United States Patent

[11] 3,583,258

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[21] Appl. No. **855,953**
[22] Filed **Sept. 8, 1969**
[45] Patented **June 8, 1971**

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[54] **GENEVA MOTION INDEXER WITH HEMISPHERICAL HEAD**
7 Claims, 13 Drawing Figs.

[52] **U.S. Cl.** **74/820**
[51] **Int. Cl.** **B23q 17/00**
[50] **Field of Search** 74/820, 435, 436

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Primary Examiner—Manuel A. Antonakas
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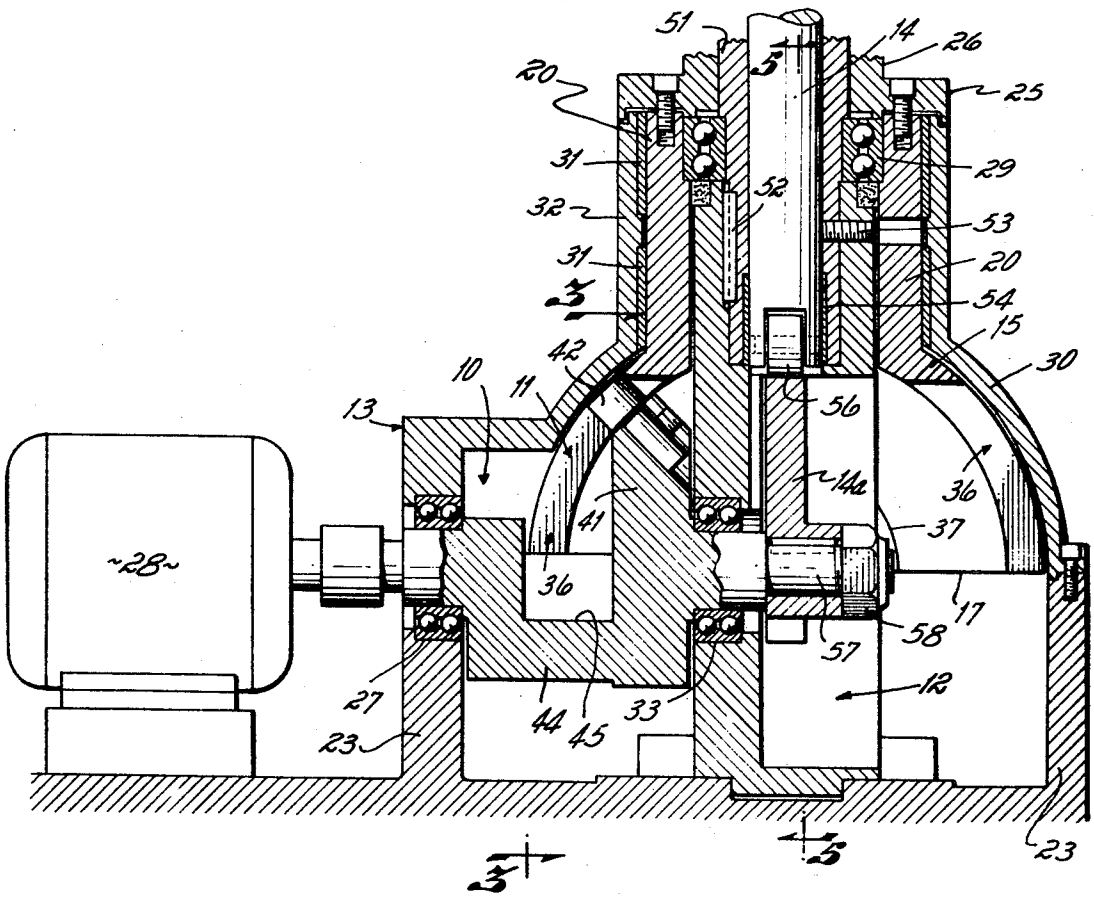
ABSTRACT: An indexer for establishing Geneva-type motion, in which the rotation of the head changes according to a sinusoidal curve and whereby instantaneous or abrupt changes in velocity are avoided. The mechanism includes a head having a hemispherical surface and rotatable about a first axis. The head is rotated in indexed motion by a cam driven by a drive shaft rotating about a second axis perpendicular to the first axis and intersecting the latter at the center of the hemisphere. Automatically locking means prevent rotation of the head between successive indexing advancements. Optional means for generating a timed reciprocating motion along the first axis are also provided.



