

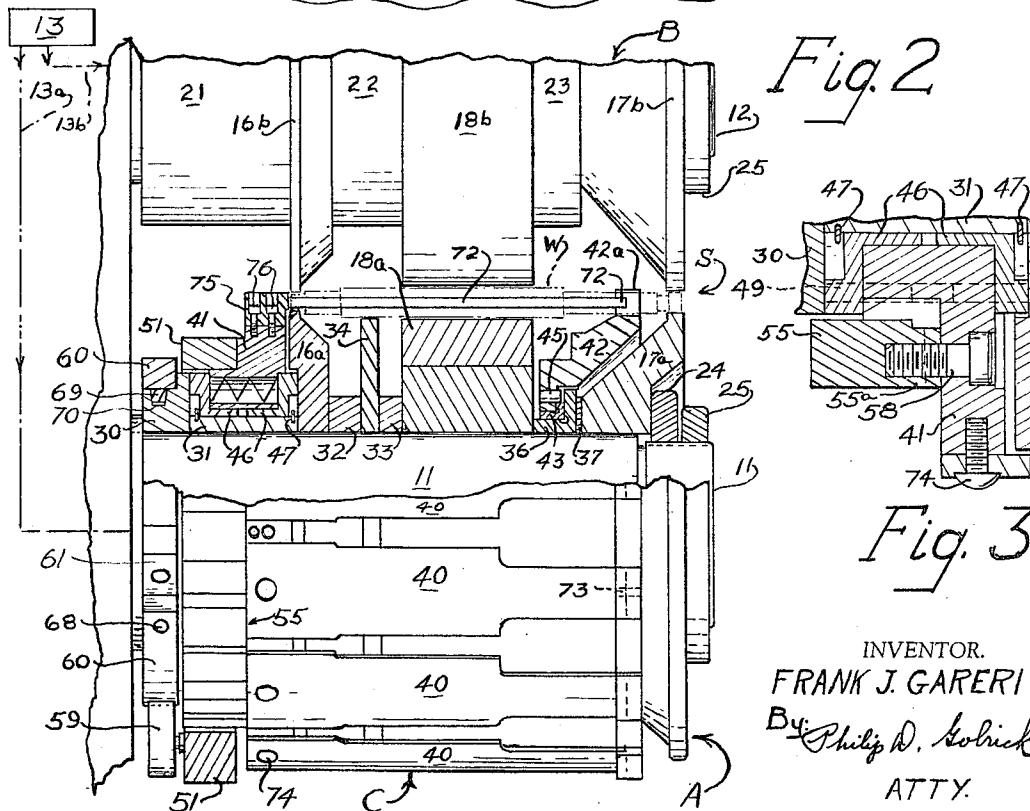
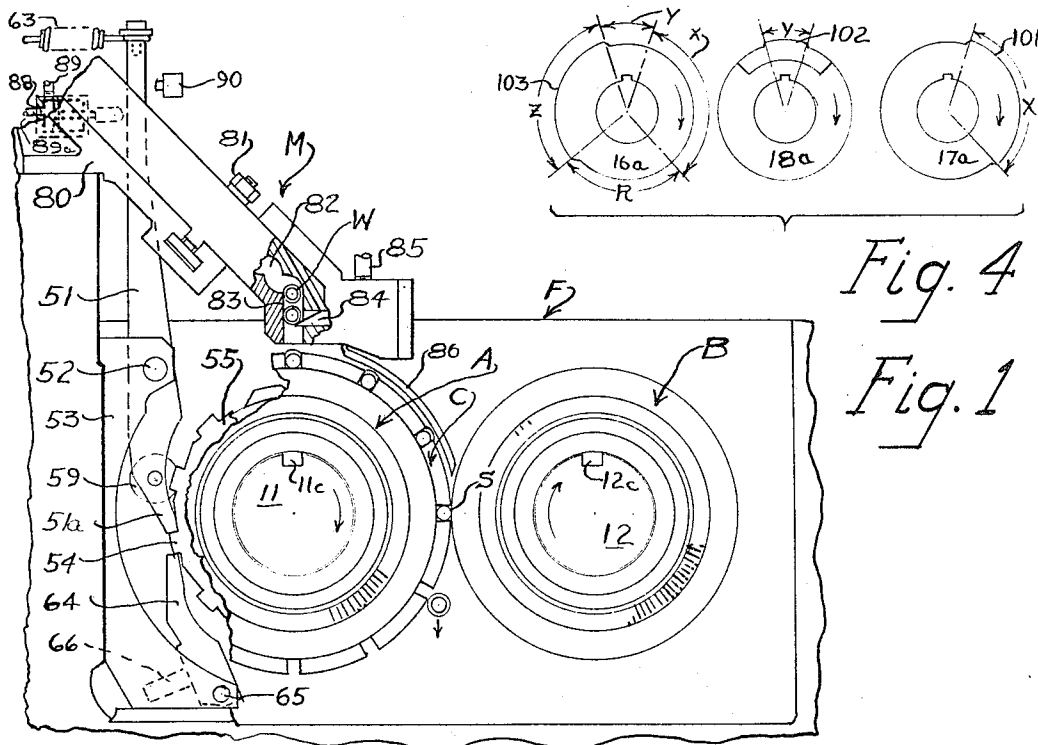
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MEANS AND METHOD FOR SHAFT ROLLING

