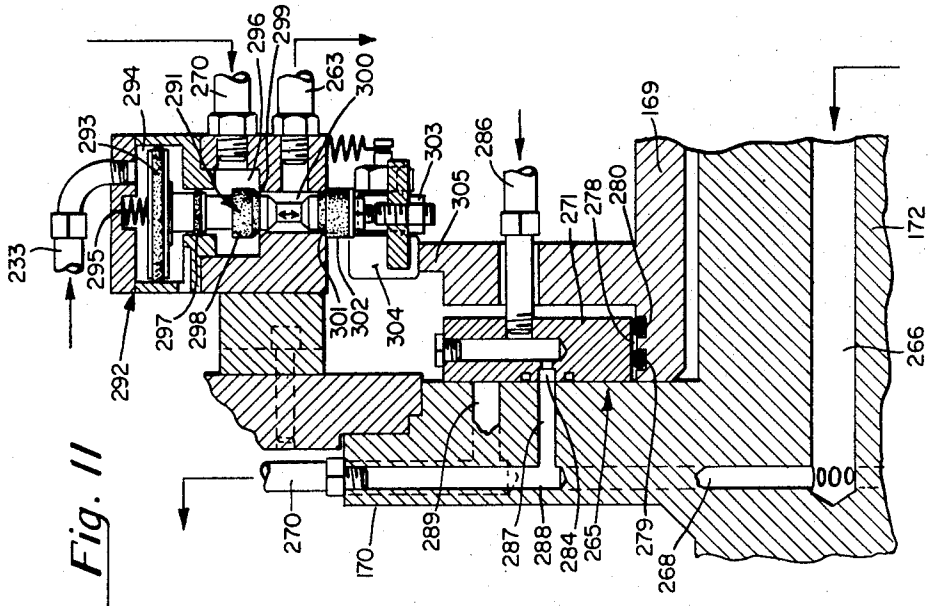


Fig. 11

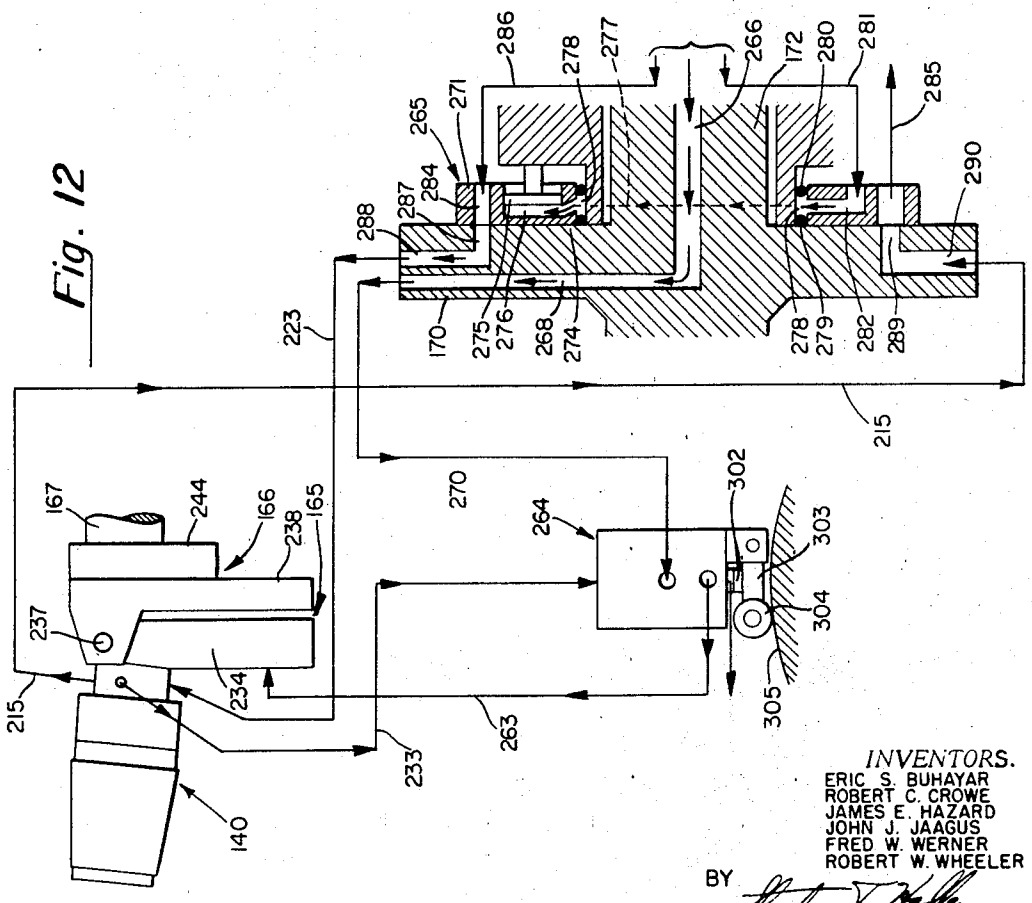


Fig. 12

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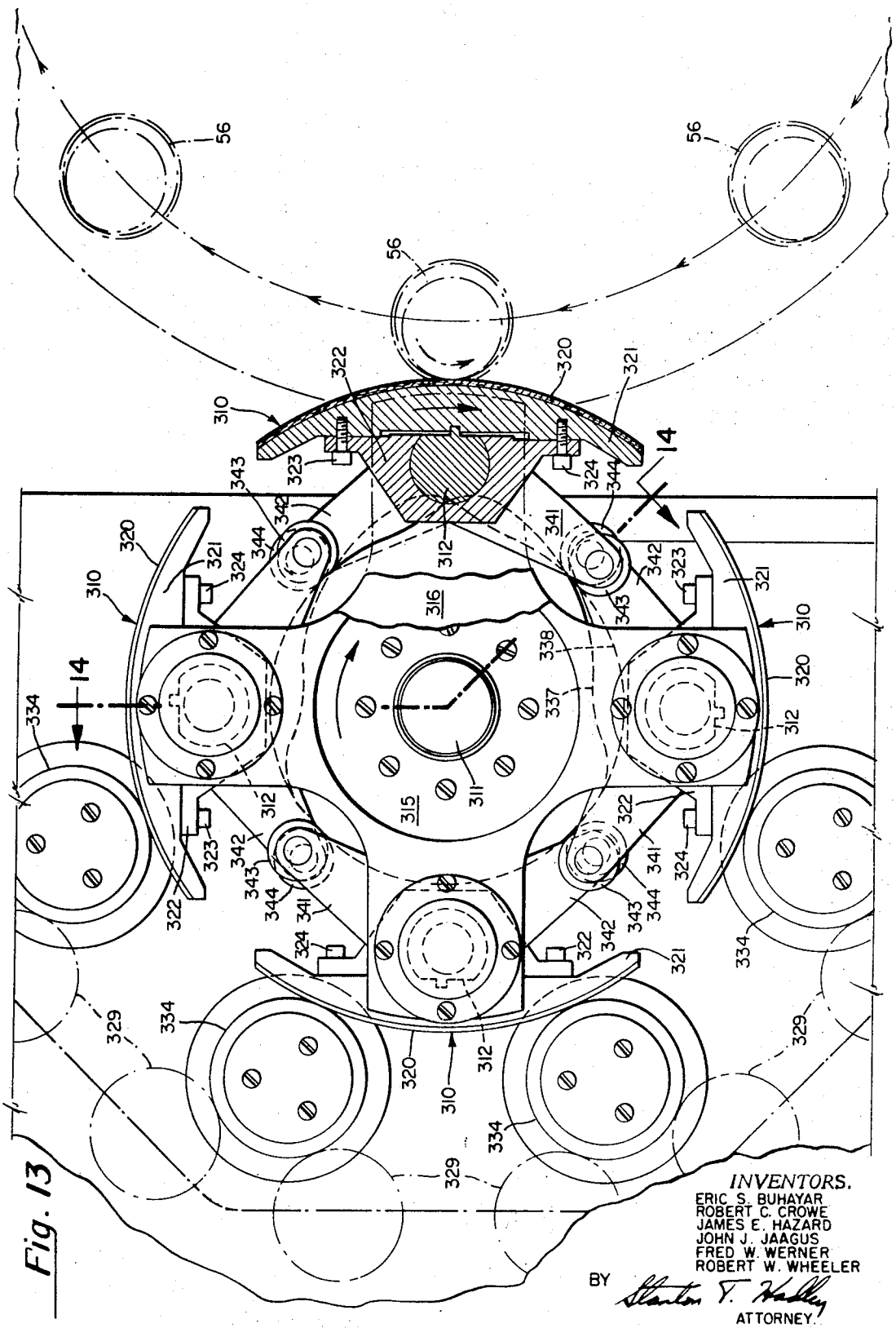