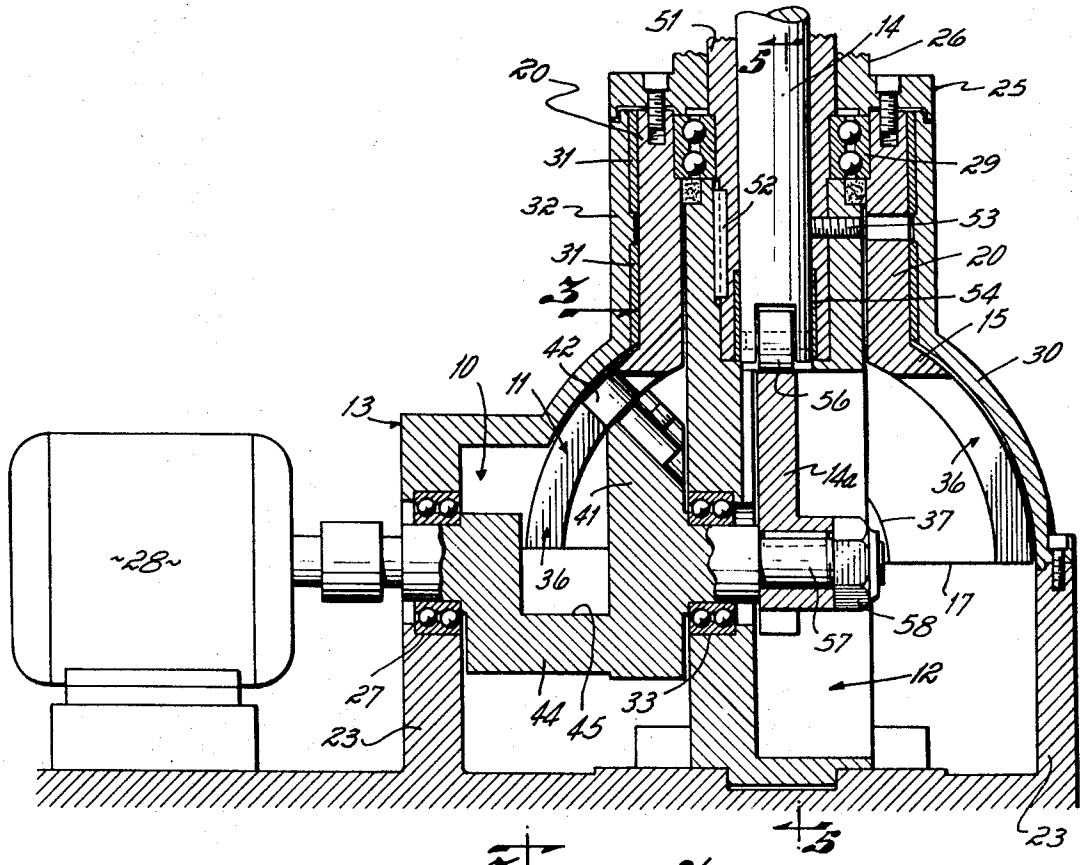


Fig. 1

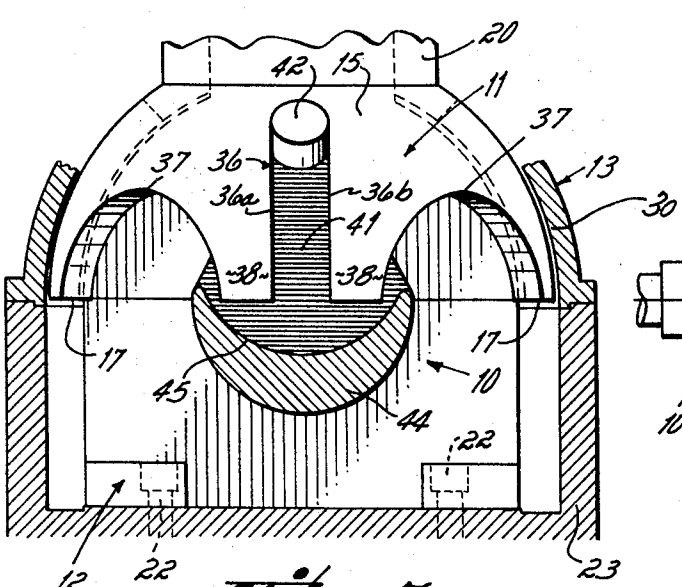


Fig. 3

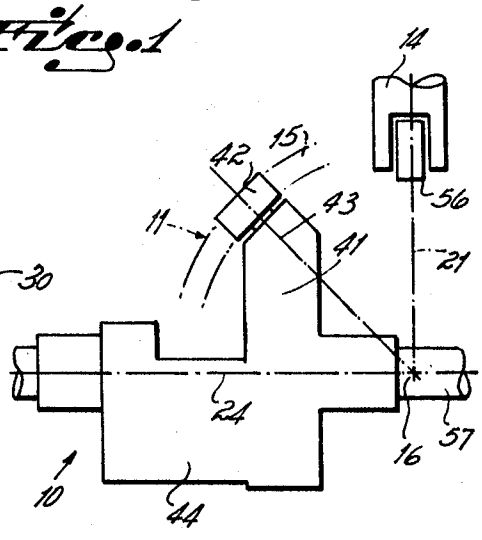


Fig. 2

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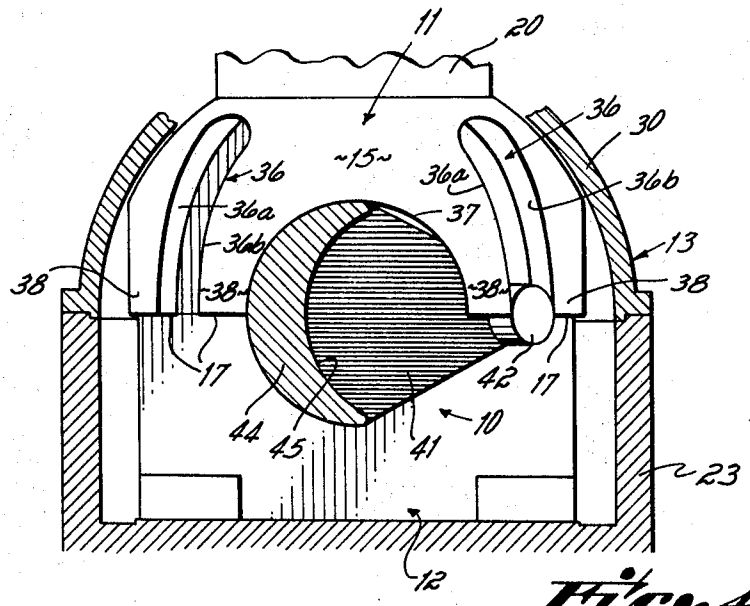