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MEANS AND METHOD FOR SHAFT ROLLING
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This application is a continuation-in-part of application, Serial No. 302,604, filed August 16, 1963, now abandoned.

The present invention is concerned generally with the art of rolling multiple formations circumferentially on cylindrical objects, more particularly distinct formations including threads at axially special portions of different diameters.

Various methods and apparatus for rolling threads, knurls, splines or other formations around cylindrical surfaces, e.g., in screws, bolts, shafts and the like, have been long and well known. Objects have been so produced with distinct formations rolled into metal at regions of different diameters. However, so far as is known to me there has not been hitherto provided an apparatus or method whereby threads, splines, or knurls or combinations of these are rolled on portions of different diameter on one work-piece at one work-station in one setup and without moving distinct tooling into position for working engagement with a work-piece supported entirely exteriorly.

Although the present invention will be described in terms of production of a motor shaft having near opposite ends thread formations of different diameters and an intermediate splined portion for a more firm mechanical interlock with a stack of rotor laminations press-fitted thereon, it is to be understood that what is here disclosed is of wider application in the rolling art.

By the particular embodiment of the invention, which hereinafter is described in detail, a shaft blank ground to the diameters requisite for rolling is supported between an opposed pair of similar rolling die assemblies simultaneously and continuously driven and having in each assembly axially spaced rolling die formations for producing a rolled thread at one end of the shaft, a rolled thread of a different diameter at the other end of the shaft, and a circumferential knurled or splined formation at an intermediate portion of the shaft of a still different diameter. Each cooperating opposed pair of die formations for working or rolling each of the distinct formations on the shaft is designed and constructed according to principles and in the manner well known to the art; but the circumferentially directed rolling formations in the assemblies each extends only over a part of the circumference, and the formations in each assembly are angularly offset or displaced from each other so that upon one revolution of the die assembly, the pairs of formations come successively into rolling contact with the work-piece, without simultaneously engaging two regions of the work-piece of distinct diameter.

Since the two die assemblies are driven simultaneously in the same sense to engage simultaneously diametric portions of each distinct diameter on the work-piece as it is being worked by an opposed pair of dies in the assemblies, the offsets of the formations in each die assembly are of the same sense and angularly displaced to a like extent. The total extent of the die formations in each assembly is suitably less than 360° to provide an angular portion or extent of the assembly for clearing the work-piece entirely, thereby to provide during each rotation of the die assemblies a clearance period during which a finished work-piece passes out of and a new blank is brought into the working station between the die assemblies.

Moreover, the present invention may be carried out on standard well known rotary die type thread rolling machines having a pair of cantilevered rotary die mounting spindles adjustable toward and away from each other to accommodate both dies and work-pieces of different diameters and simultaneously driven in the same rotational sense at the same rate by suitable drive mechanism and gearing selectable or adjustable in speed. The cantilever disposition of the spindles in such machines permits removal or mounting of dies with suitable shims for spacing from the free ends of the spindles whereon the same are clamped and keyed by suitable clamping nut arrangements.

The invention as hereinafter described has the object and advantage that a plurality of rolled formations of different diameters is produced without advancing the work-piece from one work-station to another for production of corresponding rolled formations and also without moving different tooling into and out of position relative to a fixed work-piece station. There is then the further object and advantage of obtaining a more rapid production of rolled objects of the type described with attendant lower cost. There is the further object and advantage of producing rolled objects of the character described with a minimum of required operator attention or skill. Other objects and advantages will appear from the following description and drawings wherein:

FIG. 1 is a fragmentary front elevational view of an apparatus for carrying out the present invention showing the general relation of primary elements with certain parts broken away;

FIG. 2 is a fragmentary plan view of the two rotating die assemblies with certain parts broken away;

FIG. 3 is a detailed view showing a portion of the friction slip clutch; and

FIG. 4 is a schematic representation of three dies from one die assembly showing certain orientations of functional parts.