Fig. 13

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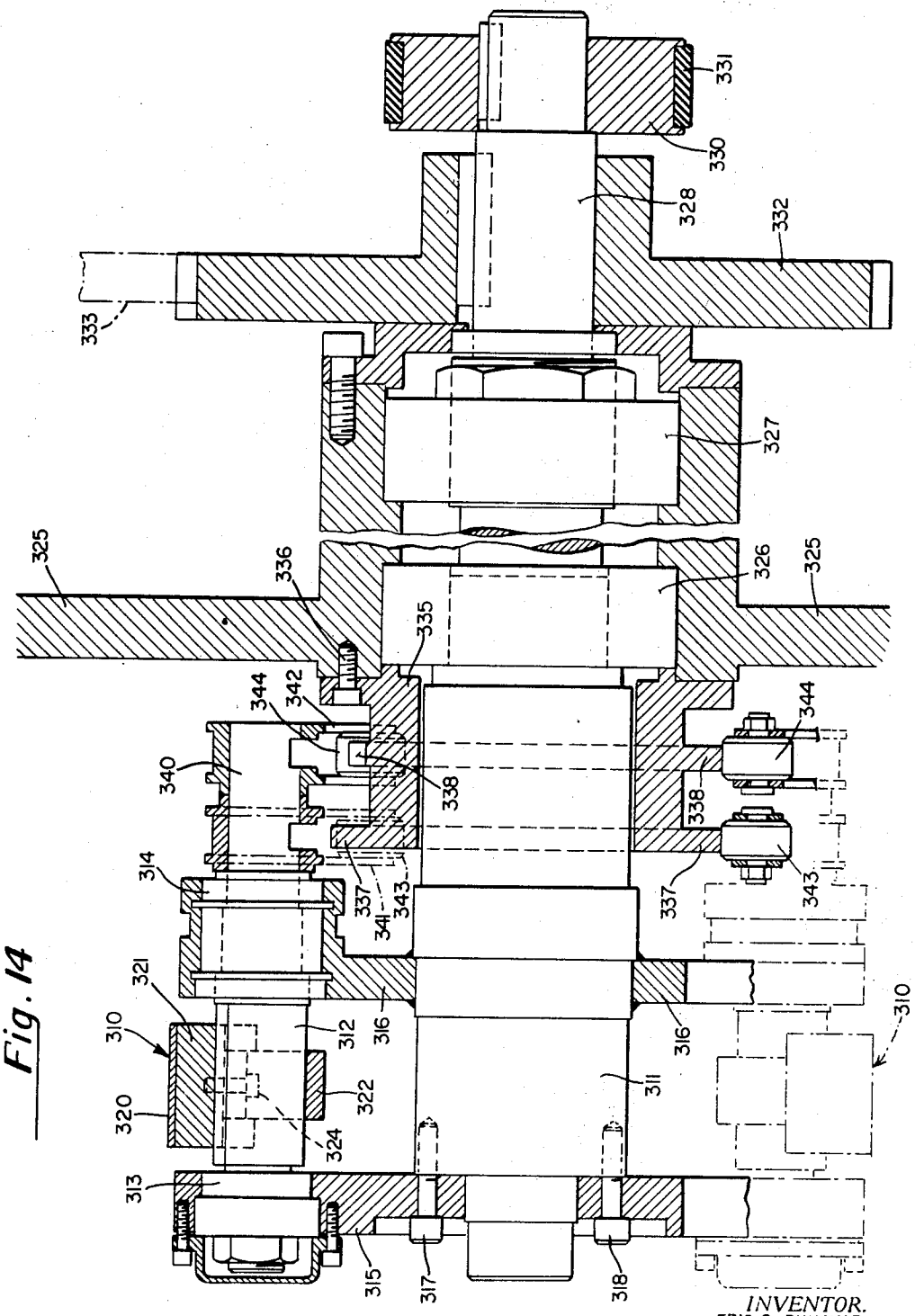
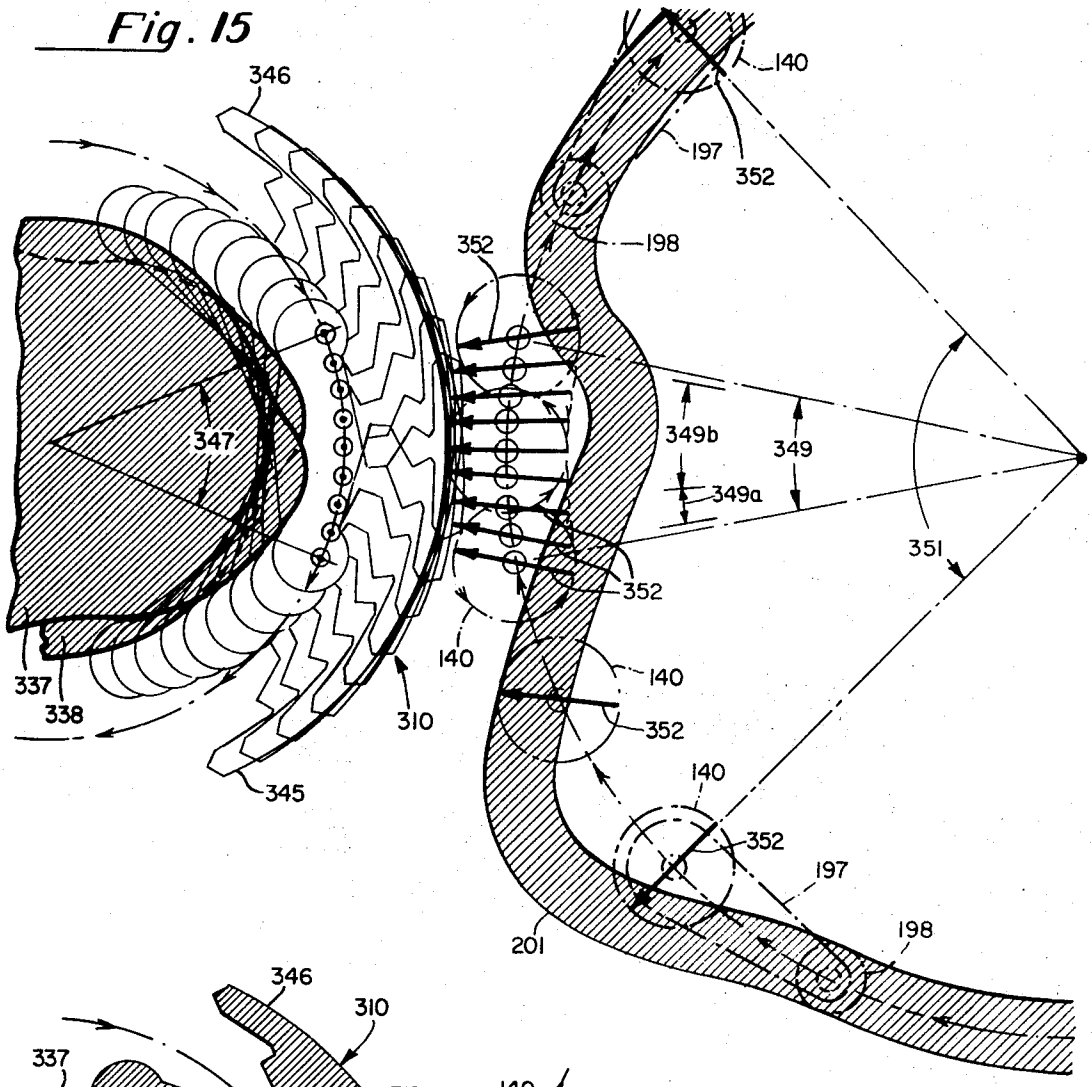


Fig. 14

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Fig. 15



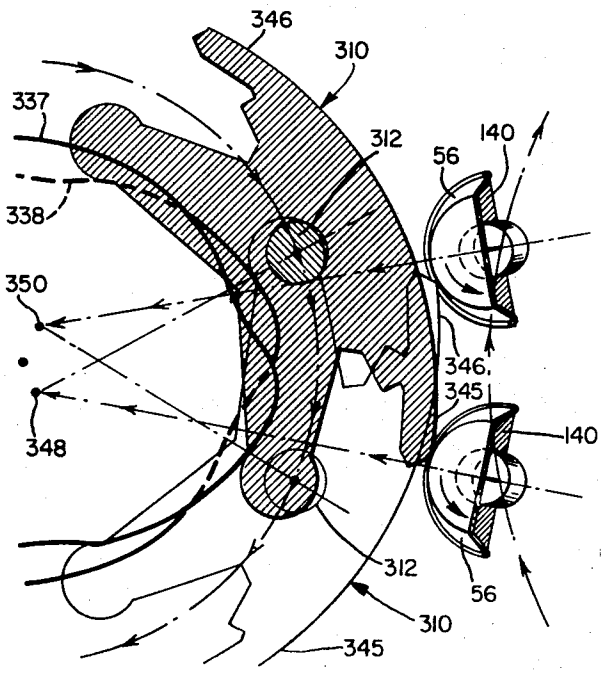


Fig. 16

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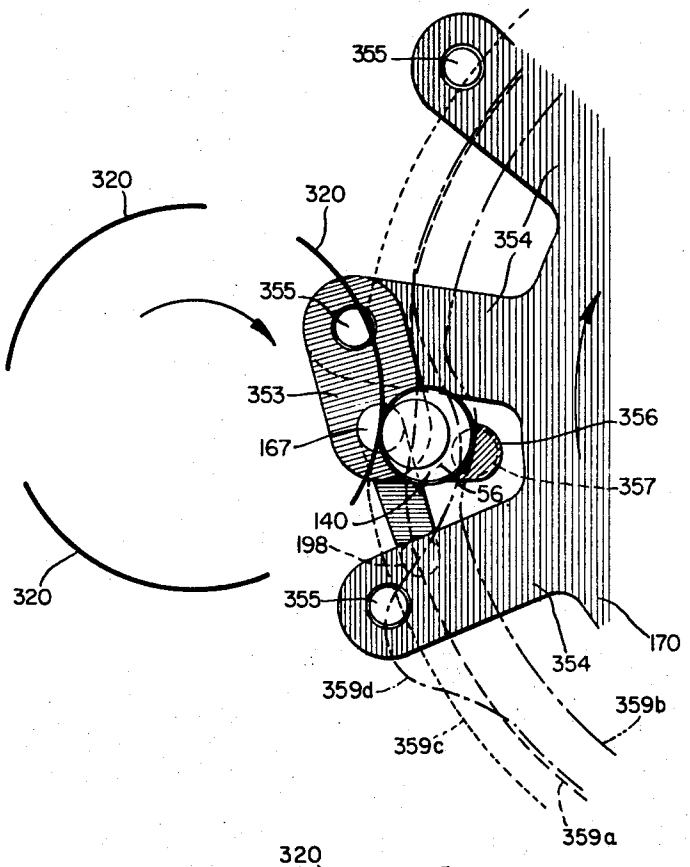


Fig. 17

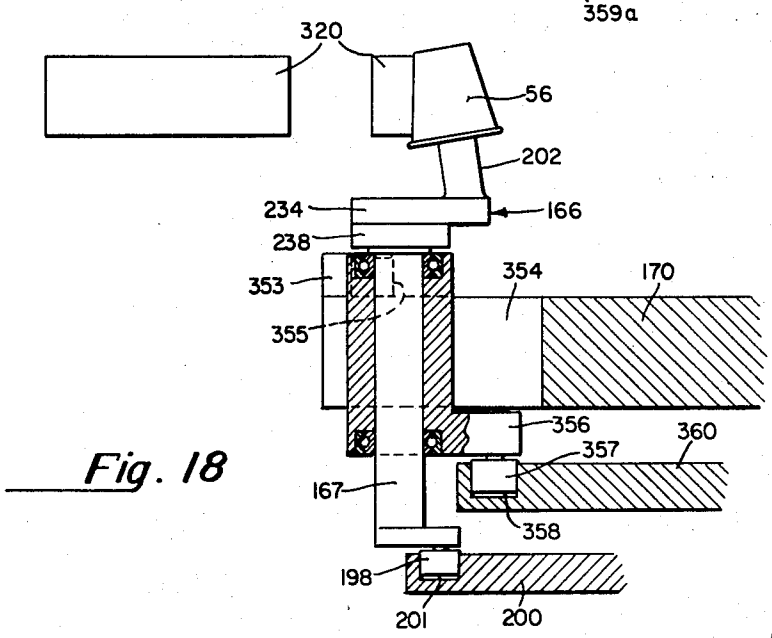


Fig. 18

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APPARATUS FOR PRINTING CONTAINER SIDEWALLS

This application is a division of U.S. Pat. application, Ser. No. 644,955, filed June 9, 1967, now abandoned, entitled METHOD AND APPARATUS FOR PRINTING CONTAINER SIDE WALLS.

