June 14, 1966 B. E. RICKS 3,255,623

METHOD AND APPARATUS FOR FORMING BALL STUDS

Filed Dec. 26, 1962 2 Sheets-Sheet 1

Fig. 1

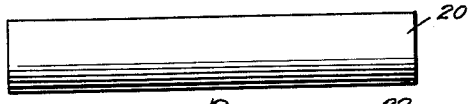


Fig. 2

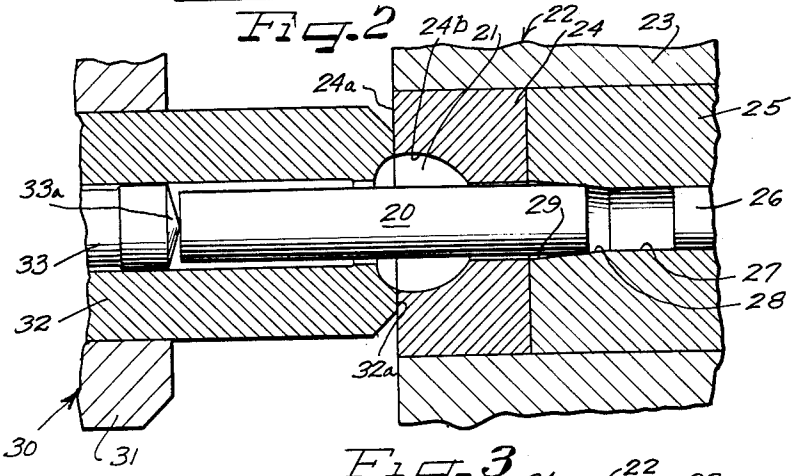


Fig. 3

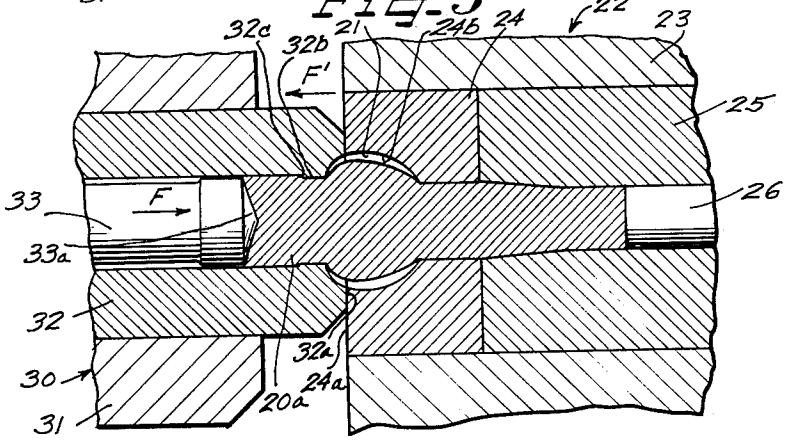


Fig. 4

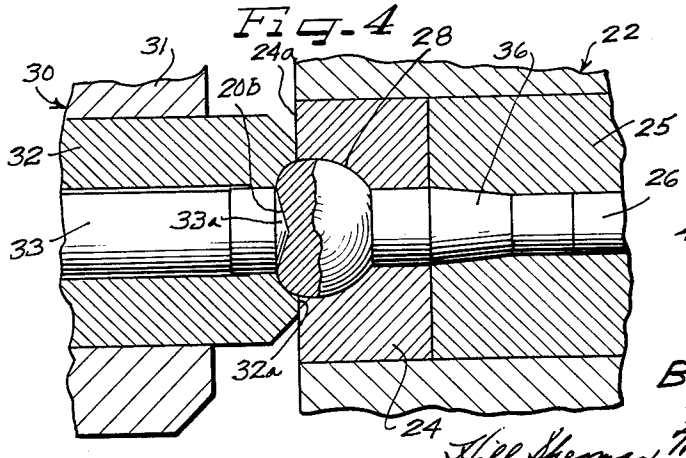
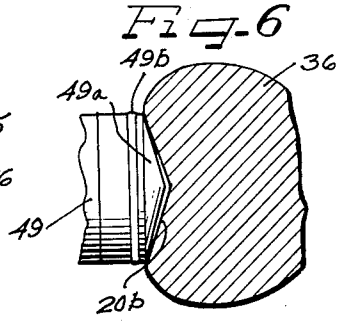


