April 28, 1964 O. A. G. SPECHT **3,130,611**

SWAGING MACHINE

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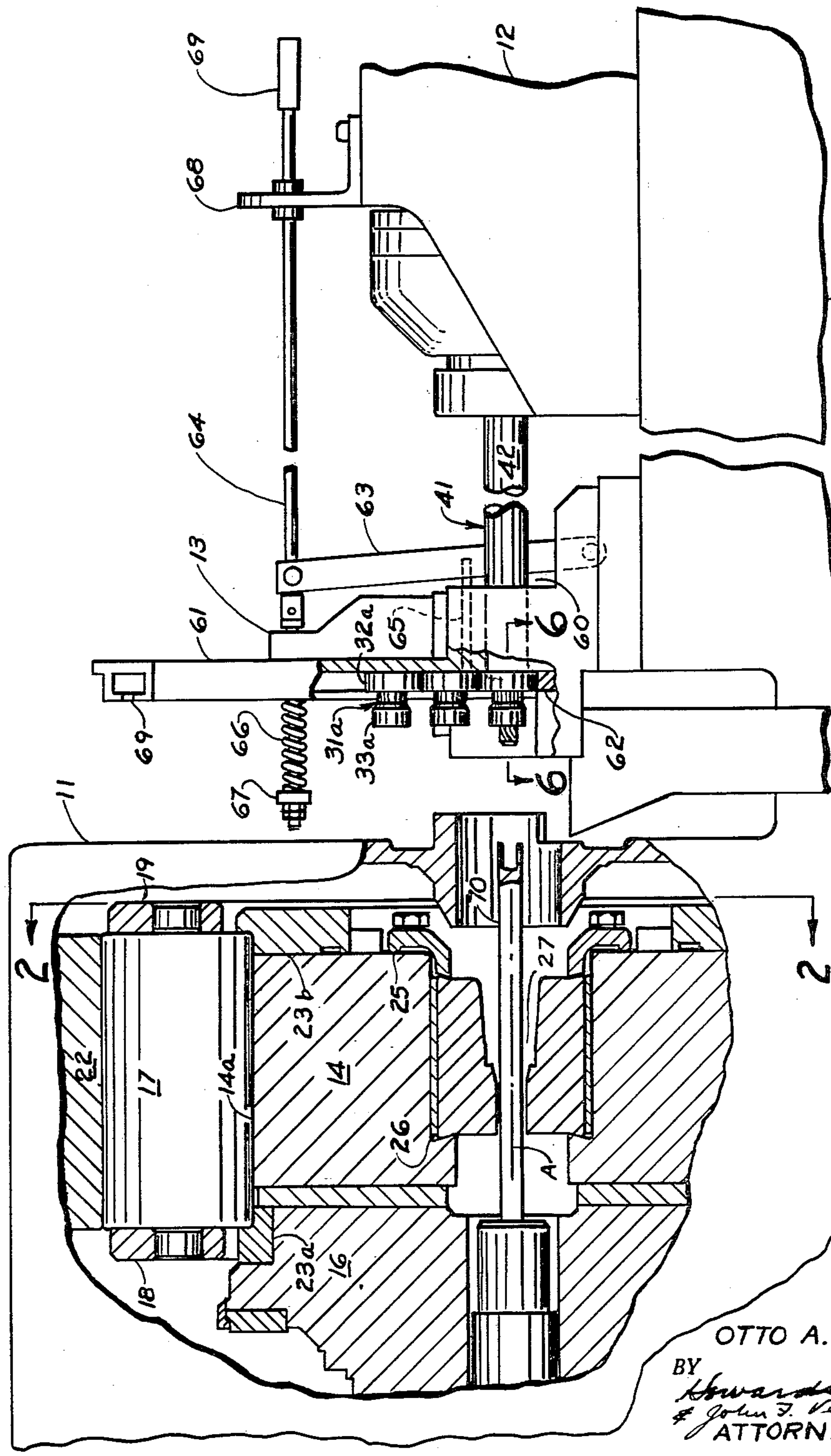

Fig. 1

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Filed March 13, 1961 4 Sheets-Sheet 2