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to an apparatus for printing and, more particularly, to an apparatus for printing container sidewalls.

In the broader aspects of the invention, the surface to be printed may be any printable exterior surface of revolution of an article, of which a container such as a cup or a can is one example, which surface appears either in a transitory or final stage of article formation. The articles to be printed or decorated preferably have a generally circular cross-section. Certain forms of the invention are particularly advantageous for decorating and printing hollow containers having either a cylindrical or a frusto-conical shape.

The term "cylindrical object" as used throughout the specification and claims is intended to include right cylindrical objects such as cans as well as other hollow objects whose outer surface is substantially a surface of revolution generated by the rotation of a line about an axis, including objects, such as cups and the like, which may have one or more frusto-conical surfaces. When the term "frusto-conical object" is used in the specification and claims, a cylindrical object as defined above which has at least one frusto-conical surface, such as a cup, is intended. It will be apparent and should clearly be understood that the invention relates to the treatment of these and other articles of a nature similar to that described above where this extension is warranted and practicable.

In some specific embodiments of the invention, the cylindrical or frusto-conical objects have an outwardly depending flange or lip which is contacted during treatment and handling of the object. Generally, containers such as cans have an outwardly depending raised strip or bead about the peripheral junction between one or both closed ends of the container and the adjoining sidewall. Similarly, containers such as cups generally have an outwardly depending bead or rolled lip disposed about the periphery of the open end.

This invention relates, in a more specific aspect, to a turret assembly and, more particularly, to a turret assembly adapted for moving cylindrical objects through a treatment stage where a treatment such as printing is performed on their sidewalls. One particular embodiment of this aspect of the invention is especially designed to handle frusto-conical objects. This embodiment of the apparatus is utilized in a specific embodiment of the over-all printing apparatus of the invention to receive frusto-conical objects from an object feeding unit and to move them in an oriented disposition through a treatment station, after which it feeds them to an object removal or take-off station, all of the above being done in continuous motion as distinguished from intermittent or indexed motion.

2. Description of the Prior Art

In the past, the printing of the sidewalls of cylindrical objects such as containers has been extremely difficult and laborious. This is especially true of frusto-conical objects having tapered sides and arises largely from the difficulty of moving the surface of the tapered sidewall relative to a printing blanket in a uniform manner to accomplish printing without smearing the image. The high volume use and concomitant low cost of such objects dictate that any treatment process must be performed at a very high speed in order to be economical. The printing of paper cups is often done on the paper material in the flat sheet condition prior to its formation into the frusto-conical or cylindrical shape. However, such treatment is not possible or practical in the printing of plastic cups where the material undergoes considerable deformation during the formation of a cup. It is clearly impossible to do on glass containers. Thus, to perform the printing step prior to formation in either of the above types of objects would result in the complete or substantial destruction of the image detail during formation.

The need for printing the side walls of containers has increased with the advent of thin walled plastic containers of solid sheet, foam, or laminates since these articles are generally formed at extremely high production rates by processes such as differential pressure forming, blowmolding, injection molding and the like. In addition to drinking cups, such articles are widely used in a large number of packaging and storage applications. In addition to decoration, it is desirable that the sidewalls of such containers and cups be printed to identify either the contents of the package, the manufacturer, or both.

Several economic aspects have a bearing on the printing problem. Such articles generally sell for a very low price which represents a nearly negligible fraction of the value of the package contents. Therefore, any printing process must be of sufficient low cost and high rapidity such that it adds very little to the cost of the article. In addition, any articles printed incorrectly must be discarded or, in some instances, ground to scrap and remolded. To achieve the above-mentioned low cost, manufacturers have to maintain a very low percentage of error and resulting scrap loss throughout the process of manufacture, including the printing stage. Thus, any printing process must be highly accurate and devoid of any treatment or handling which will damage the articles. This has been found difficult in the past at the high speeds required and with these types of articles.

In the past, printing systems have operated intermittently for separately positioning, stabilizing, and printing articles such as cups. Those familiar with mechanical devices can readily appreciate the speed limitations of intermittently operating apparatus. The inertia of the elements involved as well as the fragile nature of the article being treated makes it impracticable to consider treating more than about 150 to about 200 articles per minute. On the other hand, it generally has been thought to be too difficult to perform such an operation on articles of this nature in a continuous operation. Typical printing apparatus of the intermittently operating type is disclosed in U. S. Pat. No. 3,195,451 issued July 20, 1965 to J. C. Hovekamp et al.

Such printing apparatus as has been designed for continuous operation has been solely for the printing of the sidewalls of cylindrical cans, as distinguished from tapered sidewalls of frusto-conical objects such as cups. In this regard, see U. S. Pat. No. 3,261,281 issued July

19, 1966 to R. J. Hartmeister. In many respects, the complexity of this apparatus makes the problem of high speed printing of container sidewalls more foreboding. The rotating push rod assembly and dual can holding system of mandrels and retractable pockets dictate that the apparatus be made quite accurately and be adjusted carefully to insure reliability. While such apparatus might be used for printing metal cans, it is very doubtful that such apparatus could be used for printing more fragile objects such as containers or cups of paper, plastic, or glass.

In view of the above-mentioned difficulties and other deficiencies and shortcomings of the prior art, it was surprising to discover that reliable apparatus can be constructed which is capable of printing container sidewalls in a continuous manner, as distinguished from an intermittent manner, in an economical operation at much higher speed, on the order of **500** articles per minute and higher, with extremely low scrap losses due to article damage or printing inaccuracies in the high speed operation.

It is a principle object and advantage of the present invention to provide a method and apparatus for printing the sidewalls of cylindrical objects including frusto-conical cups or containers in a manner which not only overcomes many of the difficulties of the prior art, but which results in a number of significant advantages and improvements. In accordance with the invention, clear and accurate printing may be done on the sidewall of a cylindrical object by a continuous process which is extremely rapid and is quite economical. The printed image may consist of up to three or even more separate colors without encountering problems. The apparatus of the invention may be utilized to print in continuous operation the sidewalls of frusto-conical objects such as cups having tapered sides.

In order to successfully overcome the above-mentioned problems and to develope the printing apparatus and to carry out the printing method of the invention, it was found necessary to develop a number of ancillary methods and apparatus which form a part of the over-all printing method and apparatus but which are believed to have considerable application and utility separate and apart from the over-all printing method and apparatus. These developments arose from one or more of a variety of requirements such as the high speed continuous operation, the fragile nature of the article to be printed, and the shape of the surface to be printed.

In the manufacture of hollow cylindrical objects and especially frusto-conical objects such as cups and the like, such objects are generally transported between manufacturing stages in a stacked or nested condition so that they can be conveniently moved about in a minimum amount of space. These objects, especially when they are made of plastic or other materials are often quite brittle even though they possess some flexibility.

Unexpectedly, it was discovered that cylindrical objects such as cups can be separated or denested and fed onto mandrels moving through such an orbital path relative to the path of the objects. One aspect of the present invention is the ability to separate individual hollow cylindrical objects successively from one end of a stack of objects and to feed them onto a mandrel moving across the path of the objects at a remote point. This permits the mandrel to then convey the objects through a treatment stage in a supported condition.

It is an object of the invention to provide an apparatus arranged for placing hollow cylindrical objects onto a mandrel moving through an orbital path generally perpendicular to the path of the objects.

It is a further object and advantage of the invention to provide such an apparatus for handling such objects on a continuous basis rather than an intermittent basis.

One of the most difficult problems to be overcome in printing or treating cylindrical objects is to provide some means of firmly supporting the objects and moving them past the printing or treatment station. This problem is especially acute where the objects are containers made of relatively fragile materials such as paper or plastic. The supporting means must be designed to facilitate the engagement and removal of given cylindrical objects. All of the foregoing requirements are even more difficult to achieve when the printing or treatment operation is continuous rather than intermittent.

The intermittent systems of the prior art utilize turrets mounted for indexed operation and carrying mandrels for supporting containers. No means is provided for allowing emplacement, treatment or removal of containers while the turret is moving. The only known continuously operable equipment of the prior art employs a series of loose-fitting mandrels and retractable pockets for supporting containers. These were quite complex mechanisms and relied heavily on the strength of the container for their success. None of the equipment of the prior art provided any means for continuously printing tapered sidewalls of frusto-conical containers, and especially those made of relatively fragile materials.

The turret assembly of the present invention overcomes many of the difficulties of the prior art and has a number of new advantages. The turret assembly includes a number of rotatably mounted mandrels carried through a fixed orbital path about the turret axis. Means are also provided to spin successive mandrels as they pass through a portion of the orbital path to cause their surface to move at the speed required in the printing or treating operation. Where cylindrical objects or containers having tapered sidewalls are to be printed, the apparatus includes means to controllably alter the direction in which the tilted mandrel axis points as the mandrels are carried through the treatment section of the orbital path. In addition, the turret assembly of the invention includes a pneumatic system adapted to apply vacuum through the mandrel to grip or hold a container to the surface of the mandrel during certain portions of the orbital path and to apply pressure to loosen or release containers from the mandrels in other portions of the orbital path.

Accordingly, it is an object and advantage of the present invention to provide an apparatus for supporting a hollow cylindrical object and for moving it past a treating or printing station.

It is an additional object and advantage of the present invention to provide an apparatus for properly orienting a hollow cylindrical object having a frusto-conical configuration and tapered sidewalls as it is carried in supported condition through a treatment station.

It is a further object of the present invention to provide a mandrel carrying turret assembly including means for facilitating emplacement of containers upon and removal of containers from said mandrels while the turret assembly is continuously moving.

Printing of container sidewalls in an intermittent operation is normally accomplished by one or more print blankets arranged about the periphery of a cylinder. In some instances the surface of the container is contacted by the print cylinder and the container is rotated in a fixed position. In the case of hollow cylindrical objects having large inertia, the objects may be separately rotated at a speed equal to the speed of the print blanket to avoid smearing of the printed image caused by slippage due to inertia.

The above method is generally unacceptable where a hollow cylindrical object is to be printed in a continuous operation while moving through an orbital path. The arcuate print blanket would have, in theory, only a momentary single line of contact with the surface of the object as it momentarily moved through a position of incidence or engagement with its surface. Therefore, some means was required of maintaining surface contact between the hollow cylindrical object and the print blanket during movement of the rotational axis of the cylindrical object relative to that of the print blanket.

Suprisingly, two ways of achieving this objective were discovered. One method is to move the mandrel, carrying the object, out of its circular orbital path and into a revised path during the printing stage in which it generally follows the periphery of the print blanket cylinder. Another more preferred method is to actuate the print blankets in a rocking motion to cause the object-contacting line on the print blanket to move through an arc path corresponding to a portion of the orbital path of the object carried on the mandrel.