Fig. 6



INVENTOR.
Bernard E. Ricks
BY
Hill, Sherman, Meroni, Gross & Simpson
ATTORNEYS

June 14, 1966 B. E. RICKS 3,255,623

METHOD AND APPARATUS FOR FORMING BALL STUDS

Filed Dec. 26, 1962 2 Sheets-Sheet 2

Fig. 5

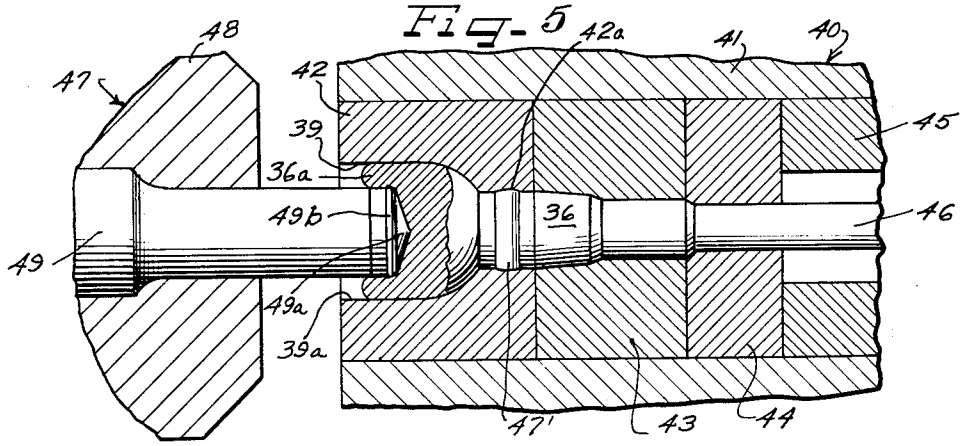


Fig. 7

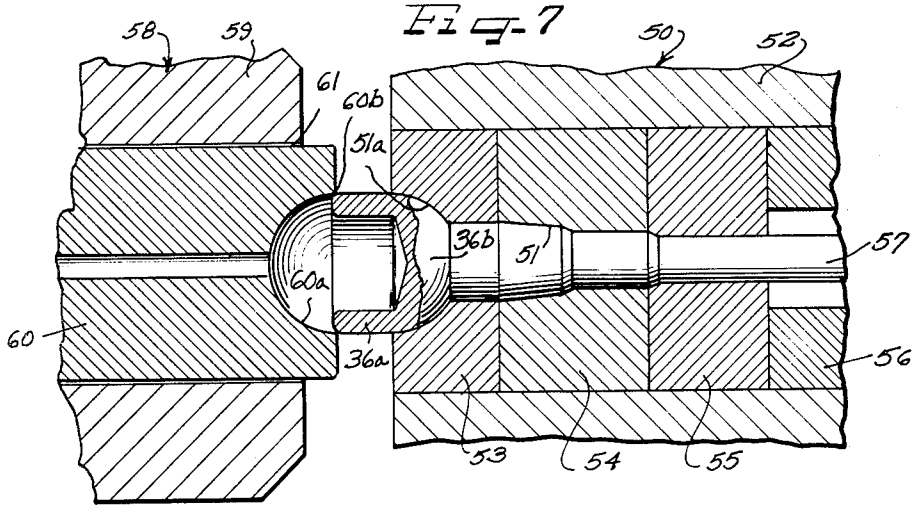


Fig. 8

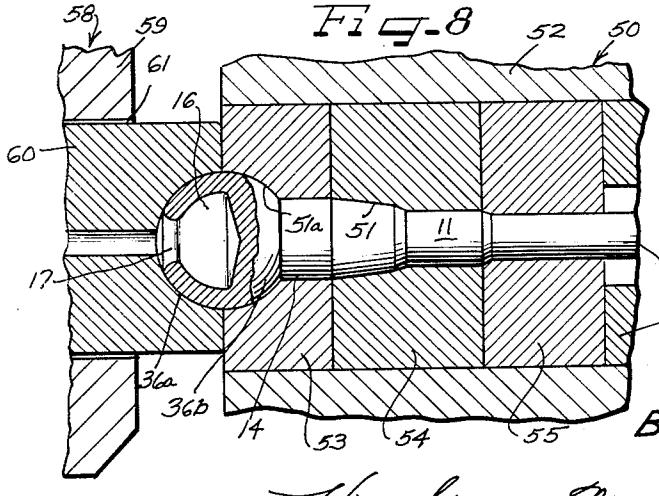
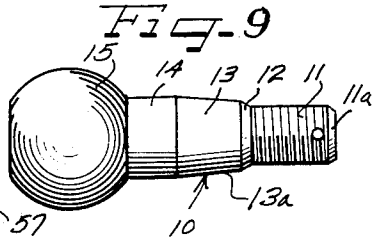


Fig. 9



INVENTOR.
Bernard E. Ricks
BY
Dill, Sherman, Meroni, Gross & Simpson
ATTORNEYS

United States Patent Office 3,255,623 Patented June 14, 1966

3,255,623

METHOD AND APPARATUS FOR FORMING BALL STUDS

Bernard E. Ricks, Birmingham, Mich., assignor to TRW Inc., a corporation of Ohio

Filed Dec. 26, 1962, Ser. No. 246,985
17 Claims. (Cl. 72—256)

The present invention relates generally to the formation of a ball stud from a metal rod. The invention is more particularly concerned with improvements in a method and apparatus for manufacturing ball studs by punch and die extrusion techniques.

The present application is an improvement upon the techniques disclosed in my earlier issued U.S. Patent No. 3,036,367 entitled, "Method of Making Ball Studs."