Fig. 4

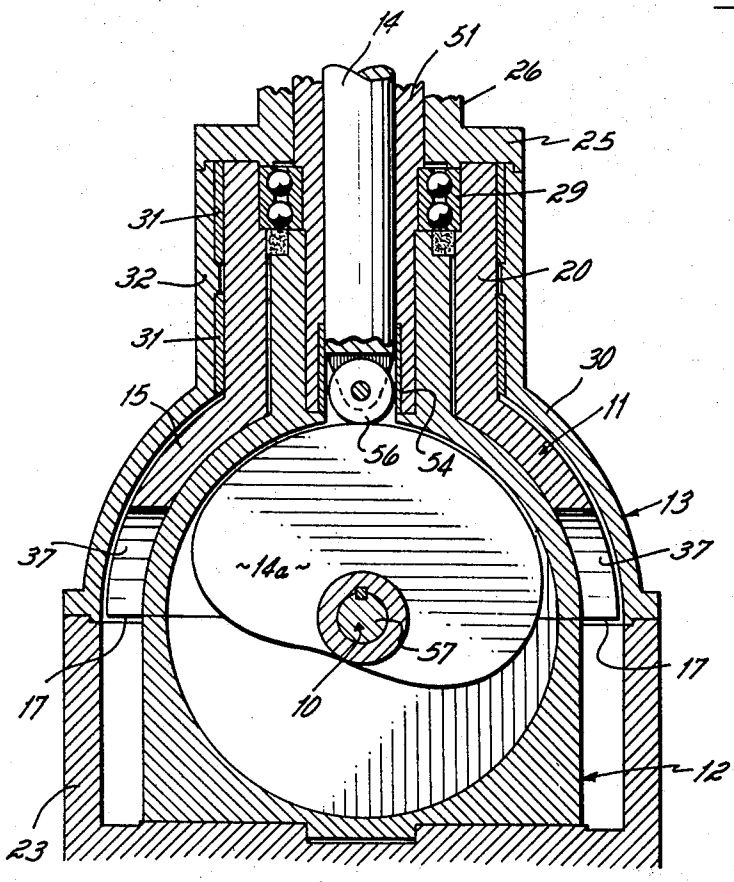

Fig. 5

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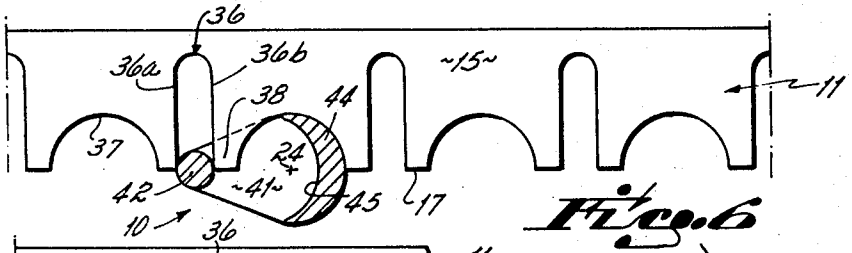