Accordingly, it is an object of the present invention to provide an apparatus for enabling longer surface contact between a moving print blanket and a surface carried through an orbiting path.

It is a further object of this invention to provide such an apparatus by which a mandrel carrying a cylindrical object through an orbital path is moved out of its circular orbital Path into a revised path following the periphery of the print blanket cylinder.

These and other objects and advantages of the invention will become apparent from the detailed description of specific embodiments thereof which follow.

BRIEF SUMMARY OF THE INVENTION

The high speed continuous printing, treating, and handling apparatus of the invention includes a turret assembly which has a rotatably mounted frame, a plurality of support mandrels mounted for rotation and carried by the frame through an orbital path. Successive mandrels are substantially equidistantly spaced from one another. The orbital path has a plurality of functional sections including an object pickup section, an object rotate section, and object print section, and and object removal section. Feeding means are included for serially advancing cylindrical objects in a line and include object separating means for increasing the relative distance between the leading object and successive objects in the line. The feeding means are adapted to advance successive cylindrical objects toward the turret assembly and to place them onto successive support mandrels carried by the rotatably mounted frame through the object pickup section of the orbital path. Rotating means are included for imparting axial spin to successive support mandrels carried by the rotatably mounted frame through the object rotate section of the orbital path. Printing means are included for applying decorative indicia to the exterior cylindrical surface or sidewall of successive cylindrical objects carried by support mandrels through the object printing section of the orbital path. The printing means include at least one arcuate print blanket, a source of decorating material to be applied to the surface of the object to be decorated, at least one transfer means disposed between the source of decorating material and a position of interference with the rotating print blanket and adapted to transfer decorating material to the print blanket for application to the surface to be decorated. The print blanket is mounted for rotation about a first axis and intermittent rocking movement about a second axis parallel with the surface of the print blanket and perpendicular with the direction of movement of the print blanket, the rocking movement occuring at least during the period of time when the print blanket contacts the surface of the cylindrical object to be decorated. Handling means are included for removing decorated objects from successive mandrels as they are carried through the object removal section of the orbital path. The handling means include conveying means spaced from the mandrels carried by the rotatably mounted frame through the object removal section of the orbital path and pickoff means for gripping the cylindrical objects and for transferring them to the conveying means. Drying means are included for drying the decorating material on the surface of the cylindrical objects and include means to rotate the object while applying heat to the surface thereof. Drive means are included to drive the rotatably mounted frame, the rotatably mounted print blanket, the rotating means, the feeding means, and the object removal means, in a substantially constant speed relationship to one another.

A more specific embodiment of the invention which is adapted to treat hollow objects having a frusto-conical configuration, includes mandrels having tapered sides and a frusto-conical shape. The mandrels have their rotational axes inclined relative to the rotational axis of the turret assembly so that the line of contact of the tapered side of the mandrel with the arcuate print blanket is substantially parallel to the axis of rotation of the print blanket.

The invention also includes a method for decorating the exterior cylindrical surface or sidewall of cylindrical objects having one open end, one closed end, an upstanding sidewall, and a peripheral flange extending outwardly therefrom. This method is applicable to cylindrical objects including those having either a right cylindrical or a frusto-conical configuration. In the method, cylindrical objects are individually separated and fed from a source. The objects are successively placed onto moving mandrels which cross their path at a remote point. The objects are continuously moved in supported condition upon the mandrels through an orbital path including an object rotate section, an object treatment section and an object removal section. As the cylindrical objects pass through the object rotate

section and before they move through the object treatment section, a rotational moment is applied to cause them to rotate about their axes. The exterior surface of successive objects is treated as each object moves in continuous motion through the object treatment section of the orbital path after which the objects are removed from the continuously moving mandrels as they pass through the object removal section.

The invention includes a turret assembly for supporting hollow cylindrical objects for treatment of the outside surface thereof by a continuous object treatment process. The turret assembly has a frame mounted for rotation in a plane about a rotational axis. A plurality of object support mandrels are carried by the frame through an orbital path which has an object pickup section, an object rotate section, an object treatment section and an object removal section. The mandrels have an outside surface configuration conforming substantially to the inside surface configuration of the cylindrical objects. Driving means are provided for rotating the frame. Object rotate means **24** are provided for applying a rotational moment to mandrels carried through the object rotate section of the orbital path to cause the outside surface of the objects carried thereon to attain a predetermined rotational speed. Some embodiments of the turret assembly have mandrels mounted for radial movement relative to the rotational axis of the frame and include mandrel actuation means adapted to change the distance between the mandrels and the rotational axis of the frame during rotation of the frame and a pneumatic system for detecting the presence and absence of a cylindrical object on successive mandrels. The pneumatic system is operably connected to the mandrel actuation means so that the distance between successive mandrels and the rotational axis of the frame is controlled in response to the presence or absence of an object upon the respective mandrels.

The invention also includes a method for continuously moving hollow cylindrical objects in supported condition through an object treatment process. The method includes moving the objects along a path through a treatment station, and applying a rotational moment to the objects to cause them to rotate about their axes prior to movement through the treatment station. The angular orientation of the rotational axis of each of the cylindrical objects relative to the path is controllably varied as the objects are carried through the treatment station so that the portion of the exterior surface of the rotating object being treated which momentarily is nearest the treatment station is uniformly spaced therefrom along the length of the cylindrical object as it moves in rotation along the path.

The invention is useful with an apparatus for printing indicia on the exterior surface of hollow cylindrical objects. The apparatus includes support means for carrying an object through a curvilinear orbital path about a fixed axis and rotating means for rotating the cylindrical object about its axis in a direction counterrevolutionary to the curvilinear direction of the orbital path. At least one pivotably mounted arcuate print blanket having a printing surface containing an image is provided which is adapted for pivotal movement about a pivot axis parallel with its axis of curvature. The print blanket has a leading end and a trailing end and is mounted for rotation through an orbital path about a rotational axis more remotely spaced from the print blanket than is the pivot axis. Drive means are provided for rotating the print blanket about its rotational axis in a direction counterrevolutionary to the direction of rotation of the object. Actuating means are operably connected to the print blanket to effect controlled pivotal movement of the print blanket about the pivot axis so that contact of the exterior surface of the cylindrical object is maintained along a line with a continuous changing portion of the printing surface of the arcuate print blanket while the rotating object is carried in continuous motion through a printing section of the orbital path. Generally, the leading end of the print blanket is initially advanced radially outwardly from the rotational axis as it approaches the oncoming surface of an object to be printed and is gradually withdrawn radially inwardly toward the rotational axis as the object is carried through the printing section of the orbital path while the trailing end of the print blanket is advanced radially outwardly.

The invention has been generally described and some of its features pointed out in the foregoing. Specific embodiments will now be described with reference to the accompanying drawings in which like reference characters have been used to refer to like parts wherever they may occur.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective view of a specific embodiment the high speed continuous printing, treating, and handling apparatus of the invention,

FIG. **2** is a sectional end elevation view of a specific embodiment of a turret assembly of the invention, employed with the apparatus shown in FIG. **1**,

FIG. **3** is a sectional side elevation view taken along line **18—18** of FIG. **2**, FIG. **4** is a sectional view taken along line **19—19** of FIG. **3**, illustrating the manner in which the control valves are cam actuated,

FIG. **5** is a sectional view taken along line **20—20** of FIG. **3**, illustrating the manner in which the plate valve is connected to the control valves, the mandrels, and the mandrel tilting cylinder,

FIG. **6** is a sectional elevation view showing the detailed construction of a mandrel and its supporting assembly, taken along line **21—21** of FIG. **5**,

FIG. **7** is a sectional view taken along line **22—22** of FIG. **6**, illustrating the manner in which the mandrel tilt angle is adjusted,

FIG. **8** is a sectional view through the central portion of a mandrel core taken along line **23—23** of FIG. **6**,

FIG. **9** is a sectional view through a mandrel taken along line **24—24** of FIG. **6**, showing internal passages in the mandrel,

FIG. **10** is an end view of a mandrel taken along line **25—25** of FIG. **6**,

FIG. **11** is a sectional elevation view of a control valve taken along line **26—26** of FIG. **4**,

FIG. **12** is a schematic flow diagram of a pneumatic system employed in the apparatus of the invention,

FIG. **13** is a side elevation view of object printing apparatus used with the turret assembly of the invention,

FIG. **14** is a sectional view of the object printing apparatus taken along line **29—29** of FIG. **13**,

FIG. **15** is a diagrammatic elevation view illustrating sequential stages of motion of the printing blanket and

a moving object to be printed which occur upon operation of the object printing apparatus used with the turret assembly of the invention,

FIG. 16 is a diagrammatic elevation view of a portion of the object printing apparatus used with the turret assembly of the invention showing two positions of the printing blanket relative to a moving object to be printed,

FIG. 17 is an elevation view of an alternative embodiment of a turret assembly of the invention and,

FIG. 18 is a sectional view taken along line 33—33 of FIG. 17,

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. 1 illustrated a preferred embodiment of high speed continuous printing, treating and handling apparatus of the invention. The apparatus illustrated in FIG. 1 is adapted for the decoration of the exterior surfaces of frusto-conical objects having tapered sidewalls and one open end such as plastic cups and the like. Such cups generally have a radially outwardly depending flange or bead which forms the lip of the cup. With slight modification of certain minor aspects in a manner which would be generally understood by one skilled in the art and as pointed out to some degree throughout this description, the apparatus can also be used to decorate the exterior surfaces of other types of cylindrical objects, including right cylindrical objects such as metal or plastic cans and the like. These objects generally have a peripheral raised strip or bead at one or both ends, allowing them to be handled in a similar manner.

The apparatus includes as elements thereof the following subassemblies, indicated generally by the respective reference numeral: object feeding apparatus **50**, object printing apparatus **51**, object removal apparatus **52**, a turret assembly **53** for receiving objects from the object feeding apparatus **50** and for moving them past the object printing apparatus **51** to a position where they are transferred to the object removal apparatus **52**, and object drying apparatus **54** arranged for receiving objects from the object removal apparatus **52** and for drying or curing decorating material applied to the surfaces of said objects by the object printing apparatus **51**. In its broader aspects, the invention includes embodiments of the apparatus described above in which object printing apparatus **51** is replaced with other apparatus for treating the surfaces of objects while they are moved through the treatment in a supported condition by the other apparatus of the invention. For example, object printing apparatus **51** could be replaced by embossing apparatus for texturizing the surface of cylindrical objects such as cups to impart certain frictional or insulating characteristics.