The method disclosed in my earlier patent illustrated how a blank of predetermined diameter and length was formed into a ball stud by locating the blank in alignment with a die having a cavity substantially corresponding to the outer shape of the final stud with the exception of the entire head thereof, and directing against one end of the blank a sliding gather punch to provide upon the blank, the stem, taper, shank and portion of the head ultimately desired. An extrusion punch was then directed at the center of the partially-shaped head to form a thimble-shaped cavity therein, and then a die was employed to reduce the open end of the partially-shaped head into the desired ball-shaped spherical configuration. This patent disclosed the technique for forming the thimble-shaped recess into an essentially round inner cavity in the head providing a lubricant reservoir for the tie rod socket or other structure within which the ball stud is normally received.

In the practice of my new method, essentially the same steps are employed in the formation of the ball stud described in my issued patent, but each of the steps has been improved. During the initial forming step and according to important features of my invention, I have found that by providing a constricting shoulder on a sliding punch sleeve that a locking metal mass may be formed upstream of the die cavity for developing a forward force vector in excess of a backward force vector enabling the sliding punch to be held in face-to-face contact with the die member to prevent rod metal leakage between these engaged faces. After the rod metal has been substantially displaced into the die cavity, the locking metal mass is also forced into the cavity and free of the constricting shoulder whereupon a conical recess is formed in the spherical head portion of the rod by the end of the metal rod at the end of its stroke.

According to still other important features of this invention, the thus formed rod is placed into a second die member and an extrusion punch is forcefully engaged against the spherical head portion at the area of the conical recess and this extrusion punch is provided with a conical end having an included angle larger than the included angle of the conical recess whereby an oil trap is provided between the sliding punch and the conical recess to permit oil to flow axially from the oil trap with the metal of the spherical head portion as the extrusion punch is forced into the spherical head portion displacing the material of the head portion around the extrusion punch to form an extended skirt portion.

According to yet other important features of this invention, as the extrusion punch is urged against the spherical head portion to form the extended skirt portion, a portion of the metal in the shank of the blank is displaced into a locking cavity in the second die member locking the shank with the second die member to enable the extrusion punch to be withdrawn and disengaged from the extended skirt portion. Thereafter, a knock-out pin is actuated to eject the ball stud blank from the second die member while simultaneously wiping back or displacing the bulge of metal lodged in the locking cavity or metal trap into the shank of the blank.

The thus formed blank is then rigidly held while being struck by a floating punch permitting the punch cavity to be properly aligned with the extended skirt portion as the skirt portion is displaced to provide a spherical head on the ball stud.

Other important features of this invention relate to the provision of a new and improved apparatus for securing engaged ends of a tubular punch holder and a die member in face-to-face relation while a punch is being actuated causing a spherical head portion to be formed in the die cavity on the end of a metal rod.

It is, therefore, an important aim of the present invention to provide improvements in the ball stud forming methods disclosed in my aforesaid patent. Another object of this invention lies in the provision of a method of providing a new and improved oil trap between the extrusion punch and the ball stud blank for forming an annular skirt on a partially shaped head of the blank.

Still another object of this invention is to provide a new and improved method for separating an extrusion punch from a partially formed ball stud blank.

Yet another object of this invention is to provide a new and improved method for aligning a skirt shaping punch with respect to a partially formed ball stud blank so that the skirt portion can be more readily collapsed to provide a spherical head portion on a ball stud.

Other objects and advantages of the present invention will more fully become apparent in view of the following detailed description taken in conjunction with the accompanying drawings illustrating a single embodiment and in which:

FIGURE 1 is a view of a typical blank from which the finished ball stud may be formed;

FIGURE 2 is a sectional view of a first forming die showing the stud blank being directed therein by a sliding gather punch;

FIGURE 3 is a sectional view of the die of FIGURE 2 and showing the manner in which a locking metal mass is built up for securing the punch and the die member in face-to-face engagement as the metal of the rod is displaced into the die cavity;

FIGURE 4 is a sectional view of the die of FIGURE 3 showing the partially formed ball stud having a lubricant recess in the head portion thereof;

FIGURE 5 is a sectional view of a second die illustrating the method for forming an extended skirt portion on the head end of the ball stud blank;

FIGURE 6 is a fragmentary enlarged view illustrating the relationship of the punch shown in FIGURE 5 with respect to the enlarged head portion of the ball stud as shown in FIGURE 4 for the purpose of illustrating the oil trap;

FIGURE 7 is an enlarged vertical section of a third die for collapsing the extended skirt portion;

FIGURE 8 is an enlarged vertical section similar to FIGURE 7 only illustrating the manner in which the stud head portion is formed to final shape; and

FIGURE 9 is a side elevation of a finished ball stud of the type produced from the operation of the dies shown in FIGURES 1–8.