Fig. 6

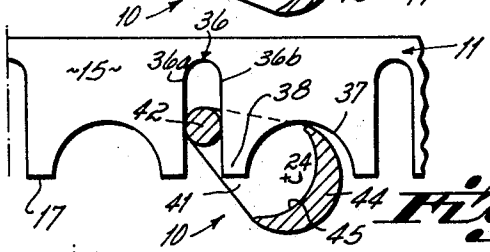

Fig. 7

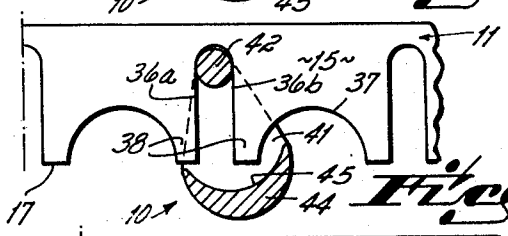

Fig. 8

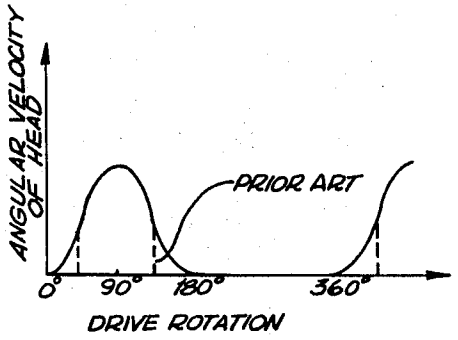

Fig. 13

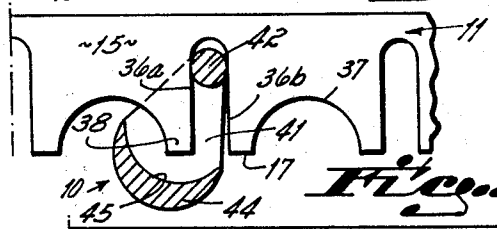

Fig. 9

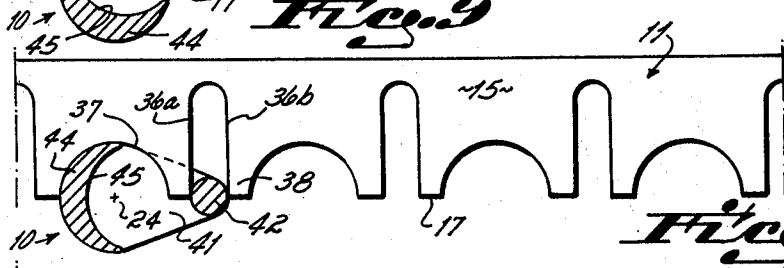

Fig. 10

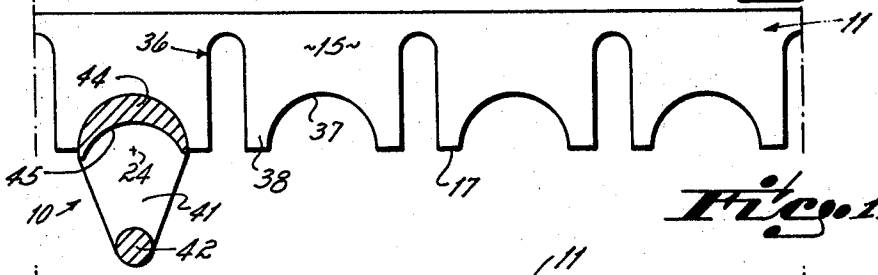

Fig. 11

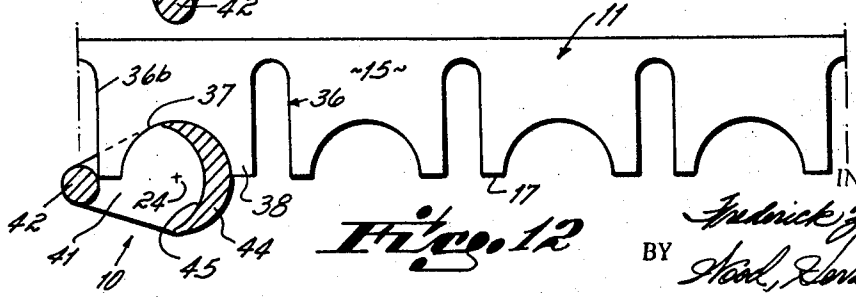

Fig. 12

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GENEVA MOTION INDEXER WITH HEMISPHERICAL HEAD

DESCRIPTION

This invention relates to indexing mechanism of the general class of devices which convert a continuous rotary input motion to a discontinuous incrementally advanced rotary motion. Such motions are generally known as Geneva motions.

In the conventional type of indexer for generating a Geneva motion, a continuously rotating drive shaft rotates a cam which is sequentially engageable in radial slots in a star wheel. The star wheel and the cam rotate in the same plane, i.e., their axes of rotation are parallel. In such devices, as is well known, when the cam enters a slot it imparts rotation to the star wheel, and moves it incrementally to a new indexed position at which the cam leaves the slot. The star wheel remains in this indexed position while the cam completes its full cycle of revolution and returns to the position at which it engages a succeeding slot that has been advanced, as a result of the indexing movement, into position to receive the cam.

In such conventional devices the starting and stopping movements of the star wheel or index plate are inevitably abrupt. Starting and stopping are relatively jerky, regardless of speed of rotation, for velocity changes in a very short distance from zero to that finite component of the velocity of the cam which is directed transversely to the slot. This results from the fact that the cam does not engage the slot tangentially, but rather at skew angle, and has a component of velocity that is perpendicular to the slot. The contact between the cam and the slot is abrupt, and the cam in fact impacts upon the side of the star wheel slot. Hence the initial acceleration of the star wheel is very rapid and relatively jerky startup results. At slow rotational speeds of the drive such very rapid accelerations are acceptable and indeed have been accepted for many years. Nonetheless, it is inescapable that as the rate of rotation of the drive shaft increases, the instantaneous acceleration at the moment the cam engages the slot in the star wheel becomes higher and higher. Any given machine has an ultimate speed limit at which the rate of acceleration and resulting vibration are so great that a further increase is not tolerable by reason of unacceptably severe handling of the workpieces being indexed, or too rapid wear of the parts, or noise or excessive vibration of the machine itself, or a combination of these factors.

Geneva-type motions are utilized in a very great range of applications. Such equipment is, for example, commonly employed to transfer workpieces to and/or from a work station at which work performing machinery performs work upon the workpiece. For this purpose the index plate may operate or actuate machinery which will receive the workpiece at one location, transfer it to machinery for drilling, punching, soldering, molding, etc. at a second location where the work is performed while the workpiece is stationary at that station. The next following index motion removes the workpiece from the work station and transfers it to another location at which other work may be performed or to a conveyor, etc.

Modern manufacturing and workpiece handling techniques on a production basis require rates of index motion which are very high in relation to earlier requirements, and for that reason manufacturers have in some cases pushed such devices to speeds at which the vibration or acceleration of the indexer sets the operating limit for the entire system of which the indexer is a part.

To overcome this defect, more sophisticated Geneva indexers have been made. Mechanisms have been developed by which the indexer is accelerated more smoothly and less abruptly, by avoiding an angular impact of the cam on the Geneva head which starts and stops the rotational motion. Such mechanisms utilize complex three-dimensional cam tracks to impart gradual acceleration. Manufacture of such structures is a relatively expensive machining or shaping operation. One patent which is representative of this type of prior art solution is U.S. Pat. No. 3,049,017 to McDonald et al., in which the cam tracks in a spiral groove connected to the index table. Such devices are effective to avoid the abrupt acceleration which otherwise limits operating speeds, but nonetheless the production of such complex cams in materials hard enough to resist wear over prolonged periods at high speeds is difficult and expensive, and the structures are bulky.

The problem is especially critical in the glassware manufacturing industry, in which indexers are required to transfer glassware from one line to another, or to transfer glassware to and from mold stations or blowing stations or pressing stations, and which commonly must operate in environments that are dirty, at high temperature and subject to severe abrasion from glass chips. By reason of the nature of the glass material to be handled there is a relatively low limit at which the workpiece can be accelerated in transfer. It cannot be subjected to very sharp or sudden movements above a certain acceleration, depending upon the nature of the specific item and the conditions at which it is worked, else strain or breakage will result in the hot glassware.

This invention is directed to an indexer of a new type by which the index head is accelerated smoothly and gradually between rest position and maximum speed, without any instantaneous, abrupt or discontinuous change in velocity. This new indexer avoids the difficulty of abrupt startup inherent in conventional Geneva machinery in which it arises from angular or nonparallel contact of the cam with the cam track. In the new device, a special cam and cam slot arrangement is provided in which the cam enters the slot in absolute parallelness with the sides of the slot so that at the moment of contact of entering the slot the cam imparts no velocity to the index head. As the cam continues to rotate about its axis its velocity is smoothly, gradually and sinusoidally transferred to the index head, reaching a peak speed as the cam moves to an end point in the slot, thereafter decreasing to zero according to the same curve as the cam is withdrawn from the slot. At the same time, the mechanism by which these results are obtained does not require a complex or expensive cam shape, yet is desirably compact and is adaptable to a full variety of applications and spatial requirements.