The object feeding apparatus **50** shown in FIG. 1 includes stack advancing means **57**, denesting means **58** and feeding means **60**. The stack advancing means **57** receive a stack **55** of nested cups **56** arranged with their axes in a horizontal position and their open ends disposed in the direction in which they are to be fed. The stack **55** is urged forward toward turret assembly **53** by a portion of stack advancing means **57** to a point where the lips of cups **56** in the stack are frictionally engaged by another portion of stack advancing means **57** which causes the portion of the stack **55** preceding the gripped cups **56** to be advanced forward with a greater force than the remainder of the stack **55** and rotates the cups **56** in the preceding portion of the stack about their axes. Generally, the trailing portion of the stack is not rotated but is merely urged in a forward direction until gripped.

The lead cup **56** in the preceding rotating portion of the stack **55** is gripped at spaced points about its peripheral flange or lip by the denesting means **58** and separated from the next successive cup in the stack **55** by rapid advance in a forward direction at a rate substantially greater than the rate of advance of the trailing portion of the stack **55**. The cup **56** thus separated from the stack **55** is gripped at spaced points about its peripheral flange by feeding means **60** and transferred in the forward direction to a point where it is received by cup support means **61** on the turret assembly **53**. The placement of the cup **56** onto the cup support means **61** of the turret assembly **53** is accomplished at high speed in continuous motion and is facilitated by supporting the cup **56** to be placed upon the turret assembly **53** in a predetermined position by feeding means **60** prior to its placement and in a manner allowing movement of the cup **56** in the direction of motion of the cup support means **61** of the turret assembly **53** during the transfer.

The transferred cup **56** is then carried in a supported condition upon cup support means **61** of the turret assembly **53** through an orbital path along which the surface of the cup **56** is decorated and after which the cup **56** is removed from the turret assembly **53**. Turret assembly **53** includes a rotatably mounted frame **62** upon which cup support means **61** are rotatably mounted in a manner permitting each cup **56** to rotate about its axis. Driving means (not shown) are provided to rotate frame **62**. In addition, object rotate means **64** are provided which apply a rotational moment to cups **56** as they are carried through their orbital path. In some embodiments, means (described below with reference to FIGS. 17 and 18) are provided in the turret assembly **53** to move successive cups through a modified orbital path as they are carried past the object treatment apparatus to lengthen the interface time between the surface of the cup **56** and the object treatment apparatus while maintaining the cup **56** in continuous motion.

Where frusto-conical objects such as cups **56**, as distinguished from right cylindrical objects, are being treated as shown in FIG. 1, by object printing apparatus **51** in continuous motion, the cups **56** are carried by the turret assembly **53** in a manner in which their rotational axes are inclined relative to the rotational axis of the turret assembly **53**. In addition, axis control means **65** are provided to controllably alter the direction of inclination of the axes of the cups **56** as they are carried by turret assembly **53** past the object printing apparatus **51** along their orbital path and at least during that portion of their travel in which contact is had between the continuously moving surface of the cup **56** and the object printing apparatus **51**. Axis control means **65** operate upon cup support means **61** to change the direction of inclination of the axes of the cups **56** relative to a given radial through the rotational axis of turret assembly **53**. These provisions enable an image to be transferred from a cylindrical print blanket to the

frusto-conical cup surface. In addition, object printing apparatus **51** is designed to enable contact with the continuously moving surface of the continuously moving cup **56** over a period of time in which the cup **56** is carried a discrete distance along its orbital path. This makes possible the treatment of the cup surface in continuous motion which is one of the significant features of the invention.

The cup is then carried along its orbital path to a point where it is contacted by the object removal apparatus **52**. The closed end of the cup is engaged by object engagement means **66** of object removal apparatus **52**. Object engagement means **66** is connected by linkage means **67** to an actuating means **68** which is designed to cause movement of the cup **56** carried by object engagement means **66** through a predetermined motion path to a conveying means **70**. The cup is carried to a point where it is gripped by conveying means **70** at spaced peripheral points about its outwardly depending flange and deposited upon a surface also forming a portion of conveying means **70** for transfer to the object drying apparatus **54**. During the removal of the cup **56** from the turret assembly **53**, contact with the exterior sidewall of the cup is avoided so that the wet or uncured decorating material thereon is not smeared.

The cup **56** is then transferred to conveyor means **71** of the object drying apparatus **54** for drying or curing the decorating material on its sidewalls. In drying apparatus **54**, the cup **56** is rotated about its axis while heat is applied by heating means **72** to its exterior surface, rotation being imparted to cups **56** by guide means **73** which move the cups transversely across conveyor means **71** during a portion of their travel. In some instances, decorating material is used which requires a combination of heating and cooling to dry, cure or set it, and certain embodiments of the apparatus include cooling means in the object drying apparatus **54**.

FIGS. **2** and **3** illustrate in greater detail the turret assembly **53** of the invention by means of which cups **56** disposed upon mandrels **140**, shown in greater detail in FIG. **6**, are carried in a circular orbital path through a treatment process, such as printing. Thus, the orbital path has a pickup section **160** in which cups **56** are placed upon mandrels **140**, a rotate section **161** in which the mandrels **140** and the cups **56** carried thereon have spin imparted to them so that they rotate about their axis as they are carried through the orbital path, a treatment section **162** in which the surface of the cups **56** is treated as by printing or decorating, and a removal section **163** in which cups **56** are moved from mandrels **140** and transferred to a remote point. These sections are indicated in FIG. **2** for the process performed by the apparatus shown in FIG. **1**.

The apparatus shown in FIGS. **2** and **3** is adapted for the printing of the external sidewalls of frusto-conical objects such as plastic cups **56**. Thus, the mandrels **140** are mounted for rotation about axes disposed at a slight angle of inclination to the rotational axis of the frame **62** in a direction generally radially outward from the rotational axis of the frame **62**. In addition, mandrel axis control means **65** are provided for altering the direction of inclination of the rotational axis of the mandrels **140** with respect to a given radial extending from the rotational axis of the frame **62** as the mandrels **140** are carried through the object treatment section **162** of the orbital path. FIG. **3** illustrates one type of mandrel axis control means **65**.

FIGS. **2** and **3** also illustrate mandrel tilt angle control means **165** for controlling the angle of inclination of the mandrel axis relative to the rotational axis of the frame **62**. Mandrel tilt angle control means **165** also enable withdrawal of mandrels **140** radially inward toward the rotational axis of frame **62** and out of contact with treating apparatus when no object is carried on mandrel **140**, the above being controlled by a pneumatic system which is described below. Details concerning the mandrel tilt angle control means **165** and their operation are described in greater detail below with reference to FIGS. **6**, **7** and **12**.

A pneumatic system, schematically illustrated by FIG. **12**, and illustrated in part by FIGS. **3**, **6** and **8** through **11**, is provided in the turret assembly **53** to control the gripping of cups **56** by the mandrels **140** as mandrels **140** move through the object rotate section **161** and the object printing section **162** of their orbital path. The pneumatic system also provides a means for releasing cups **56** from the mandrels **140** after they pass through the printing section **162** of the orbital path and before they arrive at the object removal section **163** of the orbital path. The gripping function is performed by a vacuum system operating through openings in the surface of mandrel **140** which holds the cup **56** firmly to the surface of the mandrel **140** and the removal function is accomplished by supplying pressurized air to the interior of the cup **56** through a passageway in mandrel **140** to blow it at least partially off of the mandrel **140**. The pneumatic system of turret assembly **53** also provides a means for detecting the presence or absence of a cup **56** on mandrel **140**. An abutment member **164**, shown clearly in FIG. **1**, is disposed adjacent the closed ends of cups **56** carried by mandrels **140** through the section of the orbital path between the printing section **162** and the object removal section **163**. This abutment member **164** limits the extent of removal of cups **56** from the mandrels **140** by the application of compressed air to their interiors until they have been placed in a position where they will be engaged by object removal apparatus **52**.

Referring now to FIGS. **2** and **3**, each mandrel **140** is attached to a mandrel supporting assembly **166** which is carried on the ends of a shaft **167** which is rotatably mounted on a turret plate **170** spaced apart from another turret plate **171**. Plate **170** forms a portion of the rotating frame **62** of the turret assembly **53** of the invention. Plate **170** is fixedly secured to a radial flange **168** of an axle **172** which is rotatably journaled in bearings **173** and **174** carried on end support members **175** and **176**. Turret plate **171** comprises a radial flange of a hub member **169** secured by bolts to end support member **176**. A portion **177** of axle **172** extending beyond end support member **176** is keyed to a drive wheel **178** mounted thereon about which a toothed timing belt **180** is arranged in partial wrapping engagement. The belt **180** connects wheel **178** to a drive motor (not shown) to drive axle **172**. A second drive wheel **181** mounted upon and keyed to portion **177** of axle **172** is connected by a toothed timing belt **182** to a printer unit **51** which forms the treatment apparatus of the embodiment shown and is described below.

Between turret plate 170 and end support member 175, a portion of axle 172 carries a cylindrical sleeve 183 which is eccentrically mounted about the axle 172 and secured to end support member 175 having been positioned from annular flange 184 extending about axle 172 from end support member 175 by means of set screws 185 and 186 acting against flange 184. By adjusting set screws 185 and 186, it is possible to control the degree of eccentricity. Cylindrical sleeve 183 carries bearing assemblies 187 and 188 upon which is rotatably mounted a second cylindrical sleeve 190 having a radially outwardly depending peripheral flange 191 connected to sleeve 190 by a spider 189 forming a portion of the object rotate means 64 for imparting rotation or spin to the mandrels 140. Cylindrical sleeve 190 is driven by a poly-V-belt 192 which is carried in partial wrapping engagement therewith and extends to a drive wheel (not shown) fixedly mounted on a drive shaft (not shown) connected through a speed control device (not shown) to a drive motor (not shown). Flange 191 has a peripheral strip 193 of elastomeric rubber-like material which has a relatively high coefficient of friction. The outer peripheral surface 194 of strip 193, which contacts the mandrels 140 as they are carried through the object rotate portion 161 of their orbital path, is slightly beveled to conform with the shape and inclination of the portion of the mandrel 140 contacted which, in the case of frusto-conical objects, such as cups 56, is inclined outwardly, as shown in FIG. 8.

Mandrel 140 and mandrel supporting assembly 166 are carried on the end of shaft 167 which is rotatably journaled by bearings 195 and 196 in the outer periphery of rotatable turret plate 170. The rotational axis of shaft 167 is parallel with the rotational axis of frame 62 while, as pointed out above, the rotational axis of mandrel 140 is inclined radially outwardly from the rotational axis of frame 62.