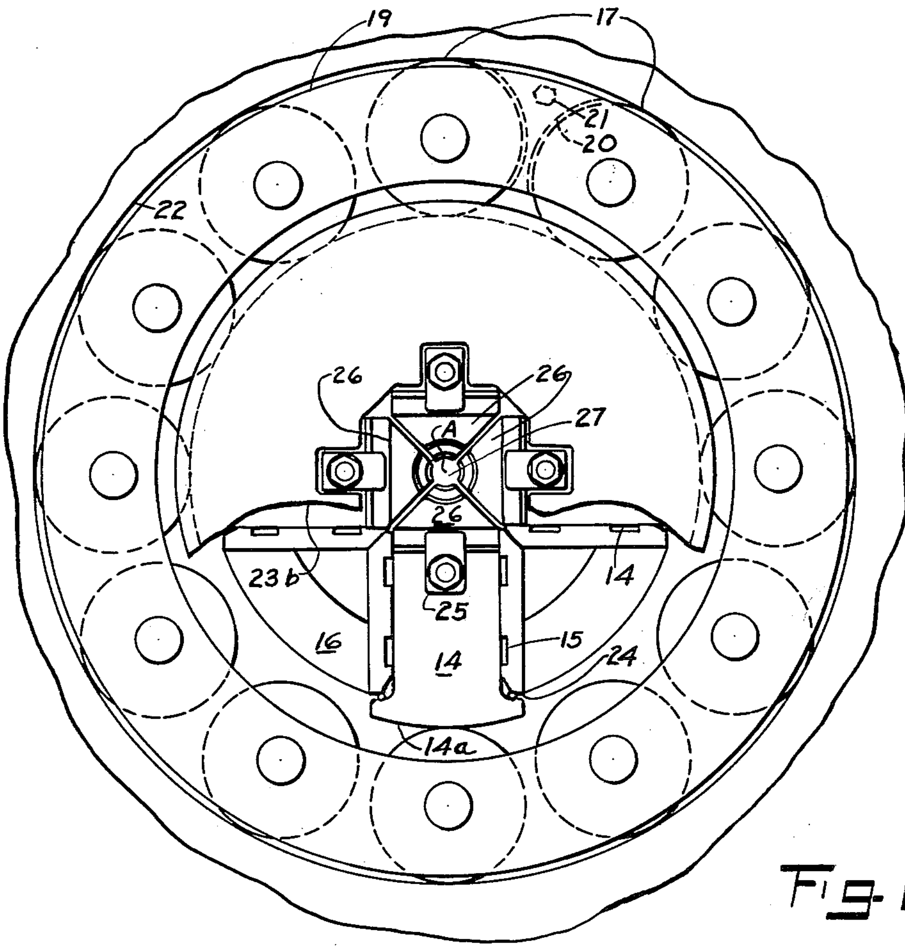

Fig. 2

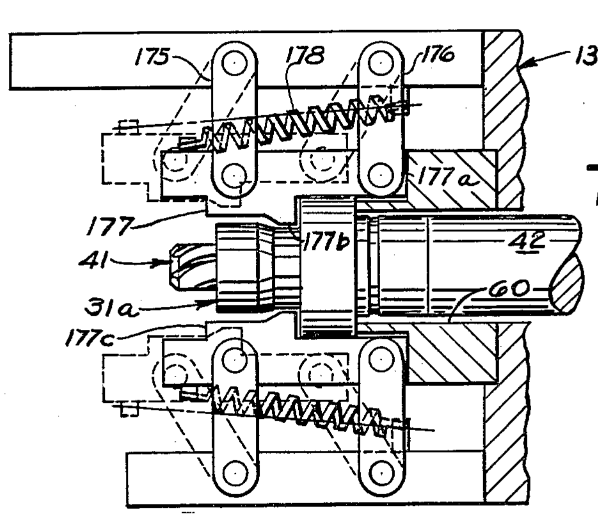

Fig. 6

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SWAGING MACHINE

Filed March 13, 1961 4 Sheets-Sheet 3

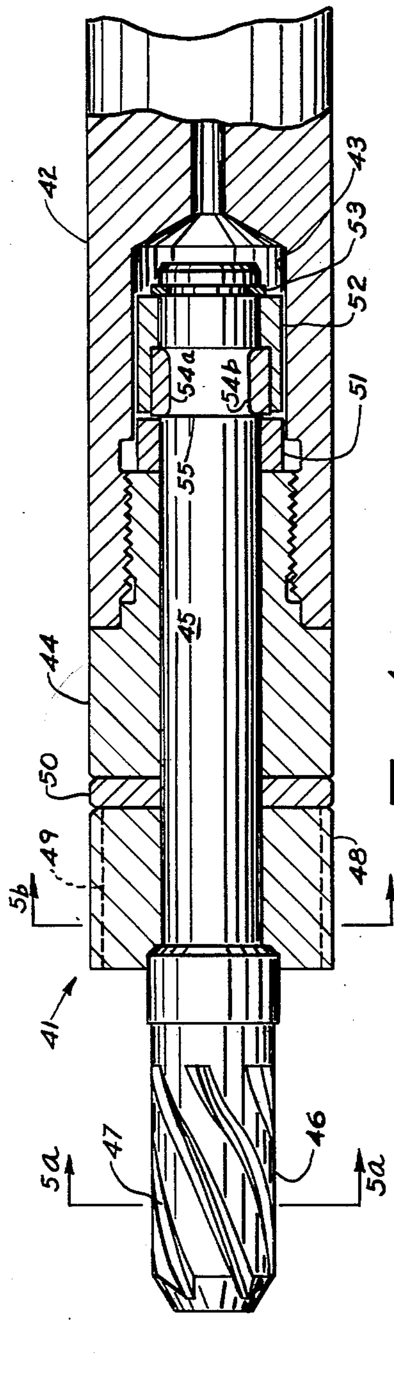

Fig. 4

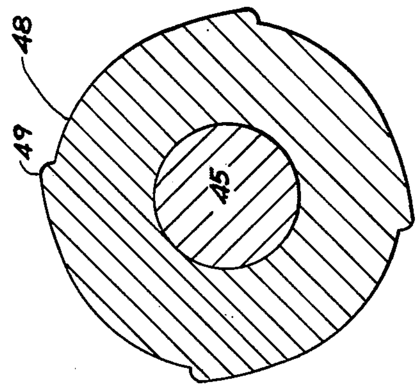

Fig. 5b

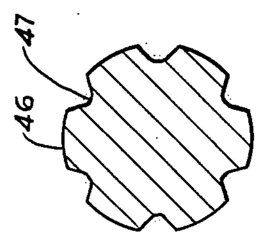

Fig. 5a

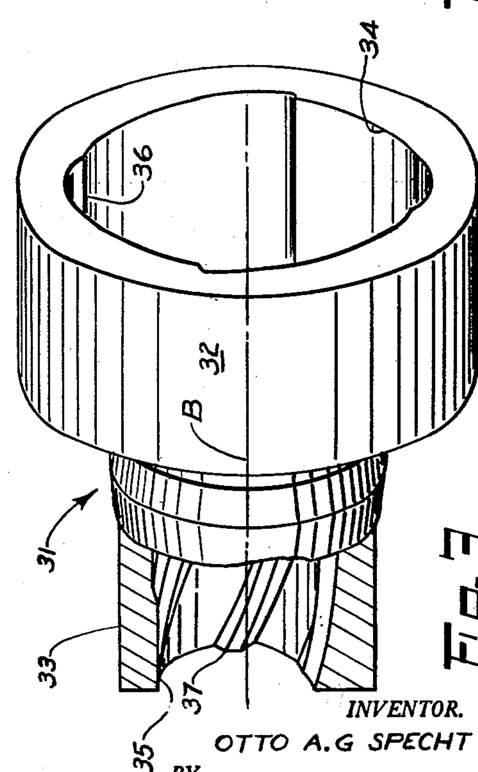

Fig. 3

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Filed March 13, 1961 4 Sheets-Sheet 4

