Method and Apparatus for Variable Multiple Position Indexing Rotary Turntable

Technical Field

This invention relates to a worktable or turntable machine whereupon a work piece may be secured for machining operations. More particularly, the work piece's position on the turntable can be indexed on multiple rotary positions on the turntable.

Background Art

In manufacturing process, a particular work piece requiring multiple machining operations may be secured to a rotary turntable whereby the work piece may be positioned accurately by specific rotations of the turntable for each of the operations to be performed thereunto. Each of these multiple rotations may be indexed in terms of the degrees of rotation of each position, i.e. angular positions, so that the proper sequence of orientating the work piece may be attained precisely for each of the operations to be carried out within acceptable tolerances.

Among the earliest indexing rotary turntables, the indexing mechanism is incorporated or formed as part of the rotary drive system using, for example, worm gears. As a result, after some time of use, wear on the rotary drive teeth progressively affects the precision of indexing.

To overcome such deficiency, later prior art turntables provides for the indexing system to be separated from the rotary drive system. Examples of such mechanism are disclosed in the following U.S. Patents - US-3,795,155 (Price), US-3,717,912 (Lahm) and US-3,724,291 (Goebel) which employed complicated and, hence, expensive arrangements for engaging and disengaging the indexing system to/from the rotary drive system.

These 3 patents, as well as US-4,159,658 (Parkinson), employed disengageable radial "curvic coupling" teeth to determine the successive angular positions of rotary index tables. In Parkinson, the curvic coupling comprises two cooperating annular sets of engageable teeth, which are in V-shaped radial ridges and grooves, and equally spaced about a complete circle. Such disengageable coupling, in particular the "curvic coupling" gears' teeth, is difficult to tool precisely and such machines are therefore expensive to make.

Indexing mechanism may also be built into the rotary drive means such as that disclosed by US-5,330,333 (Holmes) whereby the rotary actuator is provided with clutch pistons whereby unidirectional rotation of the drive output shaft through a specific angle for each indexed angular position may be achieved without cumulative error.

A deficiency common to all the prior art turntables is that the number of indexable positions is fixed. When the need arises for the number of stops on the turntable to be increased, the prior art indexing mechanisms cannot increase the number of indexable positions. To accommodate the increase, the indexing unit has to be replaced with one having the desired number of stops.

Objects of the Invention

The present invention endeavours to provide for a multiple position indexing rotary turntable which number of positions may be increased or variable without replacing the indexing unit.

It is also an object of the invention to provide for a direct translation of angular movement or rotation on the indexing unit to the turntable to achieve greater precision using standard parts and components at each rotary stops without the need for tooling accurate gear engagements of custom-made parts such as the "curvic coupling" of the prior art which are necessarily expensive.

Another object is to incorporate the advantage of unidirectional rotary drive without cumulative error of the indexed rotations over time.

Statement of Invention

In the general aspect of the invention, a method of providing variable multiple positions on an indexing rotary turntable may comprise of translating rotation on an indexing plane to a work plane wherein said indexing plane includes an indexing disc and said work plane includes a turntable. Implemented in an apparatus, the indexing rotary turntable includes an indexing disc which angle of rotation is translated to corresponding rotation of the turntable.

In a specific embodiment of the method, indexing of and rotation to each position comprises the steps of:

(i) engaging a rotary drive means into operative contact with an indexing disc at engageable positions provided on said indexing disc;

(ii) actuating said rotary drive means to turn in a predetermined degree of rotation, thus rotating said engaged indexing disc at said predetermined degree accordingly;

(iii)transmitting said indexing disc's rotation to a corresponding rotation of the turntable;

(iv) disengaging said rotary drive means from operative contact with said indexing disc;

(v) locking at least one of said indexing disc and turntable from rotary movement;

wherein the number of indexed positions on the turntable is variable by -

- configuring the degree of rotation of the rotary drive; and
- configuring the corresponding number of engageable positions on the indexing disc.

In a specific embodiment of the apparatus, an indexing rotary turntable is provided comprising -

(i) a rotary actuator which degree of rotation per actuation is predeterminable;

(ii) a linear actuator operable between a contracted and extended positions;

(iii) an indexing disc which is -

- arranged to come into
  - engagement and operative contact and
  - disengagement and dissociated from operative contact

with said rotary actuator upon the relative

operation of said linear actuator;

- provided with a plurality of engagement means positioned substantially along the periphery of the disc;
- in operative contact with the turntable so that the rotation of the indexing disc is transmitted to a corresponding rotation of said turntable;

(iv) a chassis for mounting at least one of said rotary actuator, linear actuator, indexing disc and turntable to provide for linear sliding movement for the engaging and disengaging of at least one other components relative to said chassis-mounted component

wherein the number of indexed positions on the turntable is variable by -

- configuring the degree of rotation of the rotary drive; and
- configuring the corresponding number of engageable positions on the indexing disc.