FIGS. 3 and 4 illustrate one means for controlling the direction of inclination of the rotational axis of the mandrel 140 as it is carried through a portion of its orbital path. The mechanism shown in FIGS. 3 and 4 changes the direction of inclination of the mandrels 140 by rotating the shaft 167 about its axis in a controlled manner during the treatment section 162 of the orbital path. Shaft 167 has an arm 197 attached to its end remote from the mandrel 140 which carries a follower wheel 198 in rotation thereon. A cam plate 200 is fixedly secured to stationary turret plate 171. Cam plate 200 has a camming groove 201 cut into its surface which faces and receives follower wheel 198. The follower wheel 198 rides in camming groove 201 which follows a predetermined path thus controlling the pivotal movement of the shaft 167 about its axis by means of arm 197. During the portion of the orbital path when the cup 56 carried on the mandrel 140 is being treated, the groove 201 follows a path other than circular which is predetermined to direct the inclination of the mandrel axis in a prescribed manner.

FIG. 6 illustrates in greater detail the construction of mandrel support means 166 and the mandrel 140 itself. Mandrel 140 includes a stationary inner core 202 having a tip portion 203 of smaller diameter, a central portion 204 of larger diameter and a base portion 205 of a smaller diameter terminating in peripheral threads 206 about the end of base portion 205. A mandrel shell 207 is rotatably carried on stationary core 202 by means of bearing assemblies 210 and 211. Shell 207 has a tapered portion 212 made of tow or more pieces fastened together which is adapted to receive a hollow frusto-conical object such as a cup 56, and a cylindrical portion 213 adjacent central portion 204 of core 202 which is attached by bolts 214 to tapered portion 212 so as to rotate therewith. The object rotate means 64 shown in FIG. 1 and, more specifically, as flange 191 and strip 193 in FIG. 3, contact the surface of cylindrical portion 213 of mandrel shell 207 to impart rotation to the mandrel 140 and an object carried thereon.

FIGS. 8 through 10, in conjunction with FIG. 6, illustrate the configuration of passageways through mandrel 140 which allow the flow of air through the mandrel 140 to the interior of a cup 56 carried thereon for purposed to be described.

In the apparatus shown in FIG. 1, it has been found desirable to provide means for applying vacuum through the mandrel 140 to the interior of the cup 56 carried thereon prior to its passing through the object rotate section 161 and the object treatment section 162 of its orbital path to seat and firmly hold the cup 56 on the tapered surface 212. Vacuum enters through a conduit 215 which is secured to central portion 204 of core 202. Core 202 has a passageway 216 extending along its rotational axis from the point where conduit 215 enters to the end of tip portion 203. The passageway 216 is divided into three sections 217, 218 and 220 along a portion of its length through central portion 204 by a T-shaped insert 221 shown more clearly by sectional views in FIGS. 8 and 9. The passageway 216 is divided into two portions 217 and 218 by the extension of insert 221 through the tip portion 203 of core 202 and opening out into a concave recess 222 in the end of tapered portion 212 of mandrel shell 207, as shown in FIG. 10. Before the mandrel 140 is carried through the object rotate section 161 of the orbital path, vacuum is applied through conduit 215 and through section 217 of passageway 216 to create a vacuum within recess 222 between the closed end of a cup 56 on the mandrel 140 and the surrounding surface of mandrel shell 207. This causes a cup 56 to be drawn tightly into frictional engagement with tapered surface portion 212 of mandrel 140.

Additionally, it has been found desirable to apply air pressure through the mandrel 140 to the space between the tapered surface 212 of the mandrel shell 207 and the interior surface of a cup 56 carried thereon as well as to concave recess 222 to assist in stripping or removing the cup 56 from wedged engagement with the tapered surface 212 of the mandrel shell 207 prior to its reaching the object removal section 163 of the orbital path. Thus, compressed air is fed through a conduit 223 which connects with passageway 216 through central portion 204 of core member 202. Compressed air is fed into section 220 of passageway 216 and flows through the passageway 216 into an annular passageway 224 by means of a radial passageway 225 through core 202. This arrangement allows continuous flow of compressed air from stationary core 202 into radial holes 226 in rotating shell member 207 leading to an annular chamber 227 within shell 207. Annular chamber 227 connects to an outer annular chamber 228 within shell

207 by means of inclined passages 230. Compressed air fed to passageway 216 and introduced into outer annular chamber 228 is emitted laterally outwardly by means of a radial gap in shell 207 to grooves 231 running toward the end of tapered portion 212 of shell 207. The grooves 231 are recessed into the surface of the tapered portion 212 of shell 207, allowing the passage of compressed air beneath the inner surface of a cup 56 disposed thereon. The grooves 231 do not extend toward cylindrical portion 213 of shell 207 as far as the end of a cup 56 disposed on the tapered portion 212 of the rotatable shell 207. Longitudinal passageways 232 also connect outer annular chamber 228 with the concave recess 222 at the end of rotatable shell 207 to allow direction of compressed air fed therethrough against the closed end of a cup 56 disposed on tapered portion 212. The combination of air flowing along the sides of the cup 56 as well as air directed against the end of the cup 56 acts to release the cup 56 from its wedged disposition on the tapered portion 212 of the rotatable shell 207 to facilitate its removal from the mandrel 140.

Furthermore, it has been found desirable to provide a third passageway system operating through the mandrel 140 to enable a fluid pressure detection system (described below) to operate and to determine the presence or absence of a cup 56 on the tapered portion 212 of the mandrel shell 207. Should a cup 56 be missing from a mandrel 140, the detection system acts to withdraw the mandrel 140 radially inwardly toward the rotational axis of the turret assembly 53 so that contact of the mandrel with the treatment apparatus is avoided. A conduit 233 is connected to passageway 216 through central portion 204 of core 202. Conduit 233 connects to section 218 of passageway 216 and opens into the concave recess 222 between the end surface of rotatable mandrel shell 207 and the closed end of a cup 56 carried thereon. If a cup 56 is present on the mandrel 140, upon the application of a vacuum pump (not shown) to conduit 215, a vacuum will be quickly created in section 217 and at the outer end of passageway 216 and also in section 218 and conduit 233. However, if no cup 56 is present on the mandrel 140, the application of a vacuum pump to conduit 215 will not create a vacuum in section 218 of passageway 216 or in the conduit 233. The application of the vacuum created in conduit 233 through the above arrangement to prevent withdrawal of the mandrel 140 radially inward toward the rotational axis of the turret assembly 53 is described below.

The base portion 205 of core 202 is inserted through a hole through a pivotal member 234 and secured thereto by a threaded nut 235 engaging peripheral threads 206 and bearing against a lock washer 236. Pivotal member 234 is pivotably connected at one end by a pin 237 to a base member 238, the pivotal member 234 and the base member 238 comprising a portion of the mandrel support assembly 166. The pivotal member 234 is connected at its opposite end to the base member 238 by bolts 240 passing through the members 234 and 238. The end 241 of each bolt 240, seated within pivotal member 234, retains a compressed spring 242 which urges the end of pivotal member 234 toward base member 238.

The base member 238 is slideably mounted by a keyway 243 upon a fixed plate 244 secured to the end of mandrel shaft 167. A bolt 245 is threadedly engaged with fixed plate 244. By loosening the bolt 245, free sliding movement is permitted between base member 238 and fixed plate 244, restricted only by adjusting element 246 having shoulders which engage base member 238 and coacting with threads 247 on fixed plate 244 to radially advance or withdraw base member 238 and mandrel 140 carried thereon relative to the rotational axis of turret assembly 53.

Referring back to FIG. 6, the mandrel tilt angle control means 165 will now be described. Pivotal member 234 contains a cylinder 250 in its surface facing base member 238 in which is positioned a piston 251 carrying a peripheral seal 252 which rides in sealing contact with the walls of the cylinder 250. A tapered back snap ring 253 is peripherally mounted in a groove 254 about the open end of the cylinder 250. The snap ring 253 serves to limit movement of piston 251 toward the outer end of cylinder 250. Piston 251 carries a ball 255 in a seat 256 on its end facing base member 238 which bears against a tapered block 257 bearing on an inclined surface 258. Details as to the construction and operation of this tapered block 257 are shown more clearly in FIG. 7. The position of the tapered block 257 may be adjusted by set screws 260 and 261 so as to alter the position of the upper surface 262 of tapered block 257 against which the ball 255 bears. A conduit 263 leads into cylinder 250 between pivotal member 234 and piston 251. In response to insertion of compressed air into the cylinder 250 through the conduit 263, piston 251 is forced toward base member 238 until it contacts snap ring 253 and ball 255 is held against tapered block 257 in base plate 238. This forces pivotal member 234 away from base member 238 overcoming the urging force exerted by springs 242. This results in the movement of the mandrel 140 radially outward from the rotational axis of the turret assembly 53. The tilt angle of mandrel 140 is controlled by adjustment of tapered block 257 as described above. The application of compressed air to cylinder 250 through conduit 263 is controlled by a pneumatic system described below.

A pneumatic system, which is utilized in the turret assembly 53 of the invention to provide pressure or vacuum to various portions of the apparatus to control its operation, is schematically illustrated in FIG. 12. The system includes a control valve 264 for controlling the operation of piston 251 within cylinder 250 and, correspondingly, the radial position of mandrels 140 with respect to the rotational axis of turret assembly 53 in response to the presence or absence of a cup 56 on the mandrel 140 during a portion of the orbital path. Details of the control valve 264 are shown more clearly with respect to FIG. 11. The pneumatic system also includes a rotary plate valve 265 for controlling the distribution of vacuum and compressed air to various portions of the apparatus during predetermined sections of the orbital path. The plate valve 265 is also shown in FIGS. 2, 3, 4 and 5. The interconnection between the plate valve 265, the control valve 264, the mandrel tilt angle control means 165, and the passageway 216 of the mandrel core 202 is most clearly shown in FIG. 5.

In describing the pneumatic system, reference will generally be made only to portions required for operating a single mandrel system, it being understood that equal provisions are required for the operation of each mandrel **140** on turret assembly **53**. Referring to FIG. **12**, in conjunction with FIG. **5**, compressed air enters a passageway **266** through axle **172** by means of a rotatable fitting **267** (shown in FIG. **3**) disposed on the through-extending end **177** of the axle **172**. The passageway **266** extends to a point beyond the turret plate **170** and connects to radial drillings **268**, only one being shown, in the flange **168** of axle **172**. Radial drilling **268** extends radially outward and connects with conduit **270** which leads to control valve **264**. Control valve **264** is also connected to conduit **263** leading into cylinder **250** for feeding compressed air to the cylinder **250** which holds the mandrel **140** radially outward. Control valve **264** is connected to conduit **233** on central portion **204** of core **202** which is used to detect the presence or absence of a cup **56** on the mandrel **140** and to control the operation of the control valve **264** during a portion of the orbital path of that mandrel.