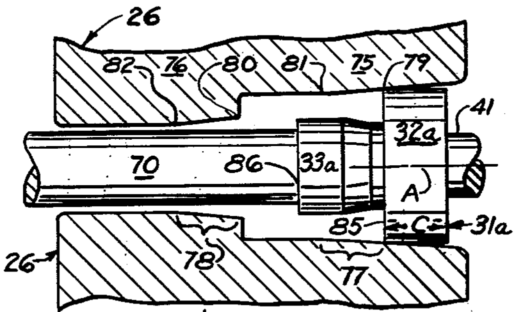

Fig 7a

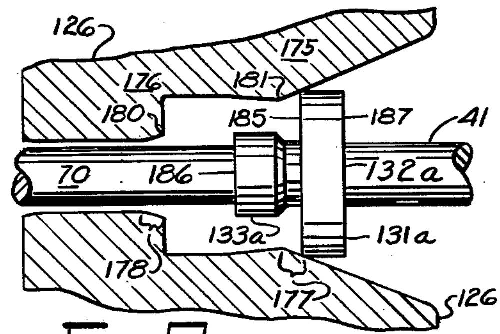

Fig 8a

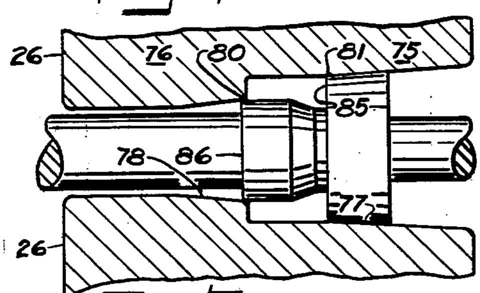

Fig 7b

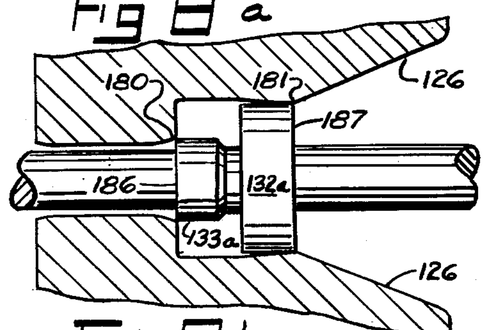

Fig 8b

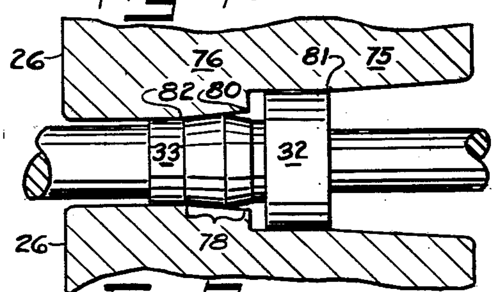

Fig 7c

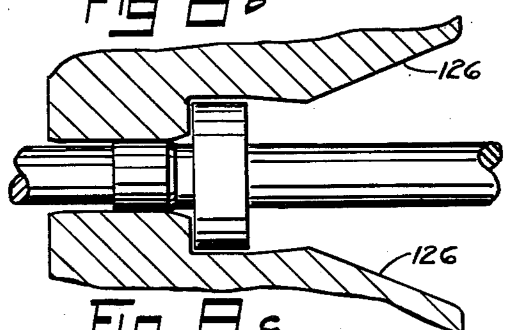

Fig 8c

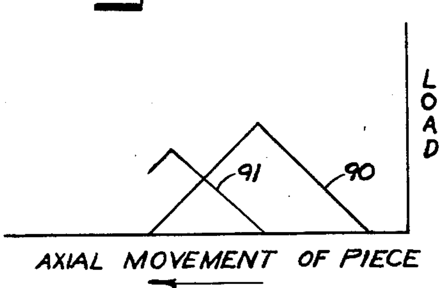

Fig 7d

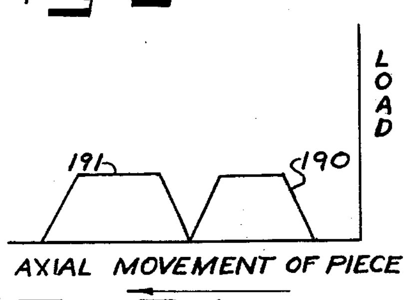

Fig 8d

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United States Patent Office

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1

3,130,611
SWAGING MACHINE

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Filed Mar. 13, 1961, Ser. No. 95,414
10 Claims. (Cl. 78—20)

The present invention relates to rotary swaging machines.

Rotary swaging machines are capable of quickly forming many types of workpieces which would be difficult and time consuming to machine by other methods. In a typical rotary swaging machine, opposed, radially pulsating, forming dies impinge on a workpiece mounted on a mandrel and received therebetween. Under the impact of the dies the metal forms about the mandrel so that the internal conformation of the workpiece is determined by the mandrel while the external conformation is determined by the dies.