Preferably, the rotary drive is actuated to turn from a reset position to a predetermined degree of rotation upon engagement with said indexing disc and to return to said reset position upon disengagement.

In one preferred embodiment, the indexing disc is detachable and replaceable with one having a desirable number of engageable positions corresponding to the desired indexed positions on the turntable. The number of engageable positions on the indexing disc may preferably be increased by providing additional engageable positions thereon.

In another preferred embodiment, the maximum number of engageable positions is provided on the indexing disc and the

rotary drive is configured to rotate at predetermined degree of rotation to correspond with the desired number of indexed positions up to said maximum number.

In yet another preferred embodiment, the disengaging and locking steps are achieved in a single action with the rotary drive means operatively disconnects from said indexing disc and simultaneously locks said indexing disc from rotating.

Still another preferred embodiment of the indexing rotary turntable, the rotary actuator comprises a rotary drive means operating to turn a cross-axle provided with means for engaging the engageable means of the indexing disc at both ends of the cross-axle's cranks.

Brief Description of Drawings

The method of operating and the configuration of the indexing rotary turntable of the present invention may be better understood with the following detailed description with reference to the drawings, which describes an exemplary and non-limiting embodiment in which -

FIGURE 1 shows in 3-dimensional view of a prototype of an indexing rotary turntable according to the method and configuration of the invention;

FIGURE 2 shows a side elevation view of said prototype wherein the indexing disc is in the engaged and unlocked position;

FIGURE 3 shows a plan cross-sectional view at the A - A section of the prototype shown in Figure 2;

FIGURE 4 shows a side elevation view of said prototype wherein the indexing disc is in the disengaged and locked position; and

FIGURE 5 shows a plan cross-sectional view at the B - B section of the prototype shown in Figure 4.

Detailed Description of Specific Embodiment

The general and basic principle of the present invention lies, in respect of the method, in translating rotation on an indexing plane to the working plane. In physical terms, it includes translating an indexing disc's angle of rotation to a corresponding rotation of the turntable.

Preferably, the translation from the indexing disc to the turntable is done directly in 1:1 ratio, i.e. for example, a 15° rotation on the indexing disc is translated directly to a corresponding 15° rotation on the turntable. However, it is also possible that the indexing plan or disc be turned in multiples of smaller, specific angular movement to achieve the desired angular rotation on the turntable (e.g. the indexing disc may be configured to turn 5° each time and 3 times' run would produce the desired 15° rotation on the turntable) although such operation would be slower and cumbersome.

FIGURE 1 shows a prototype embodiment of an indexing rotary turntable according to the method and configuration of the

invention in 3-dimensional view. The exemplary embodiment in brief comprises of (i) a rotary actuator (10), (ii) a linear actuator (30), (iii) an indexing disc (50), and (iv) a chassis (70) for mounting one or more of the preceding components or part thereof, including the turntable (100) upon which a work piece (not shown) may be secured.

Rotary/swivel drive unit

The rotary drive or actuator (10) may preferably be a rotary or swivel device driven by pneumatic, hydraulic, or electromagnetic means, including a combination of such means, which degree of rotation or swivel may be selected or predetermined by the user. An example of such off-the-shelf rotary actuator is *Festo*™ Swivel Module (Model DSM-8-180-P-A-FF No. 175831) which has the following specification.

Table I
Brief features of *Festo*™ Swivel Module
(Model DSM-8-180-P-A-FF no. 175831)

Criterion	Feature
Medium	Compressed air, filtered
Mode of operation	Double acting
Rotary/swivel principle	Rotary vane
End positions adjustable	Yes
Rotation angle adjustable	Yes
Nominal swivel angle	180°
Torque at 6 bar	0.35 Nm

This exemplary device employs compressed air to produce the forward and return stroke with its double-acting cylinder to generate rotary movement output to a shaft. It allows the rotary motion to be adjustable steplessly from 0° - 180° (although other models providing wider swivel angle may also be used). Other devices operated with hydraulic,

electromagnetic and other driving means (or combination of such driving means) may also be used as long as the rotary motion is adjustable. Preferably, the end positions of the angle of rotation is adjustable as well as the present *Festo*™ rotary device.