The new index mechanism includes a head element having a hemispherical surface and is driven in indexed rotary movement about a first axis running through the center of the surface. The hemispherical surface may be formed as a concave surface on the interior of the head, or as a convex surface on the exterior of the head; preferably the head is in the form of a hemispherical shell having concentric inner and outer hemispherical surfaces. The hemispherical surface terminates in a planar edge which lies in a diametral plane of the hemisphere, that is, a plane which passes through the center of the hemisphere, at right angles to the axis of rotation. A plurality of equally spaced cam slots are formed in the hemispherical surface, each extending from the edge toward the apex thereof. Means are provided to support and journal the head for rotational movement about the axis, which passes from the center through the apex thereof perpendicular to the plane of the edge. A rotary drive shaft is disposed at right angles to the first axis just mentioned, and its axis of rotation lies in the diametral plane and intersects the center of the hemispherical surface. A leg extends angularly from the drive shaft toward the hemispherical surface and on this leg there is provided a cam which in practice is preferably a wheel mounted for rotation about an axis that if extended will intersect the center of the hemisphere, the axis of the drive shaft and the axis of rotation of the hemisphere. This cam is positioned to interfit smoothly in the slots previously described.

Also connected to the drive shaft, but on the opposite side thereof from the cam just described, is a locking member in the form of a semicylindrical surface having a center which lies substantially on the axis of rotation of the drive shaft. This member is interengageable with a series of corresponding semicircular recesses or cutouts formed in the hemispherical surface, spaced equally between the slots therein and opening to the edge of the latter. A rotary input to the drive shaft

causes the cam to engage a slot and move upwardly or toward the apex of the hemisphere in the slot. By reason of the hemispherical surface in which the slot is formed, the cam enters it parallel to its sides; there is no impact or instantaneous velocity transfer. Thereafter as the drive shaft continues to be rotated the cam swings about the drive axis and transfers to the hemisphere the increasing component of its velocity which is perpendicular to the direction of the slot, and thereby accelerates the indexer from the initial rest attitude toward a new indexed position. When the drive shaft has rotated 90° from the position at which the cam first entered the slot the cam is at its peak travel in the slot and all of its motion is imparted to the head in the direction transverse to the slot. At this point the velocity of the head is greatest. Continued rotation of the shaft past the 90° point causes head velocity to decrease sinusoidally to zero, and after 180° of drive rotation the cam leaves the slot. As this is occurring however, the locking means on the drive shaft have rotated from an original disengaged position with respect to the head, to a position of engagement with one of the recesses to prevent rotation during which the cam itself is out of engagement with the head. At all times the head is thus positively positioned by the cam and locking means acting alternately.

Both the cam slots and the locking recesses must extend to a diametral plane of a hemispherical surface. In this connection, it is noted that a construction utilizing an index head of conical shape or other nonspherical shape, and not intersecting the plane of the drive shaft, as in West German Pat. No. 861,493, is subject to the same deficiencies as the star wheel indexers earlier discussed, for in such construction the cam does not and cannot engage the slot tangentially or when the motion of the cam is parallel to the axis of rotation of the index head; on the contrary, in all such constructions the cam impacts upon the side of the slot, starting index rotation with a jerky or abrupt motion which the present invention avoids.

The invention is further described with reference to the accompanying drawings, in which:

FIG. 1 is a vertical section of the preferred form of indexer embodying the features of the invention;

FIG. 2 is a fragmentary view showing the angular relation of the axes of the drive shaft, cam, and index head;

FIG. 3 is a vertical section (partly broken away), taken along line 3–3 in FIG. 1;

FIG. 4 is a vertical section (partly broken away) similar to FIG. 3 but showing the relation of the drive shaft to the head at a time in the rotational cycle when the cam is just entering or leaving a slot;

FIG. 5 is a vertical section (partly broken away), taken along line 5–5 of FIG. 1;

FIGS. 6—12 are a series of developed views illustrating the sequence of relative movements of the drive shaft and head as the drive shaft undergoes rotation of 360°, in which FIG. 6 shows the cam as it is starting to engage the head, FIGS. 7, 8, 9, 10 and 11 show the cam at sequential intervals during the cycle and FIG. 12 shows the elements at start of the succeeding cycle; and

FIG. 13 is a graphical representation of the angular velocity of the head as a function of the drive shaft rotation, and also shows the abrupt increase in velocity in conventional star wheel indexers.

The preferred form of indexer shown in the drawings for the purpose of illustrating the invention, broadly comprises a drive shaft 10, a head 11, a combined support and bearing 12 for the head and drive shaft, and a housing 13. As optional components, the preferred embodiment also includes a vertically reciprocable shaft 14 and a cam 14*a* for reciprocating that shaft in timed relation to the rotational movement of the indexer head 11.

Referring to head 11 as shown in FIGS. 1—5, the head has substantially hemispherical inner and outer surfaces and comprises a generally hemispherical shell 15 having a uniform wall thickness. The center of generation of shell 15 is an imaginary point or center designated by 16 in FIG. 2. Head 11 has an interrupted edge 17 which lies substantially in a plane that contains point 16 i.e., a diametral plane. In practice, as shown in the drawings, shell 15 is not a full hemisphere, but is connected, at a chordal plane adjacent the apex, to a hollow cylindrical shaft or sleeve 20 which extends upwardly therefrom.