One type of complex workpiece which is difficult to form in present rotary swaging machines is one having two tandem portions containing bores with conformations inclined with respect to each other. Such a piece might, for example, have left hand helical grooves or ribs in one bore, and right hand helical grooves or ribs, or straight grooves or ribs, in the other bore. To permit separation of mandrel and workpiece after forming, the two portions of the workpiece are formed, in two separate operations, on different mandrels.

With the structure disclosed herein a complex workpiece having conformations inclined with respect to each other on tandem bores of different size can be formed on one mandrel in one continuous operation. To accomplish this a mandrel having two relatively rotatable portions, each of said portions having conformations to form the bore of one portion of the workpiece, is provided. These mandrel portions, which are spaced axially on the mandrel in accordance with the spacing of the bores in the workpiece, are received in the workpiece and the workpiece is formed thereon by the pulsating die members of the machine. After the workpiece has been formed, the mandrel can be removed therefrom by exerting an axial force between the workpiece and the mandrel. This force will produce rotation of one or both mandrel portions, depending on the conformations impressed in the workpiece, in the required amount to permit separation of both mandrel portions in unison from the respective bores of the workpiece. The relative axial force is applied in a direction to move the smaller mandrel portion, after separation from the smaller bore, out through the larger bore. It is therefore one object of the present invention to provide mechanism for swaging in one continuous operation a workpiece having tandem bores of different size with conformations inclined relative to each other.

Another type of complex workpiece which has proved difficult to form is one having two tandem portions of different radial span. Generally, in forming a simple workpiece of cylindrical conformation, the workpiece is fed axially into the operating zone between pulsating dies having a flared forming face terminating at a trailing edge, the diameter of the trailing edge corresponding to the desired outer diameter of the workpiece. The load on the machine begins to rise when the leading edge of the workpiece is initially contacted by the forming faces of the die and will reach maximum value when a maximum length (or axial span) of the workpiece is subjected to the forming action of the dies. For example, if the entire axial span of the portion of the workpiece to be formed is being contacted by the forming faces of the pulsating dies at one time, the load on the machine will begin to drop when the leading edge of the workpiece portion passes the

2

trailing edge of the forming face of the die since the workpiece is formed to final outer diameter at the trailing edge of the forming face. If, on the other hand, the entire axial span of the workpiece portion to be formed is not being contacted by the forming faces of the pulsating dies at one time, the load will not begin to drop until the trailing edge of the workpiece passes that point of the die face which first contacts the workpiece, which point may be defined as the effective leading edge of the die face. In either case, the load will be maximum when maximum contact occurs between the forming faces of the dies and the workpiece, and the load, which is a function of axial position of the workpiece relative to the die members, will begin to drop when the axial span of contact between the workpiece and the die diminishes.

If a workpiece has two tandem portions of different radial span, there must be two die forming faces to engage the respective portions of the workpiece, each forming face portion having a trailing edge to bring the respective portions down to the different desired outer diameters. To form the two portions of the workpiece simultaneously would increase the load on the machine and consequently each portion of such a workpiece is generally formed in a separate operation. With the structure disclosed herein, such a workpiece can be formed, without any significant increase in the maximum load, in a single operation. This is accomplished by spacing the forming faces of the die, in the axial direction, a different distance than the axial spacing between the respective portions of the workpiece. With the forming face portion of the die member designed to form the workpiece of smaller radial span behind the forming face of larger radial span, one of the portions of a complex workpiece which is fed into the operating zone between the pulsating dies, small end first, will contact one forming face before the other portion of the workpiece contacts the other forming face. At no time is the load caused by one portion of the workpiece at a maximum value when the load caused by the other portion of the workpiece is at a maximum value. Instead, it is only after the load caused by one portion of the workpiece has diminished that the load caused by the other portion of the workpiece reaches its maximum value. It is therefore another object of the present invention to provide a swaging machine for forming complex workpieces of different radial span in one continuous operation in which the load resulting from operations on the two portions of the workpiece is distributed to avoid excessive load.

The load resulting from operations on two tandem workpiece portions of different radial span can be satisfactorily distributed even though there is an intermediate axial position of the advancing workpiece when both portions thereof are operated on. There are conditions, however, where no simultaneous operation on the two portions is desired. For example, if the mandrel supporting the workpiece is made in two portions, one for each portion of the workpiece, the slightest eccentricity between the mandrel portions will result in bending forces which can snap the mandrel if simultaneous operation occurs at any time on the two portions of the workpiece. A similar result may ocur if there is any eccentricity between the forming faces of the die. Since the size of the mandrel is dictated by the desired bore in the finished workpiece, the mandrel cannot be enlarged to resist these forces. Under these conditions it is desirable to space the forming faces of the dies in the axial direction a distance sufficiently different from the axial spacing between the workpiece portions so that operation on one portion of the workpiece is finished before operation on the other portion is begun. With this spacing of the die faces, the mandrel is not subjected to bending forces which would occur if both portions of the workpiece were being operated on at the same time. It is therefore another object of the present invention to provide a swaging machine which will complete formation of one portion of an advancing workpiece before operation on a second portion of the workpiece is begun.

Other objects and advantages of the present invention should be readily apparent by reference to the following specification, considered in conjunction with the accompanying drawings forming a part thereof, and it is to be understood that any modifications may be made in the exact structural details there shown and described, within the scope of the appended claims, without departing from or exceeding the spirit of the invention.