Output drive from the output shaft may be transmitted via a cross-axle (12) which ends are provided with means to engage an indexing disc (50).

Linear actuator unit

The linear actuator (30) is a device which is slidably operable between a contracted and an extended positions. The operation of the linear actuator (30) is to bring components attached appropriately thereto into linear engagement or disengagement. In the present invention, its purpose is to bring the rotary drive's (10) cross-axle (12) into engagement and disengagement with the indexing disc (50).

A suitable example of such a device, which is available off-the-shelf as a standard component, is *Festo*™ Miniature Guide Unit (Model DFC-6-10-P-A-GF No. 189456) which has the following specification.

Table II
Brief features of *Festo*™ Miniature Guide Unit
(Model DFC-6-10-P-A-GF No. 189456)

Criterion	Feature
Medium	Compressed dried air; lubricated and unlubricated
Mode of operation	Double acting
Guide principle	Plain bearing guide
Torsion protection	Guide rod
Stroke	10mm
Effective force (theor.) at 6 bar; advance/return	17 / 12.5 N

This exemplary device comprises a double-acting cylinder to provide for accurate guidance for linear movement and to cope with high load and has guide rod to protect against torsional stress. It is powered by compressed air to produce the forward and return stroke. Linear drive delivery is thus protected against rotation around the longitudinal axis of the drive.

Indexing disc

The indexing disc (50) is a unique component central to the inventive concept of this invention. Generally, it comprises of substantially a disc with its axle in operative contact with the turntable. The disc is provided with multiple positions of engagement means, preferably along the periphery or rim to maximise the angular spacing of the engagement positions so that the maximum number of the engagement positions may be provided.

For purposes of the prototype shown in Figure 1, the indexing disc (50)'s engagement positions may be provided as holes which may be engaged by complementary keys or pins provided on the engaging ends of the cross-axle (12) extending from the rotary drive unit (10). The extending or advance and return stroke of the linear actuator (30) will bring the keys of the cross-axle's (12) engaging ends into engagement with, and disengagement from, the complementary holes of the indexing disc (50).

Chassis

As certain parts of the aforesaid components need to be moved in relation to the others, a chassis (70) may be provided to affixed certain components to enable the relative movement. As shown in Figure 1, the prototype provides for the chassis in the form of a base piece in rectangular shape whereupon the components may be mounted thereon.

Operation

The operation of the turntable according to the invention may now be described with collective references to FIGURES 2 to 5 wherein FIGURES 2 and 3 shows the apparatus in an engaged and unlocked position and FIGURES 4 and 5 in disengaged and locked position.

In the present prototype embodiment, the turntable (100), indexing disc (50) and linear actuator (30) (hereinafter referred to as the "affixed components") are secured onto the chassis (70) while the rotary actuator (10), being attached to the slidably moveable end (32) of the linear actuator (30), are linearly moveable in relation to the affixed components by virtue of the extension and contraction of the cylindrical arms (34) of the linear actuator body (36).

FIGURE 2 shows a side elevation view of said prototype wherein the indexing disc is in the engaged and unlocked position whereas FIGURE 3 shows a plan cross-sectional view at the A - A section of Figure 2.

In this view, the linear actuator (30) is shown with the cylindrical arms (34) contracted to bring the moveable end (34) close up to the linear actuator body (36). As the rotary actuator (10) is secured to this moveable end (34),

the rotary actuator (10) is pulled up to the affixed components, causing the cross-axle (12) to insert its pair of keys (14) into the corresponding holes (52) of the indexing disc (50), thus engaging said indexing disc (50).

As compressed air is supplied to the rotary actuator (10), the cross axle (12) rotates from the reset position (0°) to the user-preset angular motion and turning the indexing disc (50) to a corresponding angle of rotation. As the indexing disc is in operative contact with the turntable at 90° via bevel gears (54, 55) in a 1:1 ratio the turntable is in turn rotated to said corresponding angular motion thus bringing the work piece (not shown) to the desired position on the turntable. Pins (102) are shown in Figure 2 as the stop positions or work piece engageable means corresponding to the positions of the holes (52) on the indexing disc (50).

Once the turntable (100) has been brought to the desired angular position, the linear actuator (30) may be activated to extend its cylindrical arms (34) as shown in FIGURES 4 and 5. FIGURE 4 shows a side elevation view of said prototype wherein the indexing disc is in the disengaged and locked position while FIGURE 5 shows a plan cross-sectional view at the B - B section of Figure 4.

