A workpiece forming apparatus is disclosed having a workpiece forming station including upper and lower workpiece forming devices. A rotatable workpiece index table transfers workpieces toward and away from the forming station. The forming devices are actuated simultaneously and the index table selectively rotated in order to transfer a formed workpiece away from the station and an unformed workpiece toward the station.
SUMMARY OF THE INVENTION

This invention relates generally to workpiece forming apparatus and, more particularly, to a new and improved apparatus for cold forging or impact extruding aluminum, copper, or other soft metallic materials of different diameters and lengths.

It is accordingly a general object of the present invention to provide a new and improved workpiece forming apparatus.

It is a more particular object of the present invention to provide a new and improved workpiece forming apparatus for forming electrical compression sleeves or similar type workpieces by cold forging from solid, generally cylindrical slugs of predetermined bar-stock diameter and cut-length.

It is another object of the present invention to provide a new and improved apparatus of the above described type wherein the workpiece slugs are forged by piercing or extruding bores in the upper and lower ends thereof with opposed upper and lower punches.

It is a related object of the present invention to provide a new and improved apparatus, as above described, wherein each workpiece is completely finished and sized to preselected outside and hole diameters and depths in a single operation.

It is still a more particular object of the present invention to provide an apparatus of the above described type comprising four work stations arranged generally 90° apart on a rotatable workpiece indexing table, the stations comprising a loading station, an idle station, a workpiece forming station, and a workpiece unloading station, with the table being selectively rotatably advanced 90° during each operational cycle.

It is another object of the present invention to provide a new and improved workpiece forming apparatus of the above described character which is of a relatively simple design, is economical to manufacture, and which is simple to assemble and maintain.

Other objects and advantages of the present invention will become apparent from the following detailed description taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is an elevated perspective view of a workpiece forming apparatus in accordance with the principles of the present invention;

FIG. 2 is a longitudinal cross-sectional view of the workpiece forming apparatus illustrated in FIG. 1;

FIG. 3 is an enlarged cross-sectional view, similar to FIG. 2, of the workpiece forming apparatus shown in FIG. 1, and illustrates the upper and lower punches in an actuated or cycled position;

FIG. 4 is an enlarged longitudinal cross-sectional view of a workpiece forming apparatus in accordance with a modified embodiment of the present invention;

FIG. 5 is a longitudinal cross-sectional view of the apparatus illustrated in FIG. 4, with the upper and lower punches thereof in a deactuated or extended configuration, and;

FIG. 6 is a horizontal cross-sectional view of the workpiece forming apparatus illustrated in FIG. 1 and shows the actuating and locking arms which are operatively associated with the workpiece index table.

DETAILED DESCRIPTION OF THE INVENTION

Referring now in detail to the drawings and in particular to FIGS. 1–3, a workpiece forming apparatus 10, in accordance with one preferred embodiment of the present invention, is shown as comprising a workpiece forming station 12 having an upper punch assembly 14 and a lower punch assembly 16. A generally horizontally disposed circular index table 18 is mounted for rotation about a generally vertical axis and is provided with four equally circumferentially spaced workpiece holders or dies, generally designated by the numeral 20, which functions to move and retain successive workpieces toward and away from the workpiece forming area 12, as will hereinafter be described.