Referring now to the drawings, and first to FIGURE 9, a full ball stud **10** as produced in accordance with this invention comprises a stem **11** of generally uniform diameter, which is illustrated as being threaded and as having a tapered end portion **11***a*. The ball stud **10** is also provided with tapered portions **12** and **13** having diameters greater than the stem **11**. Integral with the tapered portions is a shank **14** of generally uniform cross

section throughout its length and upon which an integral head **15** is received. The head is generally circular in cross section, as shown, and is provided interiorly thereof with a generally dome or bell-shaped cavity **16** (FIGURE 8) connected with an open ended passage **17**. The passage **17** provides a fluid path for lubricant into and out of the cavity, and said cavity thereby constitutes an effective grease reservoir that can be drawn upon throughout the life of the tie rod socket or other structure with which the ball stud **10** is associated.

Illustrated in FIGURE 1 is a blank **20** which may be cut from coil stock to the desired diameter and length. The blank is adapted to be located partially within and in alignment with the axis of a die cavity **21** of a die member **22**. The cavity **21** corresponds in general to the outer shape essentially of the ball stud **10**, with the exception of the open end **17**. It will be noted that the stem, taper and shank portions of the final ball stud are of lesser diameter and greater length than the forming surfaces of the cavity **21**. Specifically, the die **22** includes a die case **23**, a top die insert **24**, a die liner **25** and a knock-out pin **26**. The die cavity **21** includes a section **27** of relatively uniform diameter which provides the stem **11** of the stud. The cavity **21** is further comprised of tapered sections **28** and **29** which preliminarily form the portions **12** and **13** on the stud **10**. It will, of course, be appreciated that for certain applications in practice, only a single taper on the stud is required, and accordingly the die cavity design may be suitably modified.

At the outer end of the cavity **21** is a semi-circular or semi-spherical shape within which a configuration is shaped comprising a ball head portion as shown in FIGURES 3 and 4.

Mounted adjacent the die **22** is a punch assembly **30** which includes a punch casing or sleeve **31**, a sliding punch or sleeve punch or punch guide **32** and a sliding gather punch **33** having a conical head **33***a*.

In the initial practice of the first step of the present process, the blank **20** is located with respect to the die cavity **21** in the manner shown and circumferentially surrounded by the sleeve punch or guide **32**. In this position, the guide **32** has its end **32***a* engaged in face-to-face relation with end **24***a* of the die insert **24**. The sliding gather punch **33** is then forcefully urged against the end of the blank **20** at which moment the blank is forced to move into the die cavity **21** causing the blank to extrude into the cavities or bores **29**, **28** and **27** of die liner **25** until the blank comes in contact with the end of the knock-out pin **26**. While the blank is being extruded in this manner, the inside diameter of the tubular punch **32** supports the outside diameter of the blank and thereby prevents snaking of the blank. The forward motion of the punch pin **33** then continues after the blank comes into contact with the knock-out pin **26** and since the blank cannot move deeper into the die cavity at this point, the blank begins to "bulge" or upset into a spherical cavity **24***b* of the die insert **24**.

As the material is caused to flow, a force vector F' develops which tends to cause the faces **24***a* and **32***a* to move apart leaving a gap. If these faces were to separate, a dual gathering would occur, leaving a step on the end of the blank. Therefore, according to an important feature of this invention, the tubular punch holder **32** is provided with an annular rib **32***b* providing a stricture shoulder **32***c* upstream from the face **32***a*. Thus, as the blank is forced into the die, a locking metal mass **20***a* is upset behind the shoulder **32***c* developing a forward force vector F on the sliding punch **32**. Because metal from the mass **20***a* must extrude past the shoulder and is confined to a smaller diameter by the rib **32***b* and because the metal gathering in the cavity **21** has not yet filled the cavity, the forward force vector F is greater than the backward force vector F'. As a result the faces **24***a* and **32***a* are held together in tight contact as the metal is upset into the semi-spherical cavity **24***b*.

The stricture or rib **32***b* is only a few thousandths of an inch and there is a gradual taper from the large diameter at the shoulder **32***c* to the opposite end of the stricture **32***b*. When the rib **32***b* becomes worn, the tubular punch holder **32** will move backward and produce defective ball studs unless the holder **32** is held against the die face **24***a*.

At the end of the forward stroke of the sliding gather punch **33**, a conical indent **20***b* is coined in the end of the blank **20** by the conical end **33***a* of the punch **33**. It will further be appreciated that as the conical end **33***a* of the punch **33** moves past the rib **32***b*, the locking metal mass is caused to flow from behind the shoulder **32***c* and is forced into the die cavity **21** so that the engaged faces **24***a* and **32***a* may be separated by moving the punch assembly **30** away from the die assembly **22**. The knock-out pin **26** is then actuated to force a partially formed ball stud blank **36** from the die cavity **21**.

The partially formed ball stud blank **36** is then placed into a second die cavity **39** provided in a second die **40**. The die **40** includes a die case **41** having a die insert **42**, a taper insert **43**, a bottom insert **44**, a filler insert **45**, and a knock-out pin **46**. The insert **42** is provided with an annular recess **42***a* defining a metal trap which is only a few thousandths of an inch larger than the inside diameter of the cavity **39** at the area of the trap **42***a*.