In the drawings:

FIG. 1 is a fragmentary view in elevation, with portions broken away, of a swaging machine constructed in accordance with the present invention;

FIG. 2 is a view taken on line 2—2 of FIG. 1;

FIG. 3 is a perspective view of a workpiece formed in one continuous operation by the mechanism of the present invention;

FIG. 4 is a view, partly in cross-section, of the mandrel of the machine of FIG. 1;

FIG. *5a* is a view taken on line *5a*—*5a* of FIG. 4;

FIG. *5b* is a view taken on the line *5b*—*5b* of FIG. 4;

FIG. 6 is a view taken on line 6—6 of FIG. 1;

FIGS. *7a*, *7b*, and *7c* are views of a workpiece being fed between the dies for forming and showing a workpiece when it is first contacted by the dies, at an intermediate position, and as it approaches its final position, respectively.

FIG. *7d* is a chart showing the load on the machine resulting from operation on the two portions of the workpiece when the forming faces are spaced as shown in FIGS. *7a*, *7b*, and *7c*.

FIGS. *8a*, *8b* and *8c* are views similar to FIGS. *7a*, *7b*, and *7c* except that the die faces are spaced so that only one portion of a workpiece is operated on at one time; and

FIG. *8d* is a chart showing the load on the machine resulting from operation on the two portions of the workpiece when the forming faces are spaced as shown in FIGS. *8a*, *8b*, and *8c*.

There is shown in FIG. 1 a rotary swaging machine having a base 10. Mounted on the base 10 are a head 11, a feed carriage 12, and, between the head and the feed carriage, a loading and stripping mechanism 13. Within the head, as shown in FIGS. 1 and 2, four rams 14, spaced 90 degrees apart around a longitudinal axis A, are mounted for limited movement in radially extending ways 15 of a driven hub 16. A plurality of rollers 17 are rotatably supported between a pair of annular plates 18 and 19. Plate 18 has a plurality of spacer portions 20 extending between the rollers and plate 19 is secured to the end of the spacer portions, in spaced relation to plate 18, by bolts 21. The ring of rollers 17 is carried between an outer race member 22 secured in the head, and a pair of inner race members *23a* and *23b* secured in hub 16 and spaced apart to receive the rams therebetween. Each ram 14 has a head *14a*, the inner side of which is engaged with resilient spacers 24 seated in the hub and the outer side of which is adapted to engage the rollers 17 between the races *23a* and *23b*. As the hub 16 is rotated the rams 14 are urged outwardly by centrifugal force and the resilient strips 24 but are periodically driven inwardly by contact with a roller. The rotation of driven hub 16, and the inner race members *23a* and *23b* connected thereto, causes rotation of rollers 17 about their axes. With outer race 22 fixed, the ring of rollers rotates about axis A at lower angular speed than that at which hub 16 is driven. Thus, by virtue of the relative angular speed between the rams and the ring of rollers, the rams are caused to pulsate radially about the longitudinal axis A. Each ram has secured thereto at its inner end by clamp 25 a forming die 26 which pulsates with the ram to define operating zone 27.

A typical workpiece formed in one continuous operation by the mechanism of the present invention is shown in FIG. 3. The formed workpiece 31 has two tandem portions 32 and 33 having outer cylindrical conformations, the portions having central bores 34 and 35, respectively. The outer diameter of portion 32 is larger than the outer diameter of portion 33 and the diameter of bore 34 is larger than the diameter of bore 35. Bore 34 has straight conformations, or grooves, 36 extending in the axial direction (parallel to the central longitudinal axis B of the workpiece) while bore 35 has helical ribs 37 which constitute conformations inclined relative to the straight conformations 36 in bore 34 (and inclined relative to axis B of the workpiece).

The feed carriage 12 is mounted on bed 10 for movement towards and away from the head 11 and has extending therefrom a mandrel 41 on the longitudinal axis A. The mandrel 41 includes a rod 42 mounted in the carriage and, as shown in FIG. 4, the rod has a bore 43 at its outer end. A bushing 44 is threadedly received in bore 43 and rotatably supports a shaft 45. Shaft 45 has a mandrel portion 46 secured to its outer end which has helical grooves 47. These grooves correspond to the desired helical ribs 37 in the bore 35 of the finished workpiece portion 33 so that when the metal workpiece blank is pressed on the mandrel by the forming dies, the helical ribs on the mandrel will form the helical grooves in the workpiece. Rotatably mounted on shaft 45 and abutting mandrel portion 46 is a second mandrel portion 48 having straight conformations, or ribs, 49 corresponding to the desired conformations, or grooves, 36 of the finished workpiece portion 32. The shaft 45 has spacers 50 and 51 at each end of bushing 44 and, behind the spacer 51 in bore 43, the shaft has a sleeve 52 retained thereon by snap ring 53. Sleeve 52 holds two locking shoes *54a*, *54b* in a groove 55 on shaft 45. Thus shaft 45 (and hence mandrel portion 46) is free to rotate on mandrel rod 42 and mandrel portion 48 is free to rotate relative to shaft 45 and mandrel portion 46. At the same time mandrel portion 46 and mandrel portion 48 are held against axial movement relative to mandrel rod 42 and thus move axially therewith.

The mandrel 41 in its retracted position is behind the loading and stripping mechanism 13. As shown best in FIG. 6, the mechanism 13 has an opening 60 therethrough to permit advance and retraction of the mandrel. The mechanism 13 has a loading chute 61 terminating at the opening 60, and a seat 62 to hold a workpiece dropped from the chute with the central axis B of the workpiece on the longitudinal axis A. As shown in FIG. 1, a lever 63 has one end pivotally connected to the frame of mechanism 13 and has the opposite end connected to an actuating rod 64. A pin 65 pivotally connected to lever 63 advances as the lever 63 is moved forward and slides between the piece on seat 62 and the piece thereabove to hold the pieces above seat 62 after the advancing mandrel has engaged the piece on the seat and moved it toward the head. The actuating rod 64 extends through the frame of mechanism 13 and the lever 63 and rod 64 are biased toward the head by compressed spring 66 received on the rod between collar 67 thereon and the frame of mechanism 13. The actuating rod 64 also slidably extends through bracket 68 on carriage 12 and is retracted, to retract lever 63 and pin 65, when collar 69 is engaged by bracket 68 as carriage 12 approaches its fully retracted position. As pin 65 retracts the next piece falls onto seat 62.