FIG. **3** illustrates in greater detail the construction of plate valve **265**. A nonrotating but floating stationary plate **271** is disposed adjacent a radial flange **272** extending from hub **169** and is prevented from rotating by a keying dowel **273**. The rotating plate **274** of the plate valve **265** is formed by one side of the radially extending portion or flange **168** of turret plate **170**. The stationary plate **271** is pressed into engagement with the rotating plate **274** by means of a plurality of pistons **275** within cylinders **276** which receive compressed air through radial drillings, indicated in FIGS. **3** and **12** by reference numeral **277**, leading to an annular passageway **278** formed between stationary plate **271** and hub **169** by two spaced "O" ring seals **279** and **280**. The annular passageway **278** receives compressed air from a conduit **281** through a radial drilling **282** as shown in FIG. **11**. The opposite end of each piston **275** bears against radial flange **272** on hub **169**. Stationary plate **271** has arcuate grooves **283** and **284** cut into its surface directed toward rotating plate **274**. Conduits **285** and **286** extend through flange **271** and into grooves **283** and **284**, respectively, in stationary plate **271**.

Compressed air is fed to plate valve **265** by means of conduit **286** into groove **284** in stationary plate **271**. A hole **287**, cut into the rotating plate **274** of plate valve **265** at a point opposite groove **284** of plate **271**, connects with radial drilling **288** which connects to conduit **223** leading to central portion **204** of core **202**. In this manner, during a predetermined portion of the orbital path of each respective mandrel **140**, compressed air is fed through section **220** of the passageway **216** in the manner described below.

In a similar manner, vacuum is drawn through conduit **285** connected to groove **283** in stationary plate **271** of plate valve **265** which extends around a portion of the orbital path of the turret assembly **53**. A hole **289** cut into the rotating plate **274** at a point opposite groove **283** in plate **271** connects to radial drilling **290** in the rotating plate **274** of plate valve **265** which terminates in a conduit **215** which leads to central portion **204** of core **202**. In this manner, vacuum is applied to respective mandrels **140** during a predetermined portion of their orbital path.

FIG. **11** illustrates one form of control valve **264** in which a reciprocating valve member **291** is disposed within a valve housing **292**. The valve member **291** and the interior of the valve housing **292** are cooperatively contoured to form a plurality of chambers and valve seats. The upper end of valve member **291** is surmounted by a piston **293** disposed within an upper chamber or cylinder **294** in housing **292**. A spring **295** is disposed in compression between the upper end of housing **292** and the piston **293** and is arranged to urge the valve member **291** in a downward direction. The conduit **233** from the central portion of core **202** leads into the upper chamber **294** between piston **293** and the upper end of housing **292**.

An intermediate chamber **296** is present in valve housing **292** separated from upper chamber or cylinder **294** by a ring seal **297** about valve member **292** which contacts housing **292**. The conduit **270** from radial drilling **268** leading to the passageway **266** connects to control valve **264** and enters chamber **296**. Valve member **291** has a radially enlarged portion **298** within chamber **296** which forms an upper valve **299** with the lower portion of housing **292**. Below valve **299** a bottom chamber **300** is formed in housing **292** by a portion of valve member **291** of lesser diameter. The valve member **291** is radially enlarged below bottom chamber **300** and forms a lower valve **301** with the bottom edge of housing **292**. The conduit **263** leading to cylinder **250** connects to the control valve **264** into the bottom chamber **300** between upper valve **299** and lower valve **301**. The valve member **291** has a through-extending lower end **302** which bears against a pivotably mounted arm **303** carrying a cam follower **304**. The cam follower **304** rests upon a stationary cam **305**, as shown in greater detail in FIG. **4**.

In operation, during a portion of the orbital path, cam follower **304** in response to urging by stationary cam **305** holds valve member **291** in its uppermost position so that compressed air from conduit **270** entering cavity **296** within housing **292** passes through upper valve **299** which is open and into conduit **263** through the chamber **300**. In this manner, compressed air is fed into cylinder **250** and presses piston **251** against base member **238**, thus holding the mandrel **140** in its radially outermost position. In this position, the lower valve **301** is closed, preventing the passage of air from conduit **270** to atmosphere through the lower valve **301** thereby effecting its introduction into conduit **263**.

As the turret assembly **53** carries a mandrel **140** through its orbital path, the cam follower **304** contacts another portion of the stationary cam **305** where it is allowed to move radially inwardly toward the rotational axis of turret assembly **53**. This allows the valve member **291** to drop in response to urging of the spring **295** acting against the piston **293** surmounting valve member **291**. The upper valve **299** is closed when the valve member **291** lowers thus preventing the passage of compressed air from conduit **270** into cylinder **250** through conduit **263**. Instead, the compressed air within the conduit **263** and cylinder **250** is vented to atmosphere through the lower valve **301** which is now in its open position.

However, during this latter portion of the orbital path, the dropping of the valve member **291** is prevented if a cup **56** is present on the end of mandrel **140**. Thus if a cup **56** is present on the end of mandrel

140, vacuum introduced through section 217 of passageway 216 by means of conduit 215 is also introduced through section 218 of passageway 216 and through conduit 233 which enters the upper chamber of cylinder 294. The vacuum thus introduced into the cylinder 294 overcomes the urging force of spring 295 and holds the piston 293 in its upper position. In addition, since the valve member 291 is retained in its uppermost position, the lower valve 301 is closed, the upper valve 299 is open, and the flow of compressed air into cylinder 250 is maintained which holds mandrel 140 in its radially outermost position. However, if a cup 56 is not present on mandrel 140, no vacuum is present to hold the valve member 291 in its uppermost position and mandrel 140 is moved radially inwardly accordingly.

From the above, it will be apparent that as long as cups 56 are regularly placed on successive mandrels 140, no movement of valve member 291 of control valve 264 occurs. Wear of valve 264 and mandrel tilt angle control means 165 is therefore kept at a minimum, contrary to what would be the case if movement were required for every cup printed. In addition, the control valve 264 is constantly ready to trigger withdrawal of a mandrel 140 radially inwardly toward the rotational axis of the turret assembly when a cup 56 has not been properly placed thereon. This avoids the printing of ink on the uncovered mandrel 140 and the subsequent transfer of such ink to the insides of following cups 56 placed on that mandrel.

The object printing apparatus 51, disposed adjacent the object printing section 162 of the orbital path followed by mandrels 140 carried by the turret assembly 53 as shown in FIG. 1, is of particularly unique design and construction which enables the printing of a continuously moving arcuate surface similarly carried through an adjacent orbital path. Normally, when a surface is to be printed, a cylindrical printing cylinder is utilized which, during rotation, moves past one or more imaging or inking cylinders to receive the application of one or more printing fluids in the form of an image, and then moves past the surface to be printed, contacting that surface to form an image thereon. When the surface to be printed is arcuate, as is the surface of a cylindrical container, it must be held in a fixed position and allowed to rotate during printing since only one relative spatial position exists with two rotating cylinders in which line contact can be had between their cylindrical surfaces. The printing apparatus used with the turret assembly of the invention provides a means for obtaining a longer period of line contact between two rotating cylinders while both are being moved along orbital paths by alerting the path of the contracting portion of the surface of one of the cylinders during printing to cause it to coincide with the path of the surface of the other cylinder. This arrangement allows continuous printing of cylindrical container sidewalls while the container is continuously moved through an orbital path, as distinguished from an indexed or intermittent operation. Several alternative embodi-ments of apparatus of the invention are described, each of which will enable printing of the surface of a cylindrical object such as a right cylindrical or a frusto-conical container sidewall while the container is continuously carried through an orbital path.

FIGS. 1, 13 and 14 show the preferred embodiment of object printing apparatus 51 in which a plurality of arcuate print blanket assemblies 310 are peripherally disposed about a shaft 311. Print blanket assemblies 310 are keyed to shafts 312 rotatably journaled upon bearing assemblies 313 and 314 carried to two spaced support plates 315 and 316 which are fixedly attached to shaft 311. Thus, support plate 316 is welded to shaft 311 and support plate 315 is attached by bolts 317 and 318 to shaft 311.

Print blanket assembly 310 comprises an arcuate print blanket 320 secured to a blanket support 321 keyed to shaft 312 and secured thereto by a bracket member 322 which surrounds and is attached to shaft 312 and is secured by bolts 323 and 324 to opposite ends of blanket support 321. Shaft 311 is rotatably journaled in a frame 325 by means of spaced bearing assemblies 326 and 327. The through-extending end 328 of shaft 311 carries a drive pulley 330 about which runs a toothed timing belt 331 (reference numeral 182 in FIG. 3) which connects drive pulley 330 and shaft 311 to drive wheel 181 on turret axle 172 connected to a motor (not shown). Drive pulley 330 is keyed to shaft 311. End 328 of shaft 311 also carries a drive gear 332 keyed thereto which drives a pinion gear 333, indicated in FIG. 14, which connects shaft 311 to the printing cylinders 334 so as to positively drive the printing cylinders 334 in relationship with the movement of arcuate print blankets 320 about the shaft 311. This drive interconnection is important both to insure accurate placement of images on print blankets 320 by printing cylinders 334 as well as to insure registration of one image created on print blanket 320 with another image on the same print blanket 320, especially where different colors are employed to create a composite image. Inking cylinders 329 are mounted adjacent each printing cylinder 334 and arranged to transfer ink or some other decorating material from a reservoir (not shown) to the surface of printing cylinders 334 in a manner well-known to those skilled in the printing art.

A cam support 335 secured to frame 325 by bolts 336 encircles shaft 311 and extends outwardly from frame 325 toward print blanket assemblies 310. Cam support 335 carries two radially outwardly extending cam flanges 337 and 338 which extend radially outward beyond cam support 335 for a predetermined variable distance about shaft 311 to control the pivotal movement of print blanket assemblies 310 on shafts 312 as they are carried through their orbital path about shaft 311 during printing. Thus, each shaft 312 has a through-extending portion 340 which extends beyond bearing assembly 314 and carries a pair of arms 341 and 342 which are clamped to shaft 312. Each of arms 341 and 342 carry rotatably mounted cam followers 343 and 344, respectively, on their ends, which follow camming flanges 337, and 338, respectively. During rotation of shaft 311 and movement of print blanket assemblies 310 about their orbital path, pivotal movement of arcuate print blanket assembly 310 in one direction is positively controlled or limited by arm 341 and cam follower 343 in response to the shape of camming flange 337. Pivotal movement of arcuate print blanket assembly 310 in the opposite direction is controlled or limited by arm 342 and cam follower 344 in response to the shape of camming flange 338. During

printing, forces are impressed on the print blanket assembly **310** by contact between print blanket **320** and the sidewall of a cup **56** which tend to pivot it about shaft **312**. The cam flanges **337** and **338** are conjugate cams which are matched to each other so that positive control of the pivotal movement of print blanket assemblies **310** is constantly maintained. This positive control system enables precise pivotal movement of arcuate print blanket assemblies **310** against dynamic and printing forces at high rotational speed of shaft **311** which enables the high speed printing of cylindrical or frusto-conical containers.