A sliding extrusion punch assembly **47** is mounted adjacent the die assembly **40** and includes a punch holder **48** and an extrusion punch **49** having a conical end **49***a* with an included angle that is larger than the included angle of the conical indent or recess **20***b* in the end of the ball stud blank **36** as illustrated in FIGURE 6.

The purpose of the metal trap **42***a* is to permit the outside diameter of the blank **36** to swell into the trap under the heading pressure developed by the extrusion punch **49** as it is projected against the partially formed ball stud blank **36**, as shown in FIGURE 5. The swell or displaced portion of the blank is identified at **47'**. This displaced portion **47'** functions to secure the blank **36** in the die while the extrusion punch **49** is retracted out of the die cavity **39**. The "bulge" or displaced portion **47'** is then wiped back to the taper of the blank **36** in the die upon actuation of the knock-out pin **46**.

The depth of the metal trap **42***a* must be limited to a few thousandths of an inch in order for the "bulge" **47'** to be wiped back to the shank of the blank and in order to avoid giving the blank a poor appearance. If the metal trap **42***a* is too shallow, the blank will stick on the punch **49** and this will result in the blank **36** being re-struck in the die unless the operator stops the machine before the ram again actuates the punch **49**.

The included angle at the conical indent **20***b* in the end of the blank **36** is smaller than the included angle of the conical end **49***a* of the extrusion punch. When the extrusion punch **49** initially contacts the blank **36** as shown in FIGURE 6, an oil trap is formed at the face of the extrusion punch and the oil trapped at the face of the punch prevents metal to metal contact as the metal in the blank **36** is caused to flow radially of the punch during the punching operation. As the metal is caused to flow radially at the face of the punch, oil is metered out of the oil trap along with the metal flow thereby lubricating the bearing portion **49***b* of the extrusion punch. An extrusion lubricant or oil of any suitable type is directed at the extrusion punch when the punch is moving through the rear half of the stroke cycle. The lubricant has a dual purpose to lubricate the punch and to keep the temperature of the punch down to a minimum. The extrusion of lubricantion spray must be carefully controlled to prevent inadequate lubrication so that excessive heat will not be generated during extrusion of the blank. If the spray oil density is excessive and the air velocity is insufficient, the punch will be flooded with oil and excessive oil will be trapped between the extrusion punch and the end of the blank which may tend to cause ruptures in the blank and/or an excessive amount of smoke. It is also undesirable

to spray the punch and allow the punch to enter the empty die cavity, for oil will then be trapped in the die cavity and will prevent proper forming of the blank. Skin ruptures are a common result of oil trapped in the die cavity.

In order to enable the blank **36** to be removed from the die **40**, the die cavity is provided with an angled flared mouth surface **39***a*. The angle at the mouth of the die cavity is not discernible to the eye, but it is nevertheless flared slightly outwardly in a direction away from the cavity **39** permitting easier stripping of the punch out of the blank and easier stripping of the blank **36** from the die cavity **39**.

After the blank **36** is removed from the second die **40**, a third die **50** is provided having a die cavity **51** for receipt of the blank. The die assembly **50** includes a die case **52**, a top die insert **53**, a taper die insert **54**, a pointing die insert **55**, a filler insert **56**, and a knock-out pin **57**. Mounted adjacent one end of the die assembly **50** is a punch assembly **58** including a punch holder **59** and a floating forming punch **60**. A relatively large clearance **61** is provided between the outside diameter of the punch and the inside diameter of the punch holder to permit a limited float of the punch with respect to the punch holder. This float permits the forming punch to align itself to the blank as the blank is being formed and eliminates the need for precise alignment of a rigid punch with respect to a rigidly held blank.

The floating punch **60** has a semi-spherical recess **60***a* for forming the annular skirt portion **36***a* into a generally spherical shape with the head portion **36***b* of the blank.

In order to assist in the collapsing of the skirt portion **36***a* of the blank, the punch die cavity **60***a* has a small lead radius **60***b* at the mouth of the forming punch to avoid scraping of the blank surface by the leading edge of the punch. After the annular skirt portion **36***a* is formed in the manner illustrated in FIGURE 8, the punch assembly **58** is retracted and the knock-out pin **57** is actuated to free the hollow head ball stud **10** from the die **50**. The stem **11** of the stud **10** may be threaded in a subsequent machine operation.

It will be seen from the foregoing that applicant has provided a new and improved method for manufacturing a ball stud as well as improved apparatus for manufacturing ball studs. By practicing the described method, it is not necessary to heat the dies or the metal being worked. The die structures required to produce the ball studs are of relatively simple construction. By employing the method and apparatus described herein, the percentage of ball stud rejects may be materially reduced and the apparatus may be maintained in continuous operation for longer periods without mechanical failure.