As illustrated in FIG. 2, the apparatus 10 comprises a generally horizontally disposed base plate or bed 22 which is provided with a vertically upwardly extending support turret 24 that is secured by suitable screws, bolts or the like 26 to a support plate 28, the plate 28 in turn being secured by screws 30 to the bed 22. The support turret 24 is formed with a central vertically disposed bore 32 within which vertically extending shaft or post 34 is mounted. The upper end of the shaft 34 extends upwardly above the turret 24 and is adapted to carry an elongated indexing arm 36, the outer end of the arm 36 being provided with a manually engageable extension portion 38, for purposes hereinafter to be described. Disposed above the indexing arm 36 is a generally circular-shaped spacer 40 which underlies the index table 18, the table 18 being retained between the spacer 40 and a cooperative spacer or washer 42 mounted above the table 18. A plurality of suitable fastening elements, such as nuts 44 or the like, are threadably secured on an externally threaded upper end portion 46 of the shaft 34, as illustrated, whereby the table 18 is rotatable about a vertically extending axis defined by the shaft 34. As best illustrated in FIG. 6, the index table 18 comprises four workpiece stations, namely, a loading station 48, an idle station 50, a forging station 52 and an unloading station 56. The stations 48–56 are spaced at 90° intervals around the table 18 and each is provided with one of the workpiece holders or dies 20, as illustrated. The dies 20 are fixedly secured to the upper surface of the table 18 by suitable vertically disposed screws, bolts or the like 58 which extend through aligned bores 60 and 62 in the table 18 and dies 20, as best seen in FIG. 2. Generally speaking, a workpiece is adapted to be placed in a die 20 located at the loading station 48 and thereafter, the workpiece is transferred to the idle station 50 during the next operational cycle of the apparatus 10. During the following successive cycle, the workpiece is transferred from the idle station 50 to the forging station 52 where the workpiece is subjected to a manufacturing operation hereinafter to be described. During the subsequent cycle of the apparatus 10, the completed workpiece is transferred or indexed to the unloading station 56 from where it is removed for delivery to some preselected destination, as will be described in detail in connection with the overall operation of the present invention.

Referring to FIG. 6, the indexing arm 36 is adapted to be operatively secured by means of a suitable clevis assembly 68 and pivot pin 70 to the outer end of an elongated cylindrical piston rod 72. The piston rod 72
is operatively connected to a piston and cylinder assembly 74 that comprises a pressure operated cylinder 76 which is mounted by any suitable means to an associated support structure (not shown). As will be appreciated by those skilled in the art, upon proper pressurization of the assembly 74, the piston rod 72 will be reciprocated longitudinally back and forth to effect indexing of the table 18. Toward this end, a plurality of dowel pins, generally designated by the numeral 77, extend downwardly from and are fixedly secured to the lower side of the indexing table 18. The dowel pins 77 are spaced at 90° intervals and each one of which is spaced a preselected circumferential distance from the adjacent of the stations 48–56. The inner end of the indexing arm 36 is provided with a dowel pin engaging pawl 78 which is pivotally mounted by means of a suitable pivot pin and is biased downwardly by a suitable coil spring or the like 82. An elongated, generally arcuate shaped locking arm, generally designated 84, is pivotally mounted below the underside of the indexing table 18 by means of a suitable pivot pin or the like 86. One end of the locking arm 84 is provided with a locking tang 88 which is adapted to lockingly engage the adjacent of the dowel pins 77 in a manner hereinafter to be described. The opposite end of the locking arm 84 is adapted to be engaged by a biasing screw 90 which is adjustably mounted on the indexing arm 36 by being threadably received within a suitable bore 92 therein. The locking arm 84 is adapted to be resiliently biased in a generally counterclockwise direction in FIG. 6 by means of a resilient coil spring 94 that functions in a manner hereinafter to be described in controlling movement of the locking arm 84.

Normally, the indexing arm 36 is disposed in the phantom line position shown in FIG. 6; however, upon actuation of the assembly 74, the arm 36 is pivoted toward the solid line position shown in FIG. 6. As this occurs, the pawl 78 engages the adjacent of the dowel pins 77 and effects a rotation of the indexing table 18 approximately 90°, whereby each of the dies 20 is rotated 90°. As the indexing arm 36 reaches the solid line position shown in FIG. 6, the biasing screw 90 engages the end of the locking arm 84 and causes the locking tang 88 thereof to move into engagement with the adjacent one of the dowel pins 77, with the result that two of the dowel pins 77 are trapped or caged between the pawl 78 and the locking tang 88, thus locking the indexing table 18 in position preparatory to the workpiece forming operation. After this operation has been completed, the assembly 74 is again actuated so as to effect retraction of the piston rod 72 and the arm 36, with the pivotal mounting of the pawl 78 permitting movement thereof under the dowel pin 77 which is next to be engaged thereby by a subsequent cycle of the apparatus 10, as will be appreciated by those skilled in the art.