In FIG. 1 of the drawings there is shown in fragmentary and generalized manner a standard commercially available thread rolling machine having parallel horizontal spindles 11, 12 so mounted on the machine frame F as to permit adjusting the spindle spacing; and further having a mechanism 13, 13a, 13b for driving the spindles in the same sense (as indicated by the arrows) at selectable identical speeds, the spindles being connected by means such as gearing to maintain the same in phase. Like rolling die assemblies A, B are carried on spindles 11, 12 respectively, the former also having associated therewith a rotatable indexing cage C for receiving successive work-pieces W from a magazine M and transporting them to and supporting them individually in a work-station S.

Although die assembly A provides a mounting on spindle 11 for the cage C and cooperates with the latter in its indexing action, and accordingly is adapted in structure for such purposes not furthered by assembly B, the assemblies are termed "like" in the sense of having corresponding location, spacing and cooperative structure of the die elements included therein.

The work-piece W here is an electric motor shaft which is to have the opposite ends roll-threaded by cooperating pairs of dies 16a-16b and 17a-17b and an intermediate portion "splined" by rolls 18a, 18b to provide longitudinal indentations of ridges for a more secure engagement when press-fitted into a stack of rotor laminations, the left end (as seen in FIG. 2) having a smaller diameter than the right, and the intermediate portion having the greatest diameter.

Considering first the die assembly B, each assembly includes a first spacing means 21 between an innermost spindle shoulder and die 16b, second spacer means 22 be-

tween dies 16b and 18b, third spacer means 23 between dies 18b and 17b, and a heavy washer (or nut) 24 and a clamping nut 25 on the reduced threaded spindle end, which may serve as a jam-nut where 24 is also a nut; the dies, and preferably also the spacing means, being secured against rotation relative to the spindle by a key (not shown) in the spindle keyway 12c.

In the assembly A, corresponding in axial length to spacer 21, a cam mounting ring 30 and sleeve 31 are interposed between the inner shoulder of spindle 11 and die 16a; to spacer 22, spacer rings 32, 33 and disk 34 embraced therebetween, interposed between dies 16a and 18a; and to spacer 23, the circumferentially flanged spacer ring 36 and shim or washer 37 between dies 18a and 17a.

The cage proper includes a series of equi-spaced like longitudinally symmetrical transversely arcuate plates 40 and inner and outer end rings 41, 42 securing plates 40 in a hollow cylindrical cage rotatable relative to the spindle 11. The longitudinal edges of plates 40 are shaped to define equi-spaced work-piece supporting slots open inwardly and outwardly of the cage over its entire length except inwardly at one or both inner and outer end plate rims.

In the opening of its central part, inwardly offset from the rim portion to conserve space, the ring 42 is fitted a circumferentially flanged bearing metal ring 43 secured against rotation relative to the ring 42 by circumferentially spaced pins 45, the flange providing a thrust bearing surface toward the outer end only.

The margins of the plates 40 are shaped and the thickness chosen as required by the shape of the work-piece, areas thereof to be rolled, and needed die clearance. In the construction here shown the right end of each is received in a circumferential groove at 72 in the rim portion 42a of ring 42, and secured endwise by pins or screws as at 72; rim portion 42a being here notched to allow the blank to project over die 17a. The left end of each plate is secured on the periphery of ring 41 by screws 74, and between the plates the end of a stop-block 75 secured by screws 76 determines the innermost position of the piece W.

A pair of similar flanged bearing rings 46, 46, with the flanges thereof disposed away from each other and recessed endwise to accommodate retaining rings 47 engaged in circumferential grooves of spacer ring 31, loosely embraces ring 41 endwise to position it axially and afford an internal circumferential bearing.

The bearing rings 46 are also secured to ring 41 by pins 49 (see FIG. 3) preventing relative rotation but permitting axial shifting therebetween.

Angularly spaced longitudinal holes through ring 41 each contain a compression spring 48 urging the end faces of the bearing rings 46 into frictional engagement with adjacent faces of ring 30 and die 16a. Thus there is formed a slip clutch or friction connection between the spindle (i.e. elements positively driven by the spindle) and the cage, which by mechanism to be explained provides a means for driving the cage rotational from one indexed position to another carrying successive work-pieces into and out of the work-station S.