FIG. **13** illustrates the general relationship of the pint blanket assemblies **310** relative to printing cylinders **334** and to the mandrels **140** carried by turret assembly **53** through their orbital path. FIG. **13** also illustrates the directions of rotation of the various portions of the apparatus. Thus, it can be seen that the turret assembly **53** carries mandrels **140** in a direction opposite to the direction of movement of the adjacent print blanket assembly **310**. However, mandrels **140** are rotating in a counterrevolutionary direction to the rotation of turret assembly **53** after receiving rotational force from object rotate means **64** as they pass through the object rotate section **161** of their orbital path. Therefore, the portion of the surface of mandrels **140** and the surface of a cup **56** carried thereon moves in the same direction as the surface of the adjacent arcuate print blanket **320** of the printing apparatus **51**. The object rotate means **64** serve to bring mandrels **140** up to a rotational speed where their surface velocity closely approximates the surface speed of the print blankets **320**. Any small difference in surface speed between the mandrel **140** and the print blanket **320** is eliminated a short period after initial contact between them and before any printing has occurred.

As pointed out above, to avoid smearing the image transmitted by the print blanket **320** to the surface of the cup **56** carried on mandrel **140**, it is important that the surface speeds of cup **56** be substantially equal to the surface speeds of print blanket **320**. It has been found that when a frusto-conical surface is printed in this manner with a cylindrical print blanket **320**, a difference in surface speed along the length of the cup **56** due to its tapered configuration, which can differ from the average surface speed by as much as 10 percent, does not result in noticeable smearing of the image. Any smearing which may occur can be minimized to some degree by the design of the image to be imparted as well as the type of printing fluid utilized. The image on the print blanket undergoes a predictable distortion which can be readily compensated for.

As pointed out above, where a frusto-conical object is to be decorated, the direction of inclination of the rotational axis of the object must be altered during the printing section **162** of its orbital path and specifically during that portion of its orbital path in which it is contacted by the print blanket **320**. FIGS. **15** and **16** illustrate the operation of object printing apparatus **51** in conjunction with mandrel axis control means **65** of the turret assembly **53** during the printing of the sidewall of frusto-conical objects such as cups **56**. The end **345** of the print blanket **320** nearest the approaching cup **56** is initially moved radially outwardly from the center of the shaft **311** in response to tilting of the arcuate print blanket **320** about its axis by the cam means. As the cup **56** advances in its orbital path, the tilted arcuate print blanket **320** contacts cup **56** and is slowly returned to its cylindrical position. Then, as the line of contact between print blanket **320** and cup **56** moves through a line between the rotational axis of turret assembly **53** and shaft **311**, the trailing end **346** of the arcuate print blanket **320** is advanced radially outwardly and the cup **56** being printed begins to contact the last half of the arcuate print blanket **320**. After contact with the cup **56** has been broken, the tilted print blanket **320** is pivoted back to its cylindrical position and moved into contact with the printing cylinders **334** again to replenish the decorating material or ink on its surface. FIG. **15** shows the tilting action of the print blanket assembly **310** during the period of time when the surface of print blanket **320** contacts the surface of a cup **56** being carried through the printing section **162** of its orbital path. During this period of time, shaft **311** turns through an angle indicated by reference numeral **347** shown in FIG. **15**, the turret assembly **53** turns through an angle indicated by reference numeral **349**, and the center of curvature of arcuate print blanket **320** shifts from a point indicated by reference numeral **348** to a point indicated by reference numeral **350** in FIG. **16**. Angle **349** represents the angle turned by turret axle **172** during the time the surface of a cup **56** contacts print blanket **320**. Angle **349** comprises a portion **349a** during which no printing occurs but the speed of a cup **56** and its carrying mandrel **140** are synchronized by frictional contact between the two, and a portion **349*b*** during which printing of the cup **56** takes place.

As turret axle **172** turns about an angle indicated by reference numeral **351** in FIG. **15**, the direction in which the rotational axis of mandrel **140** inclines is controllably altered by axis control means **65** as described above and is pointed in the direction of arrows **352** superimposed over mandrels **140** along the orbital path shown in FIG. **15**. FIG. **31** shows how the inclined mandrel axis is directed toward the center of curvature of arcuate print blanket **320** as it shifts from point **348** to point **350** and as mandrel **140** is carried along its orbital path. Both preceding and following angle **351**, the direction of inclination of the mandrel axis coincides with a radial line from the rotational axis of turret assembly **53** through the pivot axis of the mandrel **140**.

FIGS. **17** and **18** illustrate an alternative embodiment of apparatus enabling printing of a cylindrical or frusto-conical container sidewall while the container is continually moving through an orbital path. Turret assembly **53** is modified to permit radially inward motion of mandrels **140** toward axle **172** in a prescribed manner which enables the surface of a cup **56** carried on a mandrel **140** to follow the path of movement of a cylindrical print blanket **320** for a portion of its orbital path. Thus, mandrel **140** is pulled out of its circular orbital path and moved in a modified orbital path during the treatment section **162** of the orbital path. Shaft **167** carrying mandrel support assembly **166** is not carried directly on turret plate **170** but is rotatably carried in a member **353** which is pivotably attached at its other end to an extended portion **354** of turret plate **170** by means of a pin **355**. Member **353** has an arm **356** af-

fixed to one side thereof which carries a rotatably mounted follower wheel **357**. Follower wheel **357** rides in a camming groove **358** cut into a swing frame cam **360** which is stationarily mounted upon hub member **169**. Upon rotation of turret plate **170**, mandrel **140** is moved radially inwardly in a predetermined manner due to movement of member **353** in response to action of cam follower upon swing arm **356** which rotates member **353**.

FIG. **17** shows the paths various elements of the mechanism described above. Line **359a** shows the path of the center of the bottom of a cup **56** carried on mandrel **140**. As the cup passes adjacent printing cylinder **320**, its path **359a** is modified and moves radially inward toward the rotational axis of turret assembly **53**. Line **359*b*** shows the path of follower wheel **357** which determines line **359*a***. Line **359*c*** shows the path of the pivot axis of shaft **167** and mandrel **140** while line **359*d*** shows the path of cam follower **198** which pivots shaft **167**.

It can be seen that shaft **167** is rotated by the action of cam follower **198** in camming groove **201** of camming plate **200** thereby changing the direction of inclination of the rotational axis of the mandrel **140** during the treatment section **162** of the orbital path. Alternatively, the above construction can be modified to provide sliding movement of the mandrel support assembly **166** radially inward and outward from the rotational axis of turret assembly **53** in a predetermined manner to cause it to follow the path of the print blanket during the treating section **162**.

What is claimed is:

1. A turret assembly for supporting hollow cylindrical objects for treatment of the outside surface thereof by a continuous object treatment process, comprising:

a frame mounted for rotation in a plane about a rotational axis,

a plurality of object support mandrels carried by said frame through an orbital path, said mandrels having an outside surface configuration conforming substantially to the inside surface configuration of said objects, said orbital path having an object pickup section, an object rotate section, an object treatment section and an object removal section,

driving means for rotating said frame, said drive means including a power source and transmission means connecting said power source to said frame, and

object rotate means adapted to apply a rotational moment to mandrels carried through the object rotate section of said orbital path to cause the outside surface of the objects carried thereon to attain a predetermined rotational speed prior to movement through said object treatment section, said rotation continuing through said treatment section.

2. A turret assembly according to claim **1**, wherein said orbital path is substantially circular.

3. A turret assembly according to claim **1**, wherein said objects are frusto-conical, said object support mandrels are mounted for rotation about axes disposed at a slight angle of inclination to the rotational axis of said frame in a direction generally radially outward from the rotational axis of said frame, and including mandrel axis control means adapted to alter the direction of inclination of the rotational axes of said mandrels with respect to a given radial extending from the rotational axis of said frame as the mandrels are successively carried through the object treatment section of said orbital path.

4. A turret assembly according to claim **3**, including pivot shafts rotatably carried by said frame, said shafts being mounted for rotation through at least a portion of one revolution, each of said mandrels being carried upon an end of one of said pivot shafts and mounted for independent rotation about an axis inclined to the axis of said pivot shaft, cam followers operably connected to said pivot shafts and adapted to rotate said pivot shafts in alternate directions about their axes, and stationary cam means adapted to guide said cam followers through a predetermined path at least when said mandrels are carried through the object treatment section of said orbital path, whereby the direction of inclination of the rotational axis of each mandrel is controlled.

5. A turret assembly according to claim **1**, wherein said object rotate means include a rotatably driven friction wheel mounted for frictional engagement with successive mandrels as they are carried by said frame through the object rotate section of said orbital path.

6. A turret assembly according to claim **1**, including vacuum means adapted to create a vacuum between at least portions of the surface of each of said mandrels and objects carried thereon whereby said objects are frictionally gripped by said mandrels prior to movement through the object treatment section of said orbital path.

7. A turret assembly according to claim **1**, including pneumatic pressure means acting at the surface of each of said mandrels for applying pressure to the interior walls and interior ends of said supported hollow objects for releasing objects carried thereon prior to movement through the object removal section of said orbital path.

8. A turret assembly according to claim **1**, wherein said mandrels are mounted for radial movement relative to the rotational axis of said frame, and including mandrel actuation means adapted to change the distance between said mandrels and the rotational axis of said frame during rotation of said frame, and a pneumatic system for detecting the presence and absence of an object on successive mandrels, said pneumatic system being operably connected to said mandrel actuation means, whereby the distance between successive mandrels and the rotational axis of said frame is controlled in response to the presence or absence of an object upon said respective mandrels.

9. A turret assembly according to claim **1**, including mandrel tilt angle control means adapted to alter the angle of inclination of the rotational axes of said mandrels relative to the rotational axis of said frame, and a pneumatic system for detecting the presence and absence of an object on successive mandrels, said pneumatic system being operably connected to said mandrel tilt angle control means, whereby the angle of inclination of the rotational axis of successive mandrels is controlled in response to the presence or absence of an object on respective successive mandrels.

10. A turret assembly according to claim **1**, including guide means to move successive mandrels through a modified orbital path as they are carried past the object treatment section of said orbital path while maintaining

a constant angular relationship between the rotational axis of said mandrels and the rotational axis of said frame.

11. A turret assembly according to claim **10**, including shafts upon which said object support mandrels are rotatably carried, said shafts being rotatably mounted upon said frame, in a manner permitting radial movement thereof relative to the rotational axis of said frame, and wherein said guide means include cam followers operably connected to said shafts, and stationary cam means adapted to guide said cam followers to controllably alter the orbital path of said mandrels upon rotation of said frame.

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