The index head 11 is internally supported and journaled by the bearing and support means designated at 12. Head 11 is thereby supported for rotation about an imaginary vertical axis or first axis designated by 21 in FIG. 2, which extends perpendicularly to the plane of edge 17 from the center 16 of the shell. The support and guide means 12 is secured, as by bolts 22 (see FIG. 3), to a bottom section 23 of the enclosing housing 13. The lateral sides of support member 12 are machined to conform to the curvature of the interior surface of shell 15. The support 12 has a portion which extends upwardly in the interior of cylindrical shaft or sleeve 20, above shell 15. A flange or table 25 on an output shaft 26 is secured as by the bolts shown to the upper end of shaft 20, and this flange 25 is supported by the outer race of a radial and thrust bearing 29. The inner race of bearing 29 rests upon, and is in turn supported by, the support means 12. Thus, head 11, table 25 and shaft 26 are rotatable about support 12 and first axis 21. It is contemplated that, in use, table 25 or shaft 26 will be connected to move a workpiece or a plurality of workpieces, by adapters or drives which may be conventional and are not shown. For example, the shaft 26 may be connected to operate glassware transfer apparatus to move glassware to and from a mold station or the like. Such peripheral or auxiliary equipment forms no part of the invention.

Drive shaft 10 is rotatable about a second imaginary axis designated at 24 in FIG. 2, and extends from outside housing 13 and shell 15 into the hollow interior of the shell. The axis of rotation 24 of shaft 10 lies in the plane of the edge 17 of hemisphere 15, and radially extends through the center of generation 16 of the latter, there intersecting the first or vertical shaft 21 about which the head rotates. At its outboard end, shaft 10 is supported by a roller bearing 27 supported by the lower half 23 of the housing 13. The shaft 10 is supported internally of the shell 15 by a roller bearing 33 in support 12. Shaft 10 is driven about axis 24 by a prime mover located externally of housing 13 which may be an electric motor as shown at 28, through a gear drive.

As can be seen in FIG. 1, housing 13 may generally conform to the external shape of hemisphere 15 to enclose it. The housing includes a top section 30 which is secured by the bolts shown to the bottom housing section 23 to form a closure for the drive shaft 10, head 11, and the cylindrical shaft 20 at the top of shell 15. Sleeve-type bearings 31, 31 are advantageously provided in that portion 32 of the housing which surrounds the cylindrical shaft 20, thereby to externally support and journal the latter shaft 20 for rotation relative to the housing.

As seen in FIGS. 3 and 4, hemispherical shell 15 is provided with a plurality (four in the embodiment shown) of slots 36 which extend perpendicularly from the edge 17 of the hemisphere toward the imaginary apex or top of the hemisphere. These slots are preferably formed through the thickness of the shell wall and have parallel sides 36*a* and 36*b*. The slots are equally spaced around the periphery of the hemisphere; the number of slots determines the number of indexing positions to which the head will advance during one complete rotation about its vertical axis of rotation 21.

Centered between each pair of adjacent slots 36, 36 there is cutout or locking recess 37. Each recess 37 extends upwardly from edge 17 of the hemisphere, and is semicircular when viewed in projection along a radius of the hemisphere which extends through the center of the recess. By reason of the openings thereto the slots 36 and recesses 37, edge 17 of the hemisphere 15 is interrupted and is defined by the ends of downwardly depending legs designated at 38 between each slot 36 and the adjacent semicircular recess or cutout 37.

The slots 36 cooperate with cam means (to be described) on drive shaft 10, to effect rotational indexed motion of head

11. The recesses 37, on the other hand, are periodically engaged by locking means on drive shaft 10, to be described, to prevent the head from undesired rotation during the period between successive indexed movements, that is, during the portion of each cycle when it is not being rotated by shaft 10.

The cam means just referred to on drive shaft 10 comprise a leg 41 which projects angularly from shaft 10, preferably within the diameter of hemisphere 15 and extending toward the interior surface thereof. At the outer end of this leg 41 there is mounted a rotatable roller cam 42 which is dimensioned and positioned to be closely received in slot 36. The cam 42 is preferably positioned on leg 41 so that its axis of rotation 43 if projected will intersect center point 16 of hemisphere 15, i.e., the same point at which shaft axis 24 and the axis of rotation 21 of the head intersect one another (see FIG. 2). Cam 42 may (as illustrated in FIG. 1) be a roller bearing mounted on a headed shaft which is secured in a bore by a set screw in leg 41. The distance of cam 42 from hemisphere center 16 is equal to the radius of the hemisphere, so that cam 42 will track on the side 36*a* or 36*b* of the hemisphere when shaft 10 is rotated.

The locking means above referred to, which is also connected to drive shaft 10, preferably comprises a lug 44 of crescent shape and is smoothly engageable within the semicircular locking recesses 37 of hemisphere 15. As shown in FIG. 3, the radially outer surface of this locking means 44 on drive shaft 10 is generally semicircular, preferably a few degrees more than 180° in arcuate extent, and has a radius equal to that of semicircular locking recess 37. The inner surface 45 of lug 44 is concave to provide clearance for the movement therepast of each pair of legs 38 of the hemisphere, as shown in FIG. 3. Lug 44 is oriented on the opposite side of the axis of shaft 10 from leg 41 and cam 42; in practice it is contemplated that drive shaft 10 will be cast with both leg 41 and locking lug 44 formed integrally with it, and that those elements will be machined to final dimension.

In addition to the components described above by which indexed rotation of head 11 about axis 21 is achieved, the preferred machinery shown in the drawings also includes optional components whereby a shaft 14 can be caused to 15 reciprocate vertically in timed relation to the rotational movement of head 11. Shaft 14 is longitudinally shiftable along vertical axis 21. This shaft resides within a sleeve or tubular housing 51 that extends above and is mounted within a shouldered bore in support 12. Sleeve 51 is prevented from rotational or longitudinal movement relative to support means 12 by a key 52 and a set screw 53. At the lower end of the sleeve, i.e., adjacent head 11, a bearing insert 54 is fitted in a recess or groove in sleeve 51. Thus sleeve 51 and bearing 54 support and guide shaft 14 for reciprocating vertical movement. Externally, this sleeve 51 functions as a rotational bearing for the shaft or column 26 which is rotated by index head 11 (see FIG. 1).