Referring now in detail to the workpiece holders or dies 20, as best seen in FIG. 2, each of the dies 20 is formed with a generally vertically extending central bore 114 and a plurality of circumferentially spaced, radially extending escape or relief bores 115 which are communicable at their inner ends with the central bores 114 and at their outer ends with the exterior of the associated die 20. Each of the dies 20 is formed with a reduced diameter lower end portion 116 which is adapted to be nestingly secured within a suitable complimentary shaped bore or opening 118 in the table 18. The bores 114 are adapted to be dimensioned so as to be complimentary in shape with respect to the workpieces, herein generally designated by the numeral 120, which are to be forged or extruded by the apparatus 10, wherein successive workpieces 120 may be placed in the bores 114 of the dies 20 as they are sequentially indexed to the loading station 48. Upon indexing of the table 18, the die 20 within which the workpiece is placed, is moved 90° to the idle station 50, during which time each of the other of the dies 20 will be simultaneously indexed or advanced 90°, thereby advancing the respective of the workpieces placed therein, as will be described in connection with the operation of the apparatus 10 of the present invention.

Together with the upper punch 14, the workpiece forming area 12 is provided with the aforementioned lower punch 16 which, as illustrated in FIG. 3, comprises a spacer block 122 that is secured to the mounting plate 97 underlying the ram 96. A pivot yoke 124 is operatively secured to the spacer block 122 and is adapted to be pivotably connected to the upper end of a crank arm 126 by means of a suitable pivot pin 128. The lower end of the crank arm 126 is pivotably connected by means of a driving pin 130 to a generally horizontally disposed cam member 132. The cam member 132 is pivotally mounted upon a cam pivot yoke 134 by means of a suitable pivot pin or the like 136, the yoke 132 being suitably secured to the base plate 22 or other fixedly mounted support structure. The cam member 132 comprises a generally horizontally outwardly extending forward end 138 which extends through or into an opening 140 formed in a vertically reciprocable cam slide 142, the slide 142 being mounted for vertical reciprocal movement by means of a suitable guide way section 144 of the assembly 112. Mounted on the upper side of the slide 142 is a holder element 146 which is formed with a central bore 148 within which the lower punch 150 is mounted. The lower punch 150 is adapted to extend upwardly through a central bore 152 formed in a lower punch guide bushing 154 that attached or secured to the underside of a bearing plate 156 upon which a portion of the indexing table 18 is supported. Together with the lower punch 150, the holder element 146 is adapted to carry a pair of guide
pins, generally designated 158, which are secured at their lower ends to the element 146 and extend upwardly through bores or recesses 160 in the guide bushing 154. The upper ends of the guide pins 158 extend upwardly through aligned bores 162 and 164 in the plate 158 and are also adapted to extend upwardly through a pair of bores 166 and 168 which are arranged at the opposite sides of each of the dies 20. The bores 162 and 164 are provided with antifriction bushings 170, while the bores 166, 168 adjacent each of the dies 20 are provided with a pair of suitable antifriction bushings 172. As best seen in FIG. 3, each of the dies 20 is provided with a pair of recessed areas 174, 176 which are aligned with the bores 166, 168, respectively, and are adapted to receive the upper ends of the guide pins 158. Suitable scrap guards or baffles 178 and 180 are provided around the outer periphery of the recessed areas 174, 176 of each of the dies 20 in order to prevent scrap metal, dirt or other foreign material from accumulating within the recesses 174, 176 or bores 166, 168.

At such time as the index table 18 is in a locked configuration, for example, when the index arm 36 is in the solid line position in FIG. 6, the ram 96 may be actuated to bias the upper punch 100 downwardly and the lower punch 150 upwardly. As the bottom punch 150 moves upwardly, the guide pins 158 simultaneously move upwardly through the bushings 170 and 172. The guide pins 158 are sufficiently long so that they enter the bores 160 in the index table 18 before the top and bottom punches 100 and 150 function to forge or extrude the workpiece 120. Thus, the indexing arm 36 roughly or approximately locates the table 18, and the two guide pins 158 at the station 52 precisely position the table 18 so that the top and bottom punches 100 and 150 are exactly on the vertical center line of the die 20 as they move toward the workpiece 120 retained therein. By way of example, the upper and lower punches 100 and 150 are designed to perform an extruding or forging operation on the workpieces 120, whereby upper and lower blind bores A and B (see FIG. 3) are formed in the upper and lower ends of the workpiece 120. It will be appreciated, of course, that various alternative manufacturing operations may be performed on the workpieces 120 by the punches 100 and 150 without departing from the scope of the present invention.