It is to be understood that variations and modifications may be practiced in the method and apparatus herein disclosed without departing from the spirit of the invention or the scope of the claims.

I claim as my invention:

1. In a method of forming a ball stud from a metal rod, the steps of

disposing an end of the metal rod within a die cavity defined between a punch holder and a die member and moving the punch holder in flush engagement with the die member,

moving a sliding gather punch having a conical end face axially through the punch holder against the end of the rod and forming a locking metal mass upstream of the cavity developing a forward force vector in excess of a backward force vector acting to separate engaged faces of the punch holder and the die member locking the punch guide and the die member together at the die cavity while directing the metal into the die cavity and while confining the path of metal flow in an opposite axial direction to form a segmented spherical head portion and with the sliding gather punch forming a conical recess in the spherical head portion of the metal rod at the end of its stroke,

placing lubricant in said recess,

directing an extrusion punch against the spherical head portion while disposed in a second cavity of a second die member with the included angle on a conical end of the extrusion punch being larger than the included angle of the conical end on the sliding gather punch providing an oil trap preventing metal to metal contact between the conical end and the conical recess causing the oil to flow axially from the oil trap with the metal of the head portion as the extrusion punch is pushed against the spherical head portion displacing a central portion of said head portion axially around said extrusion punch to form an extended skirt portion while contemporaneously displacing a portion of a shank of said rod into the second die member locking the shank with the second die member to enable the extrusion punch to be retracted and disengaged from the extended skirt portion,

knocking the thus formed ball stud blank from the second die member while contemporaneously wiping off the displaced portion on the shank of the rod, and

die forming said extended skirt portion to a contour complementing the contour of said head portion.

2. In a method of forming a ball stud from a metal rod, the steps of

disposing an end of the metal rod within a die cavity defined between a punch holder and a die member and moving the punch holder in flush engagement with the die member,

moving a sliding gather punch having a conical end face axially through the punch holder against the end of the rod and forming a locking metal mass upstream of the cavity developing a forward force vector in excess of a backward force vector acting to separate engaged faces of the punch holder and the die member locking the punch guide and the die member together at the die cavity while directing the metal into the die cavity and while confining the path of metal flow in an opposite axial direction to form a segmented spherical head portion and with the sliding gather punch forming a conical recess in the spherical head portion of the metal rod at the end of its stroke,

placing lubricant in said recess,

directing an extrusion punch against the spherical head portion while disposed in a second cavity of a second die member thereby displacing a central oprtion of said head portion axially around said extrusion punch to form an extended skirt portion,

knocking the thus formed ball stud blank from the second die member, and

die forming said extended skirt portion radially inwardly to form a generally spherical contour complementing the contour of said head portion.

3. In a method of forming a ball stud from a metal rod, the steps of

disposing an end of the metal rod within a die cavity defined between a punch holder and a die member,

moving a sliding gather punch having a conical end face axially through the punch holder against the end of the rod directing the metal into the die cavity while confining the path of metal flow in an opposite axial direction to form a segmented spherical head portion and with the sliding gather punch forming a conical recess in the spherical head portion of the metal rod at the end of its stroke,

placing lubricant in said recess,

directing an extrusion punch against the spherical head portion while disposed in a second cavity of a second die member with the included angle on a conical end

of the extrusion punch being larger than the included angle of the conical end on the sliding gather punch providing an oil trap preventing metal to metal contact between the conical end and the conical recess causing the oil to flow axially from the oil trap with the metal of the head portion as the extrusion punch is pushed against the spherical head portion thereby displacing a central portion of said head portion axially around said extrusion punch to form an extended skirt portion while contemporaneously displacing a portion of a shank of said rod into the second die member locking the shank with the second die member to enable the extrusion punch to be retracted and disengaged from the extended skirt portion,

knocking the thus formed ball stud blank from the second die member while contemporaneously wiping off the displaced portion on the shank of the rod, and

die forming said extended skirt portion to a contour complementing the contour of said head portion.

4. In a method of forming a ball stud from a metal rod, the steps of

disposing an end of the metal rod within a die cavity defined between a punch holder and a die member and moving the punch holder in flush engagement with the die member,

moving a sliding gather punch having a conical end face axially through the punch holder against the end of the rod and forming a locking metal mass upstream of the cavity developing a forward force vector in excess of a backward force vector acting to separate engaged faces of the punch holder and the die member thereby locking the punch guide and the die member together at the die cavity while directing the metal into the die cavity and while confining the path of metal flow in an opposite axial direction to form a segmented spherical head portion and with the sliding gather punch forming a conical recess in the spherical head portion of the metal rod at the end of its stroke,

directing an extrusion punch against the spherical head portion while disposed in a second cavity of a second die member thereby displacing a central portion of said head portion axially around said extrusion punch to form an extended skirt portion while contemporaneously displacing a portion of a shank of said rod into the second die member locking the shank with the second die member to enable the extrusion punch to be retracted and disengaged from the extended skirt portion,

knocking the thus formed ball stud blank from the second die member while contemporaneously wiping off the displaced portion on the shank of the rod, and

die forming said extended skirt portion to a contour complementing the contour of said head portion.