In the extended state, the linear actuator's (30) slideably moveable end (32) is pushed away from the body (36) and therefore moves the rotary actuator (10) and the cross-axle (12) away, and hence disengages, from the indexing disc (50). Once disengaged, the rotary actuator (10) may then be returned to its preset or 0° position, ready for the next actuation. With such resetting to a starting position, cumulative errors may be avoided.

Preferably, at the disengaged position, a mechanism is provided to lock and prevent the turntable (100) from rotating so that the machining or other operation to be conducted on the work piece may be carried out steadily. The mechanism may either directly lock the turntable (100) or indirectly by locking the indexing disc (50) since the latter is operatively connected to the turntable (100) via bevel gears at 1:1 ratio and at 90°.

As shown in FIGURE 5, this locking mechanism may be provided by inserting a locking pin (16) into a corresponding hole (52) of the indexing disc (50) from the other side of the disc. The locking pin (16) may be provided to extend in a manner opposed to the cross-axle's (12) keys by being attached to a locking arm (18) affixed to the other side of the rotary actuator (10).

Thus, when the linear actuator (30) contracts, the indexing disc (50) becomes engaged while the locking mechanism is simultaneously in an unlocked position as shown in Figure 3 (i.e. engaged and unlocked). When the linear actuator (30) extends, the indexing disc (50) becomes disengaged while the locking mechanism is simultaneously in a locked position as shown in Figure 5 (i.e. disengaged and locked).

It will be appreciated by a skilled person that the above configuration may be modified with respect of the relative positions of the engageable components without departing from the scope and intent of the invention. For example, the linear actuator (30) may be reverse-configured, i.e. to engage and unlock with the extension of its cylindrical arms (34), and disengaged and locked with the contraction of the

arms (34).

Variable multiple positions

With a turntable according to the present invention, the number of indexed positions (102) on the turntable may be variable by, firstly, configuring the degree of rotation of the rotary drive (10); and then, configuring the corresponding number of engageable positions (52) on the indexing disc (50).

To accommodate an increase in the number of stops (102) on the turntable (100), the corresponding additional number of engageable positions (52), or other suitable or complementary forms of engaging the cross-axle (12), may be provided on the indexing disc (50). For the prototype embodiment, corresponding additional holes (52) may be drilled onto the indexing disc (50).

Alternatively, the indexing disc (50) may be provided with the maximum number of engageable positions and the rotary drive (10) is configured to rotate at a predetermined degree of rotation to correspond with the initially desired number of indexed stops. For instance, assuming that the indexing disc (50) is large enough, a hole may be drilled at each 1° angle rotation of the disc thus providing a maximum number of 360 position holes.

If initially 10 stops are required of the turntable (100), the rotary drive (10) may be configured to rotate at 36° at each actuation. Later, as more stops are required, say 15 positions, the rotary drive may then be reconfigured to rotate at 24° per actuation without the need to re-tool or

reconfigure the indexing disc (50). Conversely, if a reduction of the number of stops is required, the rotary drive may be reconfigured to increase its angular rotation so as to reduce the number of stops.

It will be appreciated by a person skilled in the art that, apart from the key-in-hole engagement means, other forms of configurations are possible including electromagnetic means, etc. It will further be appreciated that to avoid the 90° translation of the rotary movement from the indexing disc to the turntable, the indexing disc and the other components may be provided directly underneath the turntable or provided integral with the underside of the turntable in a single axle. Of course, if the turntable is in alignment with the indexing disc, a more powerful linear sliding actuator would have to be provided since it would have to bear the weight of some of the components against gravity in sliding up or down.

From the above description on the general concept, features and principle of the present indexing turntable invention as exemplified by the specific prototype embodiment, it would be obvious to a person skilled in the art that there are many variations and alternative embodiments that may be possibly used in substitution of the aforesaid parts, configuration, materials, steps or processes. Many of such alternative features not specifically described herein may be used to effectively work the method and principles of this invention and they are not to be considered as departures from the present invention but as falling within the letter and scope of the following claims.

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CLAIMS

1. A method of providing variable multiple positions on an indexing rotary turntable comprising translating rotation on an indexing plane to a work plane wherein said indexing plane includes an indexing disc and said work plane includes a turntable.

2. A method according to Claim 1 wherein the indexing of and rotation to each position comprises the steps of:
(i) engaging a rotary drive means into operative contact with an indexing disc at engageable positions provided on said indexing disc;
(ii) actuating said rotary drive means to turn in a predetermined degree of rotation, thus rotating said engaged indexing disc at said predetermined degree accordingly;
(iii) transmitting said indexing disc's rotation to a corresponding rotation on the turntable;
(iv) disengaging said rotary drive means from operative contact with said indexing disc;
(v) locking at least one of said indexing disc and turntable from rotary movement;
wherein the number of indexed positions on the turntable is variable by -

- configuring the degree of rotation of the rotary drive; and
- configuring the corresponding number of engageable positions on the indexing disc.