As best illustrated in FIG. 1, a generally horizontally disposed support plate 182 projects outwardly from the plate 97 and is adapted to support at the outer end thereof, a generally vertically oriented workpiece extracting rod 184. The rod 184 is vertically aligned with the bore 114 of the dies 20 which are indexed to the unloading station 54 and as such, upon downward movement of the ram 96, the rod 184 moves downwardly through the bore 114 of the die 120 at the station 54 to push or otherwise bias the workpiece therein downwardly out of the bore 114. A suitable workpiece conveying trough or the like 186 is provided below the unloading station 54 and functions to transfer the workpieces extracted by the rod 184 into a suitable container, conveyor or the like.

Suitable stabilizing or positioning gibs, generally designated by the numeral 188 are spaced circumferentially around the table 18 and are secured to the frame assembly 112 or other portion of the apparatus 10 to provide for stable support of the indexing table 18.

Refferring now to the overall operation of the apparatus 10 of the present invention, assuming that each of the dies 20 is provided with a suitable workpiece 120 therein, and that the workpiece 120 in the die 20 located at the forge station has been previously forged or extruded by the upper and lower punches 100 and 150, and that the workpiece 120 at the unloading station 54 has been removed by means of the extracting rod 184, the piston-and-cylinder assembly 74 is initially actuated in order to effect indexing of the table 18, as above described. When this occurs, the die 20 at the loading station 48 is indexed or rotated 90° to the idle station 50 and simultaneously, the die 20 that was previously located at the idle station is indexed to the forging station 52. Likewise, the forge station die 20 is indexed to the unloading station 54 and the unloading station die 20 is indexed to the loading station. Thereafter, the ram 96 is actuated via suitable automatic or manually actuatable controls well known in the art. When this occurs, the upper and lower punches 100 and 150 will move into engagement with the workpiece 120 located at the forging station 52 to effect a forging thereof. Simultaneously, the extracting rod 184 will operate to remove the workpiece 120 which is located at the unloading station 54. As previously described, the guide pins 158 will move upwardly into and through the recesses 160 to effect precise positioning of the index table 18 preparatory to the forging operation being performed by the punches 100 and 150. As the extruding or forging operation is performed, any excess material of the workpieces 120 created upon engagement thereof by the punches 100 and 150 is forced radially outwardly through the relief bores 115 in the die 20 located at the forging station 52. This excess material is subsequently removed by shearing when the extracting rod 184 bisects the workpiece 120 out of the die 20 at the unloading station 54, with the result that the workpieces will have a smooth finished exterior surface upon removal thereof from the apparatus 10. Upon completion of the extruding or forging operation, the ram 96 will move upwardly to effect retraction of the upper punch 100, and simultaneously, the lower punch 150 and guide pins 158 will be moved downwardly via the cam 132 and slide 142. Upon retraction of the punches 100, 150 and the guide pins 158, the piston and cylinder assembly 74 may again be actuated to effect a subsequent indexing on the table 18 preparatory to the next operational cycle of the ram 96, as hereinabove described.

FIGS. 4 and 5 illustrate a slightly modified embodiment of the present invention wherein the upper punch assembly 16 and the lower punch assembly 18 of the forming area 12 are replaced with punches which are known in the art as guide-type punches. In particular, a modified work forming area 200 is shown as comprising an upper punch assembly 202 and a lower punch assembly 204. The punch assemblies 202, 204 are adapted to be operatively associated with the same basic structure as described in connection with the apparatus 10, which structure is referred to and identified by like numerals with a prime (') suffix.

With reference to the lower punch assembly 204, the punch guide bushing 154 is shown as having an enlarged diameter centerbore 206 which is adapted to slidably carry a generally cylindrically shaped bushing 208 for vertical reciprocal movement. The bushing 208 is normally spring biased downwardly via suitable coil springs 210 and is adapted to be biased upwardly by a
lower bushing 212 carried on the lower end of the bottom punch 150° upon upward movement of the slide 142°, as will be described.