As shown in FIG. 5, at its lower end shaft 14 is provided with a roller or cam follower 56 which rides or tracks upon the cam member 14*a*. The cam 14*a* is secured to the inner end of drive shaft 10 which projects and is extended for that purpose through support 12 as shown in FIG. 1. Drive shaft 10 is formed with a smaller diameter tip portion or stub shaft 57 and cam 14*a* is mounted on this stub shaft 57 and secured against the shoulder by a hex nut 58 at the end thereof. In the embodiment shown, cam 14*a* is shaped to provide a single up-down reciprocation of shaft 14 for each indexed advancement of head 11. For this purpose cam 14*a* has the shape shown in FIG. 5, which may be described as a bilobed or kidney shape. The timing of the reciprocation of shaft 14 with respect to the indexed movement of head 11 depends upon the angular position of cam 14*a* with respect to cam means 42. By adjusting the angular relation, the peaking of shaft 14 may be timed to coincide with, or to lead or to lag any given point in the cycle of movement of index head 11. The amplitude of the reciprocatory motion of shaft 14 will depend upon the relation of the high point on cam 14*a* to the low point. It will be apparent that the cycle and type of reciprocatory motion can be changed to suit particular applications, for example by use of a multilobed cam for multiple reciprocations of shaft 14 for each single rotation of shaft 10. It will also be understood that where a particular application for indexed rotary movement does not require the provision of such vertical movement as well, then the cam 14*a* and shaft 14 may be omitted altogether.

In use, shaft 14 may be connected to operate conventional apparatus, for example, a glassware lifting system to lift glassware, for example, a glassware lifting system to lift glassware from a mold prior to the time that the head 11 rotates to shift the ware in the horizontal direction. Such peripheral apparatus is well known and forms no part of the invention.

In FIGS. 6—12 there are shown the relative positions of the drive shaft 10 and head 11 during a complete rotation of the shaft 10. In these Figures, it is assumed that the direction of rotation of shaft 10 is clockwise, and that the movement of head 11 (as seen in development) is from left to right.

In FIG. 6, roller cam 42 is just entering the lower end of one slot 36 in head 11. Since the axis 24 of shaft 10 lies in the plane of the lower edge 17 of the hemispherical shell 15, it will be seen that when roller cam 42 is just entering a slot 36, the instantaneous velocity of cam 42 is upward and parallel to the sides 36*a* and 36*b* of slot 36. That is, when roller cam 42 first enters slot 36 its movement has no component of motion perpendicular to the sides of the slot; as a result no movement is imparted at that instant to cause head 11 to be rotated about its axis of rotation 21. However, as shaft 10 continues to turn, cam 42 describes a circular path about axis 24, and this circular movement has an increasingly large component of velocity in the direction transverse to the slot 36. As the cam rotates it moves upwardly in slot 36 (the slot being long enough to accommodate such movement), and its transverse component of motion is transferred to the head through the camming action of roller 42 against the side of the slot. This transverse motion, or indexed-rotation causing motion, increases gradually or sinusoidally from zero to a maximum when cam 42 is at the top of its movement, i.e., just after the moment illustrated in FIG. 8. At its peak height in slot 36, i.e., at the top of the arc of the rotation of cam 42, its vertical component of movement is nil and all its movement is transverse, resulting in the maximum rate of rotation of the indexer. Continued movement of shaft 10 causes cam 42 to move downwardly in the slot 36, as illustrated in FIGS. 9 and 10, and when the center of roller cam 42 is just passing through the plane defined by the edge 17 of the hemisphere the motion of the roller cam is downward only and the indexer is stationary.

The head rotates with cam 42 while it is confined between the two sides 36*a* and 36*b* of the slot. When the cam is disengaged from slot 36, the head is locked against inertial or undesired rotation from indexed position by reason of the interfit of the locking lug 44 in the locking recess 37. Otherwise stated, in the first 180° of rotation of shaft 10 the indexing of head 11 is carried out; in the remaining 180° of rotation of the shaft, the cam 42 is moved to engage the next succeeding slot 36 which remains precisely positioned (by reason of the locking of the head) to engage the cam when it returns the plane of edge 17. To accomplish this, the angle of roller axis 43 with axis 24 of shaft 10 should equal one-half of the horizontal angle between adjacent slots 36.

From the foregoing it can be seen that the mechanism of this invention imparts gradual, nonjerking, nonabrupt, smooth motion to the index head. Whenever cam 42 enters or leaves a slot, its movement is entirely tangential to the slot, and as shown in FIG. 13 the head is accelerated and decelerated in sinusoidal speed variation. In contrast, the jerky startup and stopping motion of a conventional star wheel indexer is indicated by the dotted line in that figure.

FIGS. 6—12 also illustrated the manner in which locking means 44 cooperates with the locking recesses 37 to prevent rotation or movement of the index head 11 during that portion of the cycle when the cam 42 is not rotating it. As shown in

FIGS. 6 and 7, when cam 42 moves upwardly in a slot 36, the rotation of the head moves the side of locking recess 37 out of engagement and away from the locking means. When cam 42 is at the peak of its travel in a slot 36, lug 44 is at the bottom of its rotational movement, and concave surface 45 thereof then faces upwardly (FIG. 8), so that clearance is provided for the relative movement past it of the two depending legs 38–38, on either side of slot 36. When cam means 42 is leaving slot 36 (FIG. 10) lug 44 is in a position at which it engages the approaching (left) surface of recess 37, and thus blocks further movement of the head to the right. Since more than 90° of the arc of lug 44 is engaged in recess 37, as in FIGS. 10, 11 and 12, index head 11 cannot move in either direction of rotation and thereby is locked in the indexed position until continued rotation of drive shaft 10 has again brought cam 42 into position of entry into the next succeeding slot 36 and locking lug 44 has rotated to a position such that it does not block advancement of the head.