3. A method according to Claim 1 wherein the rotary drive is actuated to turn from a reset position to a predetermined degree of rotation upon engagement with said indexing disc

and to return to said reset position upon disengagement.

4. A method according to Claim 1 wherein the indexing disc is detachable and replaceable with one having a desirable number of engageable positions corresponding to the desired indexed positions on the turntable.

5. A method according to Claim 4 wherein number of engageable positions on the indexing disc may be increased by providing additional engageable positions thereon.

6. A method according to Claim 1 wherein the maximum number of engageable positions is provided on the indexing disc and the rotary drive is configured to rotate at predetermined degree of rotation to correspond with the desired number of indexed positions up to said maximum number.

7. A method according to Claim 1 wherein the rotary drive is provided by any one of pneumatic, hydraulic, and electromagnetic means, including a combination of said means.

8. A method according to Claim 1 wherein the disengaging and locking steps are achieved in a single action with the rotary drive means operatively disconnects from said indexing disc and simultaneously locks said indexing disc from rotating.

9. A method according to Claim 1 wherein the indexing disc's rotation is transmitted to the turntable at 90°.

10. An indexing rotary turntable including an indexing disc which angle of rotation is translated to corresponding rotation of the turntable.

10. An indexing rotary turntable including an indexing disc which angle of rotation is translated to corresponding rotation of the turntable, comprising:

(i) a rotary actuator which degree of rotation per actuation is predeterminable;

(ii) an indexing disc which is -

- arranged to come into
  - engagement and operative contact and
  - disengagement and dissociated from operative contact

  with said rotary actuator;
- provided with a plurality of engagement means positioned substantially along the periphery of the disc;
- in operative contact with the turntable so that the rotation of the indexing disc is transmitted to a corresponding rotation of said turntable;

wherein the number of indexed positions on the turntable is variable by -

- configuring the degree of rotation of the rotary drive; and
- configuring the corresponding number of engageable positions on the indexing disc.

11. An indexing rotary turntable according to Claim 10 further comprising a linear actuator operable between a contracted and extended position, wherein the linear actuator allows the indexing disc to come into

- engagement and operative contact and
- disengagement and dissociated from operative contact

  with said rotary actuator;

12. An indexing rotary turntable according to Claim 11 further comprising a chassis for mounting at least one of said rotary actuator, linear actuator, indexing disc and turntable to provide for linear sliding movement for the engaging and disengaging of at least one other components relative to said chassis-mounted component.

13. An indexing rotary turntable according to Claim 10 wherein the rotary drive is actuated to turn unidirectional from a reset position to a predetermined degree of rotation upon engagement with said indexing disc and to return to said reset position upon disengagement.

14. An indexing rotary turntable according to Claim 10 wherein the indexing disc is detachable and replaceable with one having a desirable number of engageable positions corresponding to the desired indexed positions on the turntable.

15. An indexing rotary turntable according to Claim 14 wherein the number of engageable positions on the indexing disc may be increased by providing additional engageable positions thereon.

16. An indexing rotary turntable according to Claim 10 wherein the maximum number of engageable positions is provided on the indexing disc and the rotary drive is configured to rotate at predetermined degree of rotation to correspond with the desired number of indexed positions up to said maximum number.

17. An indexing rotary turntable according to Claim 11 wherein the rotary drive and linear actuator are powered by any one of pneumatic, hydraulic, and electromagnetic means, including combinations of such means.

18. An indexing rotary turntable according to Claim 11 wherein the relative operation of said linear actuator to disengage and dissociate said indexing disc from operative contact with the rotary actuator further and simultaneously lock said indexing disc from rotating.

19. An indexing rotary turntable according to Claim 10 wherein the indexing disc's rotation is transmitted to the turntable at 90° via a pair of bevel gears.

20. An indexing rotary turntable according to Claim 10 wherein the rotary actuator comprises a rotary drive means operating to turn a cross-axle provided with means for engaging the engageable means of the indexing disc at both ends of the cross-axle's cranks.

21. An indexing rotary turntable according to ay one of the preceding claims wherein the engageable means includes key-in-hole and like means.

22. An indexing rotary turntable which is an implementation of a method according to any one of claims 1 to 9.