The upper punch assembly 202 is shown as comprising a pair of generally horizontally disposed, vertically spaced upper and lower support plates 214 and 216. The plates 214, 216 are vertically aligned with the upper punch 100° and are connected by a plurality of stripper bolts 218, the upper ends 220 of which are threadably engaged with the upper plate 214, and the lower ends of which extend through and are threadably engaged with bores 222 formed in the lower plate 216. A plurality of coil springs 224 are interposed between the plates 214, 216 and function to resiliently bias the lower plate 216 toward the enlarged diameter heads of the bolts 218. The lower support plate 216 carries a central guide bushing 226 which is secured thereto by a retaining element 228 and screws 230. The bushing 226 is formed with a central annular bore 232 through which the lower end of the upper punch 100° is slidable received. Disposed directly below the plate 216 is another generally horizontally disposed guide plate 234 which is formed with a central bore 236 within which an anti-friction bushing 238 is disposed, the bushing 238 serving to resiliently support the aforementioned guide bushing 226. The plate 234 is connected to the underside of the support plate 216 by means of a plurality of stripper bolts 240 which have their upper ends 242 threadably secured to the plate 216, the lower ends of the bolts 240 extending through and being threadably within bores 244 formed in the guide plate 234. A plurality of coil springs 246 are interposed between the underside of plate 216 and the upper side of the plate 234, the springs 246 being carried on guide pins 248 and functioning to resiliently bias the guide plate 234 downwardly away from the plate 216.

The punch assemblies, 202, 204 are adapted to function in essentially the same manner as the aforesaid upper and lower punches 14 and 16, with the exception that the bushings 208 and 226 are longitudinally slidable toward and away from the associated die 20° during the operation of the associated ram, with the result that the bushings 208 and 226 will function to maintain the workpiece material within the bore 114° of the die 201 while the punches 100° and 150° are extruding or forging the blind boxes A' and B' in the workpiece 120°. The springs 246 function to maintain the bushing 226 out of the upper end of the die 20° during the indexing cycle, and similarly, the springs 210 function to bias the bushing 208 so that the upper end thereof is out of registry with the table 13 during indexing. It will be appreciated, of course, that various alternate types of punches may be utilized with the apparatus 10 of the present invention without departing from the scope or fair meaning of the claims appended hereto and that the punches 14, 16, 202 and 204 have been illustrated herein merely by way of example.

While it will be apparent that the preferred embodiment illustrated herein is well calculated to fulfill the objects above stated, it will be appreciated that the present invention is susceptible to modification, variation and change without departing from the scope of the invention.

1 claim:

A workpiece forming apparatus comprising a workpiece forming station, including first and second movably opposed work forming means, a rotatable workpiece index table for transferring workpieces toward and away from said forming station, a plurality of equally spaced work holders on said index table, means for effecting simultaneous actuation of said first and second work forming means toward and away from each other, means for selectively rotating said index table in order to move workholders so as to transfer the formed workpiece away from said station and an unforming workpiece toward the station, and first and second means for selectively rotatably positioning said index table relative to said forming station so as to position a selected workholder in alignment with said forming station.

2. A workpiece forming apparatus as set forth in claim 1 wherein said first and second work forming means are generally vertically aligned.

3. A workpiece forming apparatus as set forth in claim 1 wherein said index table includes workholders which comprise a loading station and an unloading station in addition to said forming station.

4. A workpiece forming apparatus as set forth in claim 1 which includes power operated means for selectively rotating said index table.

5. A workpiece forming apparatus as set forth in claim 1 wherein said index table comprises four equally circumferentially spaced workpiece forming dies in said workholders each of said dies comprising a workpiece forming area adapted to selectively receive and discharge workpieces therefrom.

6. An invention as set forth in claim 5 wherein the apparatus comprises a workpiece loading station, a workpiece unloading station and an idle station in addition to said workpiece forming station, said stations being equally circumferentially spaced from one another.

7. An invention as set forth in claim 6 wherein said workpiece dies are alignable, one with each of said stations, and which includes means for selectively rotating said indexing table approximately 90° whereby to advance each of said dies from one of said stations to the next adjacent station.

8. An invention as set forth in claim 1 which includes a power operated ram for actuating said first work forming means.

9. The invention as set forth in claim 8 which includes linkage means operatively connecting said power operated means with said second work forming means, whereby upon actuation of said power operated ram, both said first and second work forming means operate simultaneously.