A latch arm 51 pivoted intermediate its ends at 52 on a bracket 53 secured to a vertical face of the frame, at its bottom end is shaped to engage successive like detent tooth formations or escapement teeth 54 (here twelve teeth, corresponding to twelve work-piece slots) cut in an equi-angularly spaced relation on a tooth or indexing ring 55 fitted on a reduced portion of ring 41. Ring 55 has a plurality of spaced endwise projections or lugs 55a received in radial face slots on ring 41, with cap screws 58 passed through ring 41 and threaded into ring 55 at the lug locations. The teeth present a radial front face or shoulder to arm end 51a to restrain the ring and hence cage against rotation (clockwise in FIG. 2) thereby holding the cage in fixed position with one slot at the

work-station and another below magazine M; the friction clutch slipping.

A second finger 64 pivoted at 65 to bracket 53 is biased by spring 66 into position behind a rear face of the tooth blocked by 51a to lock the cage against any backward motion; this finger simply riding over the succeeding tooth passing thereunder.

A cam follower roller 59 on arm 51, in contact with cam ring 60 suitably secured on ring 30, upon encountering cam rise lug 61, moves arm 51 hence 51a outwardly from tooth engagement against the biasing force of a tension spring 63 secured between a fixed frame point and the upper end of arm 51, permitting the clutch to drive the cage forward, until a following tooth is blocked with the slots thereby advanced one position, with a new piece in the work-station, and an empty slot top-most beneath magazine M.

The ring 60 is secured on ring 30 by a plurality of dog-point set screws 68 each penetrating in and wedging a softer metal wedge (or ring) 69 into a correspondingly shaped groove 70 in the circumference of ring 30. This arrangement allows adjustment of the cam rise rotational position relative to the spindle keyway and therefore the dies, thereby to select the time of cage indexing relative to die positions.

The magazine M is supported on frame F by a bracket 80 in which it is adjustable in direction parallel to the spindle axis through T-bolts 81 with heads engaged in T-slots of the bracket. The inclined magazine passage 82 terminates in a vertical discharge passage 83 where two vertically stacked work-pieces are supported by an escapment finger 84, in effect a piston rod of a piston spring-biased to part-retaining or latching position and pneumatically withdrawn by air supplied to the operating cylinder of finger 84 through line 85. The discharge passage is vertically aligned with the slot top-most in the cage when at stopped position, so that when a pulse of air is supplied by suitable controls a quick retraction of finger 84 permits a piece to drop into the slot, although the following part is restrained. A guide shield 86 supported by the magazine keeps parts in the slots while advancing toward the rolling station S.

A pneumatic device 88 with air line connection 89 is actuated upon the cycle of cage-releasing movement of arm 51, which also actuates microswitch 90, for control purposes; particularly in part-releasing by the latch finger 84.

In FIG. 4 are schematically shown the dies 16a, 18a, 17a and the relative positioning in the die assembly of the roll working formations thereon, the keyways uppermost in all serving as a point of reference. The raised portion on each bears the roll working formation or elements, which are individually selected, designed and fabricated in accordance with ordinary design considerations in this art for the work to be done, but controlled by or subject to a primary consideration here given.

For the desired product, as above described, the die 17a has the thread rolling formation 101 extending over an angle X (shown about 120°); the spline rolling formation 102 over an angle Y (shown about 35°); and the thread rolling formation 102, over an angle Z (shown about 112°). The die formations of the cooperating dies in the other assembly have a similar off-set arrangement.

The relation of these formations to the spindle are indicated by the unnumbered keyways, all in top position, as would necessarily be the case where a single key is used. With the arrangement shown, assuming the right end of the shaft to be first rolled, the formation 101 first rolls the right end, then the formation 102 rolls the middle portion with splines, and the formation 103 rolls the left end thread. (It is understood, of course, that the respective dies of the pairs or sets 16a-16b, 17a-17b, 18a-18b, are cooperating in rolling action.) As a primary design consideration $X+Y+Z$ is chosen to be

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substantially less than 360° , so that in one revolution of the dies, after all three regions are rolled, there remains an angle R (shown as about 67°) of the revolution (indicated on 16a in FIG. 4 where the angles have been superimposed on 16a) in which no die is contacting the work, a clearance angle as it may be termed during which the arm 51 may be unlatched to permit cage advance, discharge of one piece, and advance of a new one, as well as other related control action.