The workpiece blank *31a*, like the finished workpiece, has two tandem cylindrical portions *32a* and *33a*, each portion having a central cylindrical bore. The outer diameter of portion *32a* is larger than the outer diameter of portion *33a* and the bore in portion *32a* is larger than the bore in portion 33*a*. The loading chute has a slot 69 through which the workpiece blank extends, with the smaller portion thereof outside the chute and toward the head of the machine, and it is in this position that the workpiece is deposited on the seat 62. The mandrel advances into the workpiece blank with mandrel portion 46 in the smaller portion of the workpiece and mandrel portion 48 in the larger portion thereof, and a workpiece blank is carried toward the head. A guide rod 70 extends through the head of the machine and between the dies thereof to engage the forward end of the workpiece and hold it on the mandrel with the mandrel portion 48 seated against the forward end of the bore in the larger portion 32*a* of the workpiece blank. The guide rod 70 is yieldable and retracts as the mandrel advances into the head.

Each forming die 26 has, as shown in FIG. 7*a*, a first, or leading, die portion 75 adapted to form the portion 32*a* of the workpiece blank, and a second, or trailing, die portion 76 adapted to form the portion 33*a* of the blank. Each die 26 thus forms a set of two die portions which together completely form the workpiece. Each portion 75, 76 of each die has a flared forming face 77, 78 respectively, extending between an effective leading edge 79, 80 and a trailing edge 81, 82. The effective leading edge of each die portion is that point on the pulsating die portion which first engages the advancing workpiece. Thus the distance of the effective leading edge 79 of die portion 75 from the longitudinal axis A when the die is closed equals the radius of portion 32*a* of the unformed workpiece blank 31*a*. Similarly, the distance of the effective leading edge 80 of die portion 76 from the longitudinal axis A when the die is closed equals the radius of unformed portion 33*a* of workpiece blank 31*a*. The trailing edge 81 of die portion 75 is spaced from the axis A a distance equal to the outer diameter of the cylindrical finished workpiece portion 32 while trailing edge 82 of die portion 76 is spaced from axis A a distance equal to the outer diameter of cylindrical finished workpiece portion 33. Thus workpiece portion 32 is operated on by forming face 77 as it advances and workpiece portion 33 is operated on by forming face 78 as it advances. Other portions of the die perform no forming action on the workpiece. The load on the machine in the formation of one portion of the workpiece will depend on the span (in the axial direction) of contact between the workpiece portion and the forming face of the die at any one time. After the workpiece portion engages the forming face the load from that portion will rise to a maximum value when maximum axial span of contact exists between the particular workpiece portion and the forming face. As the particular portion advances and is formed, the load resulting from formation of that particular portion decreases as the axial span of contact between the workpiece and forming face decreases. The load resulting from formation of workpiece blank portion 32*a* is shown at 90 in FIG. 7*d* and the load resulting from formation of workpiece blank portion 33*a* is shown at 91.

As the leading edge 85 of workpiece blank portion 32*a* passes the effective leading edge 79 of die portion portion 75 the load 90 on the machine begins to increase. The die portion 76, however, is spaced in the axial direction from die portion 75 a greater distance than the respective portions 32*a*, 33*a* of the workpiece blank so that the leading edge 86 of workpiece blank portion 33*a* does not yet contact the effective leading edge 80 of die portion 76, and portion 33*a* does not add to the load on the machine at this time. Portion 32*a*, which, in the workpiece shown for illustrative purposes, has an axial span C equal to the axial span of the forming face 77, establishes maximum forming contact with the forming face (and hence maximum load 90) when the leading edge 85 of the workpiece blank portion 32*a* is at the trailing edge 81 of the die portion 75, as shown in FIG. 7*b*. At this time the leading edge 86 of workpiece portion 33*a* is at the effective leading edge 80 of die portion 76. As the workpiece advances the load 90 resulting from operation on portion 32*a* drops (since the axial span of contact between portion 32*a* and forming face 77 decreases) and the load 91 resulting from operation on portion 33*a* begins to rise. As forming face 78 operates on an increasing axial span of portion 33*a* forming face 77 operates on a decreasing axial span of portion 32*a*. When the axial span of contact between forming face 78 and workpiece blank portion 33*a* decreases, as shown in FIG. 7*c*, the load 91 resulting from formation of this portion drops until the workpiece is formed to the desired extent. At no time is there maximum forming contact on both portions at the same time and thus, by spacing the portions of the die and the leading edges of said portions in different amounts than the spacing of the workpiece portions and the leading edges thereof, the load on the machine is distributed. With this distribution of load a smaller machine can be used. It should be noted that if the portions of the workpiece to be operated on were spaced a sufficient distance apart the portions of the die could be spaced a lesser distance axially than the spacing between the workpiece portions and the smaller leading workpiece portion would then be operated on before the larger trailing workpiece portion.

Even though the load may be distributed, simultaneous operation on two portions of a workpiece at any time during the operation can cause severe forces tending to fracture the mandrel if, for example, there is a slight eccentricity in the mandrel, in the forming faces of the die, or in the workpiece blank. Since the diameter of the mandrel is determined by the desired diameter of the bores in the finished workpiece, the mandrel cannot be designed to avoid this difficulty. With the modification shown in FIGS. 8*a*, 8*b*, and 8*c*, two portions of a workpiece can be formed in one continuous operation without subjecting the mandrel to severe bending forces. In this modification the operation on one portion of the workpiece is completed before the operation on the other portion is begun.