5. In an apparatus for forming a ball stud from a metal rod,

a die member having a die cavity for receiving an end of the metal rod,

means including a tubular punch holder and a sliding gather punch mounted therein with the punch holder being movable in flush engagement with the die member,

said sliding gather punch having a conical end for engagement against an end of the rod,

said punch holder having a constricting shoulder adjacent the area of engagement between said punch and said punch holder providing means for forming a locking metal mass upstream of the cavity for developing a forward force vector in excess of a backward force vector acting to separate engaged faces of the punch holder and the die member thereby locking the punch guide and the die member together at the die cavity while the metal of the rod is displaced into the die cavity and while the path of metal flow in an opposite axial direction is confined to form a segmented spherical head portion and with the sliding gather punch forming a conical recess in the spherical head portion of the metal rod at the end of its stroke.

6. In an apparatus for forming a ball stud from an unheated metal rod of constant cross section,

a die member having a die cavity for receiving an end of the metal rod,

means including a tubular punch holder and a sliding gather punch mounted therein with the punch holder being movable in flush engagement with the die member,

said sliding gather punch having a conical end for engagement against an end of the rod,

said punch holder having a constricting shoulder adjacent the area of engagement between said punch and said punch holder providing means for forming a locking metal mass upstream of the cavity for developing a forward force vector in excess of a backward force vector acting to separate engaged faces of the punch holder and the die member for thereby locking the punch guide and the die member together at the die cavity while the metal of the rod is flowed into the die cavity and while the path of metal flow in an opposite axial direction is confined to form a segmented spherical head portion,

said sliding gather punch being movable axially across said constricting shoulder to force the locking metal mass into said cavity and to permit the locked faces of the tubular punch holder and the die to be disengaged.

7. In an apparatus for forming a ball stud from an unheated metal rod of constant cross section,

a die member having a die cavity for receiving an end of the metal rod,

means including a tubular punch holder and a sliding gather punch mounted therein with the punch holder being movable in flush engagement with the die member,

said sliding gather punch having a conical end for engagement against an end of the rod,

said punch holder having a constricting shoulder adjacent the area of engagement between said punch and said punch holder providing means for forming a locking metal mass upstream of the cavity for developing a forward force vector in excess of a backward force vector acting to separate engaged faces of the punch holder and the die member and thereby locking the punch guide and the die member together at the die cavity while the metal of the rod is flowed into the die cavity and while the path of metal flow in an opposite axial direction is confined to form a segmented spherical head portion,

said sliding gather punch being movable axially across said constricting shoulder to force the locking metal mass into said cavity and to permit the locked faces of the tubular punch holder and the die to be disengaged,

said constricting shoulder comprising an annular rib disposed in the tube defined by the tubular punch holder.

8. In a method of forming a ball stud from an unheated metal rod of constant cross section, the steps of

disposing an end of the metal rod within a die cavity defined between a punch holder and a die member,

moving a sliding gather punch having a conical end face axially through the punch holder against the end of the rod thereby directing the metal into the die cavity while confining the path of metal flow in an opposite axial direction to form a segmented

spherical head portion and with the sliding gather punch forming a conical recess in the spherical head portion of the metal rod at the end of its stroke,

placing lubricant in said recess,

pushing an extrusion punch against the spherical head portion while disposed in a second cavity of a second die member with the included angle on a conical end of the extrusion punch being larger than the included angle of the conical recess providing an oil trap preventing metal-to-metal contact between the conical end and the conical recess with the oil preventing metal-to-metal contact during the radial flow of metal at the face of the extrusion punch causing the oil to be metered out of the oil trap along with the metal flow axially of the extrusion punch to lubricate an extrusion punch bearing at its outer diameter forming an extended skirt portion at the outer diameter of the extrusion punch,

removing the thus formed ball stud blank from the second die member, and

die forming said extended skirt portion to a contour complementing the contour of said head portion.

9. In a method of forming a ball stud from a metal rod, the steps of

disposing an end of the metal rod within a die cavity defined between a punch holder and a die member and moving the punch holder in flush engagement with the die member,

moving a sliding gather punch having a conical end face axially through the punch holder against the end of the rod and forming a locking metal mass upstream of the cavity developing a forward force vector on the sliding gather punch in excess of a backward force vector exerted between the die cavity and the punch holder acting to separate engaged faces of the punch holder and the die member thereby locking the punch guide and the die member together at the die cavity while directing the metal into the die cavity and while confining the path of metal flow in an opposite axial direction to form a segmented spherical head portion and with the sliding gather punch forming a conical recess in the spherical head portion of the metal rod at the end of its stroke,

directing an extrusion punch against the spherical head portion while disposed in a second cavity of a second die member thereby displacing a central portion of said head portion axially around said extrusion punch to form an extended skirt portion while contemporaneously displacing a portion of a shank of said rod into the second die member locking the shank with the second die member to enable the extrusion punch to be retracted and disengaged from the extended skirt portion.

knocking the thus formed ball stud blank from the second die member while contemporaneously wiping off the displaced portion on the shank of the rod, and

rigidly holding the ball stud blank while moving a floating punch axially against said extended skirt portion effecting alignment of the extended skirt portion with a punch cavity in the floating punch and causing the extended skirt portion to be collapsed radially inwardly to a contour complementing the contour of said head portion.