In FIG. 4 and the above discussion, the die offsets are assumed to be such that one rolling operation on a given piece is begun as soon as the preceding one is completed, that is, when contact of one die pair has ceased. As a practical matter a slight angular clearance is preferably provided to ensure that two sets of dies, having different peripheral speeds, do not simultaneously engage the piece. Also at times it may be desired to use in one pair of dies a rolling formation on one longer than on the other die cooperating therewith, in which case the necessary off-sets of the assembly having the longer formation are controlling.

For some materials, the die assembly B may be considered as functioning primarily to provide back-up support successively at the different axial locations at which rolling is being done by the formations in die assembly A.

Although by repetition of the rolling formations on each die with intervening clearance intervals for the assembly and a corresponding repetition of the cam lug it would be possible to roll a plurality of pieces per spindle revolution, the form shown here in the drawings is selected for detailed disclosure because of simplicity and general utility.

The device 88 may be used to cause the air pulse through connections 89-84 to unlatch finger 84, or a micro-switch located at 90 may be used to actuate a solenoidal valve for like purpose.

The only operator activity required, apart from surveillance for malfunctioning, is that of loading the usual supply hopper (not shown) for magazine M. Once the apparatus is started, the cam rise 61 having a set relation to the dies and spindles automatically releases the cage once per spindle revolution for cage advance at the appropriate time; the part advanced to the workstation then being completely rolled in the revolution following cage release. The movement of the arm 51 during cage release and advance is used to trigger an air pulse to latch 84 so that one part is released from the magazine for each revolution of the spindle.

With low air pressure continually supplied at 89a to the cylinder of piston-cylinder unit 88 and through the cylinder by the connection 89-84 to the piston of latch 84, the piston rod of 88 is kept in contact with the arm 51, but the spring bias on 84 is not overcome. However, as arm 51 is cammed against the bias of 63, the piston of 88 follows, and when the arm end 51a escapes and suddenly drops over a tooth 54, the sudden spring retraction of its upper end against the rod of 88 decreases the air space in 88 and causes a sudden short air pressure rise or pulse to activate 84 as described.

What is claimed is:

1. A method for production of objects having a plurality of external circumferential formations rolled into coaxial cylindrical portions of different diameters comprising:

providing at a work-station a work-piece having coaxial cylindrical surfaces of different diameters appropriate for rolling of the formations desired thereon and maintaining the work-piece in said station; engaging each of said surfaces successively for roll working the blank at any given time only on one of said surfaces each at diametrically opposite locations by a corresponding pair of cooperating die formations of two continuously driven rotary die

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assemblies, each said pair adapted to roll the particular formation desired at the respective work piece surface, each die assembly including one of the die formations of each said pair.

2. A method for production of objects having a plurality of external circumferential formations rolled into coaxial cylindrical portions of different diameters, comprising:

supporting at a work-station a blank work-piece having coaxial cylindrical surfaces of different diameters appropriate for rolling of the formations desired thereon and maintaining the work-piece in said station; successively engaging each of said surfaces for roll working the blank at any given time only on one of said surfaces each at diametrically opposite locations by a corresponding pair of cooperating die formations respectively included in each of two continuously driven rotary die assemblies each having one die formation corresponding to each of said plurality;

each said pair adapted to roll the particular formation desired at the respective work-piece surface;

and during a period when all die formations are out of contact with the work-piece removing and replacing a finished work-piece by a blank work-piece.

3. For producing objects having rolled formations of different diameters from rod-like elongated work-pieces having a plurality of coaxial, cylindrical external surfaces, apparatus comprising:

a pair of adjustably spaced parallel die-mounting spindles;

means for continually driving said spindles at the same speed in the same direction;

two cooperating similar die assemblies mounted on said spindles for rotation therewith including die elements axially spaced corresponding to spacing of formations to be rolled on the work-piece;

said die elements having each a work-piece rolling formation extending over a circularly arcuate extent less than a circle, in each assembly said formations being angularly offset from each other to successively and non-simultaneously contact a work-piece and having a total angular extent less than a circle to provide a work-piece clearance interval during each revolution of the assembly;

each die element of one assembly cooperating with a corresponding element of the other assembly as a rolling set, and the off-sets in the two assemblies being similar; and

work-piece advancing and supporting means for carrying successive work-pieces into and out of and supporting them in a work-station between said die assemblies substantially in the plane of the spindle axis.