In this modification the workpiece blank 131*a* has two portions 132*a*, 133*a*. Portion 132*a* has a leading edge 185 and a trailing edge 187, and portion 133*a* has a leading edge 186. The die 126 has two portions 175 and 176, with forming faces 177, 178, respectively, and is constructed so that the trailing edge 181 of portion 175 is spaced from the effective leading edge 180 of the second die portion 176 an equal or greater distance in the axial direction than the entire axial span of the workpiece (that is the distance from the leading edge 186 of workpiece portion 133*a* to the trailing edge 187 of workpiece portion 132*a*). The portion 132*a* of the workpiece blank is formed, producing a load indicated at 190 in FIG. 8*d*, as the workpiece blank moves axially from the position shown in FIG. 8*a* to the position shown in FIG. 8*b*. With this modified construction the trailing edge 187 of portion 132*a* will be at or beyond the trailing edge 181 of the die portion 175 (and hence workpiece portion 132*a* will be completely formed) when the leading edge 186 of portion 133*a* is at the effective leading edge 180 of the die portion 176 (and hence when the forming operation begins on portion 133*a*). The portion 133*a* of the workpiece blank is formed, producing a load indicated at 191 in FIG. 8*d*, as the workpiece blank moves axially from the position shown in FIG. 8*b* to the position shown in FIG. 8*c*. Since radial forming forces are applied on only one portion of the workpiece at a time, bending forces are not present on the mandrel even if there is eccentricity in the mandrel, in the workpiece blank, or in the forming faces of the die.

The mechanism 13, in addition to supplying pieces one at a time for engagement by the advancing mandrel, serves to strip the pieces off the mandrel as the mandrel retracts. As shown in FIG. 6 there is pivotally connected to the frame of mechanism 13, on each side of a workpiece resting on seat 62, a pair of parallel links 175, 176 of equal length pivotally connected to a floating link

177. The link 177 is normally biased by spring 178 to a retracted position with its rear end 177*a* abutting against the frame of mechanism 13. In this position a projecting ear 177*b* on link 177 extends into the path of a workpiece blank 31*a*. The links 177, in their retracted position, serve to support a workpiece blank received on seat 62 in a position to receive the advancing mandrel 41. As the advancing mandrel slides into the workpiece blank and moves it toward the head, the floating links 177 are swung out of the path of the workpiece but swing back to the retracted position with end 177*a* abutting the frame as soon as the advancing workpiece clears the floating links. In the retracted position of floating links 177, the ends 177*c* thereof are in the path of a retracting workpiece and define stop members therefor.

After the blank has been compressed into a finished workpiece on the mandrel by the pulsating dies, the mandrel is retracted from the head. When the workpiece contacts ends 177*c* of the floating links, which are held against the frame by springs 178, the workpiece stops while the mandrel continues to retract. Helical ribs 37 have been formed in the helical grooves 47 of mandrel portion 46 so that shaft 45 (and hence mandrel portion 46) rotate by virtue of the relative axial force applied between the mandrel and the workpiece to unscrew mandrel portion 46 from the finished workpiece 31. The conformations on mandrel portion 48 form straight conformations in bore 34 and mandrel portion 48 cannot rotate as the mandrel is withdrawn from the workpiece. However, since shaft 45 and mandrel 46 can rotate relative to mandrel portion 48, the mandrel portion 48 can withdraw from bore 34 without rotation relative to the workpiece, while mandrel portion 46 rotates relative to the workpiece to unscrew therefrom.

It will be understood that the terms "leading" and "trailing," when applied to the workpiece and die, derive their meaning from the relative axial movement between the die and the workpiece as the workpiece is advanced between the dies during the forming operation (as, for example, as the workpiece is advanced from the position shown in FIG. 7*a* or 8*a* to the position shown in FIG. 7*c* or 8*c*). Thus, for example, the leading edge of a workpiece portion is that edge first engaged by the die as the workpiece advances. Similarly a trailing edge of a forming face on a die portion is that edge of the forming face which last engages a portion of the advancing workpiece.

What is claimed is:

1. In a swaging machine having opposed forming dies mounted for radial pulsation about a central axis to impinge on a workpiece blank inserted therebetween, a mandrel mounted on said axis having two portions along its length adapted to be received within a workpiece blank, the portions of the mandrel formed to produce the desired conformations on the interior of a workpiece, one of said portions rotatable relative to the other to permit withdrawal of the respective portions of the mandrel simultaneously from a formed workpiece on relative movement in one direction between the mandrel and the workpiece.

2. In a swaging machine having opposed forming dies mounted for radial pulsation about a central axis to impinge on a workpiece blank inserted therebetween, a mandrel for forming the interior of two tandem portions of a workpiece having conformations inclined with respect to each other comprising a first portion having conformations for forming the interior of one of said portions of the workpiece, a second portion rotatable relative to the first portion and having conformations for forming the interior of the other of said portions, and means to mount said portions for longitudinal movement along said central axis spaced longitudinally in fixed axial relation in accordance with the spacing of the portions of the workpiece for insertion therein.

3. In a swaging machine for forming a workpiece having two tandem portions with interior conformations inclined relative to each other, the machine having opposed forming dies mounted for radial pulsation about a central axis to impinge on a workpiece blank inserted therebetween, the combination of a mandrel rod, two mandrel portions mounted on the rod for relative rotation therebetween and spaced on the rod in fixed relation as said portions of the workpiece are spaced to receive a workpiece blank thereon, each of said mandrel portions having conformations inclined relative to the other portion to form the interior of said portions of the workpiece, means to reciprocate said mandrel rod along said central axis to advance a workpiece received thereon to an operating zone between said forming dies and to retract the workpiece therefrom, and a stop adapted to engage a retracting finished workpiece to strip the workpiece from the mandrel portions.