10. In a method of forming a ball stud from an unheated metal rod of continuous cross section, the steps of

disposing an end of the metal rod within a die cavity defined between a punch a holder and a die member and moving the punch holder in flush engagement with the die member,

moving a sliding gather punch having a conical end face axially through the punch holder against the end of the rod and thereby directing the metal of the rod into the die cavity while confining the path of metal flow in an opposite axial direction to form a segmented spherical head portion and with the sliding gather punch forming a conical recess in the spherical head portion of the metal rod at the end of its stroke,

directing an extrusion punch against the spherical head portion while disposed in a second cavity of a second die member thereby displacing a central portion of said head portion axially around said extrusion punch to form an extended skirt portion while contemporaneously displacing a portion of a shank of said rod into the second die member thereby locking the shank with the second die member to enable the extrusion punch to be retracted and disengaged from the extended skirt portion,

knocking the thus formed ball stud blank from the second die member while contemporaneously wiping off the displaced portion on the shank of the rod, and

rigidly holding the ball stud blank while moving a floating punch axially against said extended skirt portion effecting alignment of the extended skirt portion with a punch cavity in the floating punch and causing the extended skirt portion to be collapsed radially inwardly to a contour complementing the contour of said head portion.

11. In a method of making headed metal articles by upsetting in a die, the improvement which comprises

seating a hollow punch holder against a face of the die around the upsetting cavity of the die, providing a reduced diameter extrusion throat in the punch holder adjacent the die face engaging end of the punch,

confining a metal blank in the die and punch holder, and

feeding a punch in the holder against the blank to upset the blank in the die cavity and behind the extrusion throat thereby forming a locking metal mass upstream from the throat effective to create a force vector on the punch holder from the punch force to hold the punch holder against the die face.

12. A method of forming a ball stud, which comprises

seating a hollow punch holder against a face of a die around an upsetting cavity in the die, and

feeding a sliding gather punch in the holder against a metal blank in the die and the holder to extrude a portion of the blank through an extrusion throat in the holder and to upset the blank in the die cavity adjacent the extrusion throat so that a deformed portion of the blank between the extrusion throat and the punch exerts on the holder a force which urges the holder against the die face.

13. A method as claimed in claim **12**, in which the punch, the punch holder and the die cavity cooperate to form the upset portion of the blank into a segmental spherical head in the die cavity, and the punch has a conical end face which forms a conical recess in such head, in which the blank is subsequently disposed in a second die cavity in a second die and an extrusion punch having a conical end is pushed into such recess to extrude the head of the blank to form a skirt around the extrusion punch, and in which the skirt is subsequently die formed in a further die to form the head into a ball shape.

14. A method as claimed in claim **12**, in which the conical end of the extrusion punch has an inclined angle greater than that of the conical recess in the head of the blank and lubricant is placed in such recess before the extrusion punch is pushed into such recess, and the lubricant is trapped in such recess by the extrusion punch to prevent metal-to-metal contact between the conical end of the extrusion punch and the bottom of the recess during radial flow of the metal of the blank at the conical end of the extrusion punch, the oil being squeezed from the recess to lubricate axial flow of such metal at the outer diameter of the extrusion punch.

15. A method as claimed in claim **12**, in which during the formation of the skirt a portion of a shank on the

blank is displaced radially outwardly into locking engagement with the second die to facilitate subsequent retraction and disengagement of the extrusion punch from the skirt, and the radially outwardly displaced portion of the shank is wiped off on knocking of the blank from the second die.

16. Apparatus for forming a ball stud, comprising

a die formed with an upsetting die cavity,

a hollow punch holder arranged to be seated against the die around the die cavity with an extrusion throat in the punch holder disposed adjacent the die cavity, and

a sliding gather punch arranged to be fed in the punch holder to extrude a portion of a blank through the extrusion throat and to upset the blank in the die cavity beyond the extrusion throat, such throat being

shaped so that the portion of the blank between the throat and the punch exerts on the holder a force which folds the holder against the die.

17. Apparatus as claimed in claim **16**, in which the die cavity is shaped to form the upset portion of the blank into a segmented spherical head, and the punch has a conical end for forming a conical recess in such head.

References Cited by the Examiner

UNITED STATES PATENTS

3,036,366	5/1962	Ricks	29—149.5
3,036,367	5/1962	Ricks	29—149.5

CHARLES W. LANHAM, *Primary Examiner.*

H. D. HOINKES, *Assistant Examiner.*