In this connection, it is desirable that the outer arcuate surface of locking lug 44 extend slightly more than 180° because this provides that it will lock the index head against rotation until just momentarily after roller cam 42 has been engaged in the slot. It is desirable to avoid unlocking at the exact moment of entry of cam 42 into a slot 36 lest vibration or inertia existing at the time cause relative movement of the indexer head with respect to the cam, such that the cam might misalign with the slot.

From the foregoing can be appreciated the significance of having the axis 24 of rotation of drive shaft 10 lie in the plane defined by the edge 17 of the hemisphere 15. If this relation exists (within reasonable tolerances) the cam will enter the slots 36 without a substantial component of motion in the direction transverse to the sides of the slot which would cause abrupt or jerky start of indexing. If cam 42 were to enter a slot 36 on a plane other than as illustrated, at which the cam would have a large component of velocity in the direction transverse to the sides of the slot, that contact would rapidly or abruptly start rotation of the head. As previously explained, it is just such abrupt starting of rotation of index heads which can impose a relatively low maximum limit of operation on the indexer, and which at any speed causes rougher handling of the articles being moved or positioned by the head. In avoiding such abrupt contact of the camming means with the indexing head of this invention, the indexing movement is made smoother and sinusoidal in form, and higher speeds of rotation can be achieved before unacceptably high accelerations are reached.

Slots 36 and recesses 37 are suitably formed in head 11 by milling along a path parallel to axis 24. The ease of such forming operation is a decided advantage in comparison to drives of the type previously mentioned wherein complex spiral cam paths must be formed.

What I claim is:

1. Indexing mechanism comprising:
a head having a generally hemispherical surface with an edge substantially residing in a plane intersecting the center of said hemispherical surface,
means journaling said head for rotation about a first axis extending perpendicularly to said plane from said center,
a drive shaft,
means journaling said drive shaft for rotation about a second axis lying in said plane and perpendicularly intersecting said first axis at said center,
a plurality of equally spaced slots formed in said hemispherical surface, said slots intersecting and opening to said edge and converging toward the apex of said surface,
a drive cam connected to and extending angularly from said drive shaft and movable in camming relation in the respective slots during rotation of said shaft about said second axis,
said drive cam being a right cylindrical roller which is rotatable about its axis, the said axis of said roller intersecting said second axis at the center of said head,
a plurality of generally semicircular locking recessed formed in said head equally spaced around and opening to said edge, there being a locking recess between each pair of adjacent slots
locking means connected to said shaft for rotation therewith and shaped to interfit in the respective recesses to lock said head against rotation when said drive cam is not engaged in any of said slots.

2. Indexing mechanism comprising,
a head having a generally hemispherical surface with an edge substantially residing in a plane intersecting the center of said hemispherical surface,
means journaling said head for rotation about a first axis extending perpendicularly to said plane from said center
a drive shaft,
means journaling said drive shaft for rotation about a second axis lying in said plane and perpendicularly intersecting said first axis at said center,
a plurality of equally spaced slots formed in said hemispherical surface, said slots intersecting and opening to said edge and converging toward the apex of said surface,
a drive cam connected to and extending angularly from said drive shaft and movable in camming relation in the respective slots during rotation of said shaft about said second axis,
a plurality of generally semicircular locking recesses formed in said head equally spaced around and opening to said edge, there being a locking recess between each pair of adjacent slots,
locking means connected to said shaft for rotation therewith and shaped to interfit in the respective recesses to lock sad head against rotation when said drive cam is not engaged in any of said slots,
said locking means having a recessed inner surface which lies sufficiently below said edge to provide clearance for said edge and having a semicircular outer surface which exceeds 180° in arc length.

3. Indexing mechanism comprising:
a head having a generally hemispherical surface with an edge substantially residing in a plane intersecting the center of said hemispherical surface,
means journaling said head for rotation about a first axis extending perpendicularly to said plane from said center,
a drive shaft,
means journaling said drive shaft for rotation about a second axis lying in said plane and perpendicularly intersecting said first axis at said center,
a plurality of equally spaced slots formed in said hemispherical surface, said slots intersecting and opening to said edge and converging toward the apex of said surface,
a drive cam connected to and extending angularly from said drive shaft and movable in camming relation in the respective slots during rotation of said shaft about said second axis,
a plurality of generally semicircular locking recesses formed in said head equally spaced around and opening to said edge, there being a locking recess between each pair of adjacent slots,
locking means connected to said shaft for rotation therewith and shaped to interfit in the respective recesses to lock said head against rotation when said drive cam is not engaged in any of said slot,
said head being hollow,
a drive shaft rotating a cam in the interior of said head which cams a shaft extending along said first axis.

4. The mechanism of claim 2 wherein said head is connected to rotate a shaft extending from the apex thereof, and the shaft extending along said first axis is supported and guided for reciprocating movement by the shaft extending from the apex.

5. Indexing mechanism comprising,
a hollow head having generally hemispherical inner and outer surfaces generated about the same center,

support means within the hollow interior of said head and journaling said head for rotation abut a first axis passing through the center and the apex of the hemispherical surfaces,

a drive shaft,

means journaling said drive shaft for rotation about a second axis perpendicularly intersecting said first axis at said center, the shaft journaling means including a bearing for one end of said shaft in the support means internally of said head,

a plurality of equally spaced open-ended slots formed in said head, said slots converging toward the apex of said head,

a drive cam connected to and extending angularly from said drive shaft and movable in camming relation in the respective slots during rotation of said shaft about said second axis,

a plurality of equally spaced generally semicircular locking recesses formed in said head, there being a locking recess between each pair of adjacent slots,

locking means connected to said shaft for rotation therewith and shaped to interfit in the respective recesses to lock said head against rotation when said drive cam is not engaged in any of said slots.

6. The indexing mechanism of claim **5** wherein said head has a cylindrical portion extending outwardly from the apex thereof, and said support means includes a bearing portion within the cylindrical head portion.

7. The indexing means of claim **6** wherein a housing surrounds said head and provides an external rotary bearing for said cylindrical portion of said head.