4. A swaging machine for successive production of complex workpieces having two tandem portions with interior conformations inclined relative to each other comprising in combination opposed pulsating forming dies mounted about a central axis for radial impingement on a workpiece blank inserted therebetween, a mandrel rod, two mandrel portions mounted on the rod for relative rotation therebetween and spaced on the rod in fixed relation as said portions of the workpiece are spaced to receive a workpiece blank thereon, each of said mandrel portions having conformations inclined relative to the other portion to form the interior of said portions of the workpiece, a loading chute to deposit workpiece blanks one at a time on said central axis, means to reciprocate the mandrel rod along said central axis to move said mandrel portions between a retracted position behind the loading chute and an advanced position at an operating zone between the forming dies, and a stop member between the loading chute and operating zone movable into the path of a workpiece as the mandrel rod retracts to strip a finished workpiece from the mandrel portions.

5. In a swaging machine for forming a complex workpiece having two tandem portions of different radial span, a mandrel adapted to receive and move a workpiece along an axis, opposed rams mounted for radial pulsation about said axis, each of said rams having two die portions to operate respectively on said workpiece portions, said die portions spaced in the axial direction a different amount than said workpiece portions.

6. In a swaging machine for forming a complex workpiece having a central axis and two tandem portions of different radial span from said axis, a mandrel having a longitudinal axis adapted to receive said workpiece in coaxial relation and advance said workpiece along said longitudinal axis, opposed sets for forming dies mounted for radial pulsation about said axis and having a leading die portion and a trailing die portion, said leading die portion spaced from the axis to pass the workpiece portion of smaller span without contact therewith and to impinge on the workpiece portion of larger span for formation thereof, said trailing die portion spaced from the axis to impinge on the workpiece portion of smaller span for formation thereof, said die portions spaced in the axial direction a different amount than said workpiece portions whereby one of said die portions commences formation of one of said workpiece portions before the other die portion commences formation of the other workpiece portion.

7. In a swaging machine for forming a complex workpiece having a central axis and two tandem cylindrical portions of different radii, said workpiece portions having leading edges spaced a predetermined distance apart, said machine having a mandrel adapted to receive and advance a workpiece along a longitudinal axis coaxial with the central axis of the workpiece, the combination of opposed forming dies mounted for radial pulsation about said longitudinal axis, each comprising a first flared forming face terminating at a trailing edge spaced from the axis a distance equal to the desired radius of the larger workpiece portion and a second flared forming face terminating at a trailing edge spaced from the axis a distance equal to the desired radius of the smaller workpiece portion, said second forming face spaced in the direction of

workpiece travel from the first forming face with the trailing edge of the second forming face spaced from the trailing edge of the first forming face a different distance than said predetermined distance.

8. In a swaging machine for forming a complex workpiece having a central axis and two tandem cylindrical portions of different radii, said machine having a mandrel adapted to receive and advance a workpiece along a longitudinal axis coaxial with the central axis of the workpiece, opposed sets of forming dies mounted for radial pulsation about said longitudinal axis, each set having a first forming face adapted to form one of said workpiece portions and a second forming face adapted to form the other of said workpiece portions, said forming faces spaced in the axial direction a distance sufficiently different from the spacing of the portions of the workpiece so that as the workpiece advances one portion of the workpiece is completely formed when formation of the other portion of the workpiece begins.

9. In a swaging machine for forming a complex workpiece having a central axis and first and second cylindrical portions of different radii, each of said portions having a leading edge and a trailing edge as the workpiece is advanced toward an operating zone, said machine having a mandrel adapted to receive and advance a workpiece toward the operating zone along a longitudinal axis coaxial with the central axis of the workpiece with said first portion leading said second portion, opposed forming dies mounted for radial pulsation about said longitudinal axis and each having a first forming face and a second forming face, said first and second forming faces each having a leading edge spaced from the axis when the dies are closed a distance equal to the radius of the first and second unformed portions, respectively, of the workpiece and the first and second forming faces each having a trailing edge spaced from the axis when the dies are closed a distance equal to the radius of the first and second formed portions, respectively, of the workpiece, the leading edge of the first forming face spaced from the trailing edge of the second forming face a distance not less than the distance between the leading edge of the first workpiece portion and the trailing edge of the second workpiece portion whereby one portion of an advancing workpiece has passed the trailing edge of one forming face and has been completely formed thereby when the leading edge of the other workpiece portion is engaged by the leading edge of the other forming face to begin formation thereby.

10. In a swaging machine for forming a complex workpiece having two tandem portions of different radial external span, one of said portions having internal conformations inclined with respect to internal conformations on the other portion, the combination comprising a mandrel having two relatively rotatable portions spaced in fixed relation in accordance with the portions of the workpiece and adapted for insertion into a workpiece blank to support the workpiece on an axis, one of said mandrel portions having external conformations to form the internal conformations on one portion of the workpiece and the other mandrel portion having external conformations to form the internal conformations on the other portion of the workpiece, means to move the mandrel to advance the workpiece along said axis, opposed forming dies mounted for radial pulsation about said axis, each of said forming dies having two portions to impinge on the respective portions of the workpiece and form the workpiece portions about the mandrel to desired radial span, said die portions spaced axially a different amount than said respective workpiece portions.

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,130,611 April 28, 1964

Otto A. G. Specht

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 8, line 48, for "for" read -- of --.

Signed and sealed this 15th day of September 1964.

(SEAL)
Attest:

ERNEST W. SWIDER
Attesting Officer

EDWARD J. BRENNER
Commissioner of Patents