4. Apparatus as described in claim 3 with the last said means comprising:

a hollow cylindrical cage coaxially supported on one of said spindles over the die assembly thereof for relative rotation with respect to and rotation with the spindle,

said cage including a plurality of circumferentially spaced longitudinal slots for receiving and discharging respective work-pieces in a radial direction and rotatably supporting them successively in a position for engagement at diametric regions by each die element set on a corresponding cylindrical surface; and means for selectively holding the cage at one position for part of each rotation of the die assemblies and for causing the cage to advance one slot relative to said work-station to carry out one and bring in a successive work-piece during a clearance interval.

5. An apparatus as described in claim 4, wherein: said cage is coupled to its spindle by a sliding friction clutch; and including a detent ring formation on

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said cage having equi-spaced detent-teeth corresponding in number to said slots and a pawl engageable with said teeth for holding the cage against rotation with its spindle,
and a cam on the cage supporting spindle adapted to release said pawl once each spindle rotation for a one slot advance of the cage.

6. Apparatus as described in claim 5, including a second pawl biased into engagement with a face of each successive tooth opposite the face engaged by the first named pawl to prevent backward motion of said cage.

7. Apparatus as described in claim 4, wherein: the die assemblies include rotary die elements axially spaced by interposed spacing elements, and said cage includes centrally apertured end plates supported on respective spacing elements.

8. Apparatus as described in claim 7, wherein: said cage is coupled to the spindle by a sliding friction clutch including one of said die elements as a driving member of the clutch, and one of said end plates as a driven member.

9. Apparatus as described in claim 8, including a detent ring formation on said cage having equi-spaced detent-teeth corresponding in number to said slots and a pawl engageable with said teeth for holding the cage against rotation with its spindle, and a cam on the cage supporting spindle adapted to release said pawl once each spindle rotation for a one slot advance of the cage.

10. Apparatus as described in claim 5, including a work-piece magazine and magazine escape member for releasing pieces individually into a cage slot at a loading station, and means responsive to said cam for release of a work-piece into said loading station for each cage advancing cycle.

11. Apparatus for producing from rod-like elongated work-pieces having a plurality of coaxial cylindrical external surface objects having rolled formations of different diameter comprising:

a die mounting spindle;
means for continuously driving said spindle;
a die assembly mounted on said spindle for rotation therewith including die elements having each a work-piece rolling formation extending over a circularly arcuate extent less than a circle, said formations being axially spaced corresponding to spacings of formations to be rolled on the work-piece, said formations in the assembly being angularly offset from each other to successively and non-simultaneously contact a work-piece and having a total angular extent less than a circle to provide a work-piece clearance interval during each rotation of the assembly; and work-piece advancing and supporting means for carrying successive work-pieces into and out of and supporting them in a work-station.

12. Apparatus as described in claim 11 with the last said means comprising:
a hollow cylindrical cage coaxially mounted on said

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spindle over the die assembly for relative rotation with respect to the spindle and rotation therewith, said cage including a plurality of circumferentially spaced longitudinal slots for receiving and discharging respective work-pieces in a radial direction and rotatably supporting each work-piece successively in a position for engagement successively by each die element on a corresponding cylindrical surface; and means for selectively holding the cage at one position throughout all of one rotation of the die assemblies except for a said clearance interval, and for causing the cage to advance one slot to carry out one and bring a successive work-piece into said work-station during a clearance interval.

13. An apparatus as described in claim 12, wherein: said cage is coupled to its spindle by a sliding friction clutch; and including a detent ring formation on said cage having equi-spaced detent-teeth corresponding in number to said slots and a pawl engageable with said teeth for holding the cage against rotation with its spindle,

and a cam on the cage supporting spindle adapted to release said pawl once each spindle rotation for a one slot advance of the cage.

14. Apparatus as described in claim 11 including means adapted to contact a work-piece at locations diametric to regions of contact by said rolling formations for affording back up of the work-piece during rolling.

15. A method for production of objects having a plurality of external circumferential formations rolled into coaxial cylindrical portions of different diameters, comprising:

supporting at a work-station a blank work-piece having coaxial cylindrical surfaces of different diameters appropriate for rolling of the formations desired thereon and maintaining the work-piece in said station;

successively engaging each of said surfaces for roll working the blank at any given time only on one of said surfaces by a corresponding die formation included in a continuously driven rotary die assembly having one die formation corresponding to each of said plurality;

each said die formation adapted to roll the particular formation desired at the respective work-piece surface;

and during a period when all die formations are out of contact with the work-piece removing and replacing a finished work-piece by a blank work-piece.

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