10. The invention as set forth in claim 1 which includes a locking arm comprising said first positioning means, said locking arm being moveable toward and away from a position lockingly securing said indexing table in preselected rotated positions.

11. The invention as set forth in claim 1 wherein said second positioning means is operable simultaneously with said first and second work forming means.

12. A workpiece forming apparatus comprising a workpiece forming station, including first and second work forming means, a rotatable workpiece index table for transferring workpieces toward and away from said forming station, and
means for effecting simultaneous actuation of said first and second work forming means and for selectively rotating said index table in order to transfer the formed workpiece away from said station and an unformed workpiece toward said station, first and second means for selectively rotatably positioning said index table relative to said forming station, said second positioning means being operable simultaneously with said first and second work forming means, and
wherein said second positioning means comprises locating pins movable toward and into engagement with said indexing table to precisely position said table relative to said forming station upon actuation of said first and second work forming means.

13. The invention as set forth in claim 12 wherein said first and second work forming means comprises upper and lower work forming devices, wherein said locating pins are actuated simultaneously with actuation of one of said work forming devices.

14. A workpiece forming apparatus comprising, a workpiece forming station, including first and second work forming means, a rotatable workpiece index table for transferring workpieces toward and away from said forming station, four equally circumferentially spaced workpiece forming dies in said index table, each of said dies comprising a workpiece forming area adapted to selectively receive and discharge workpieces therefrom, said table being rotatable whereby said dies are selectively moved toward and away from said workpiece forming station, said dies comprising workpiece receiving areas, and which includes means communicable with said areas for permitting the escape of excess material during a work forming operation, and means for effecting simultaneous actuation of said first and second work forming means and for selectively rotating said index table in order to transfer the formed workpiece from said station and an unformed workpiece toward said station.

15. The invention as set forth in claim 14 wherein each of said work forming dies comprises a generally vertically arranged bore, and which includes at least one generally radially extending bore communicable at its inner end with said vertical bore for permitting the escape of said excess material during a work forming operation.

16. The invention as set forth in claim 13 wherein said upper and lower work forming devices comprise upper and lower punches, said punches being generally vertically aligned at said work forming station.

17. The invention as set forth in claim 16 which includes means for retaining workpieces within each of said workpiece dies during a forming operation.

18. The invention as set forth in claim 17 wherein said means for retaining workpieces within said dies comprises bushing means moveable toward and away from engagement with the upper and lower ends of workpieces disposed in said dies during each operational cycle of said apparatus.

19. The invention as set forth in claim 1 wherein said means for selectively rotating said table comprises an indexing arm, said arm being selectively operatively engageable with said table to effect rotation thereof.

20. A workpiece forming apparatus comprising a workpiece forming station, including first and second work forming means, a rotatable workpiece index table for transferring workpieces toward and away from said forming station, means for effecting simultaneous actuation of said first and second work forming means and for selectively rotating said index table in order to transfer the formed workpiece away from said station and an unformed workpiece toward said station, an indexing arm for selectively rotating said table, said arm being selectively operatively engageable with said table to effect rotation thereof, and a plurality of equally circumferentially spaced members projecting downwardly from the underside of said indexing table, said indexing arm being selectively engageable with said members for rotating said table in approximately ninety degree increments.

21. The invention as set forth in claim 20 which includes pawl means on said indexing arm selectively engageable with said downwardly projecting members on said indexing table, and which includes power operated means for pivoting said indexing arm so as to selectively engage said pawl means with said members and thus effect selective rotation of said table.

22. The invention as set forth in claim 21 which includes a locking arm disposed adjacent to the underside of said table, said arm being selectively engageable by said indexing arm and being moveable toward a position cooperating with said arm for lockingly securing said indexing table by engaging selected of said downwardly projecting members thereon.

23. The invention as set forth in claim 22 which includes upper and lower punches comprising said first and second work forming means, and which further includes locking pins moveable into engagement with said table upon actuation of said lower punch, said locking pins functioning to precisely locate said indexing table after said locking arm functions to approximately rotationally locate the same during each operational cycle of said apparatus.