United States Patent

Harrington

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[54] APPARATUS FOR THE MANUFACTURE OF POWDER METAL HELICAL GEARS

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[52] **U.S. Cl.**.....**425/78,** 425/356, 425/418

[51] **Int. Cl.**.....**B30b 3/00,** B30b 11/02

[58] **Field of Search**.....18/16 R, 5, 7, 30 LA, 20 T, 18/19 F

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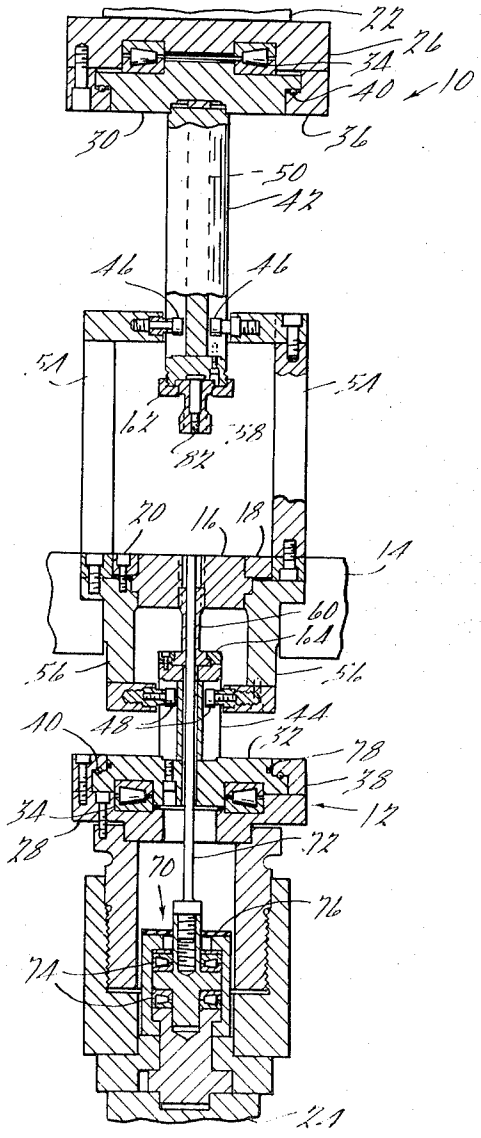
[57] **ABSTRACT**

Apparatus for pressing powder metal helical gears and similar articles of manufacture wherein the powder is pressed with a twisting motion of the punches. A cam arrangement is described for a pressing apparatus which rotates the punches during pressing.

6 Claims, 11 Drawing Figures



Patented July 18, 1972 3,677,672

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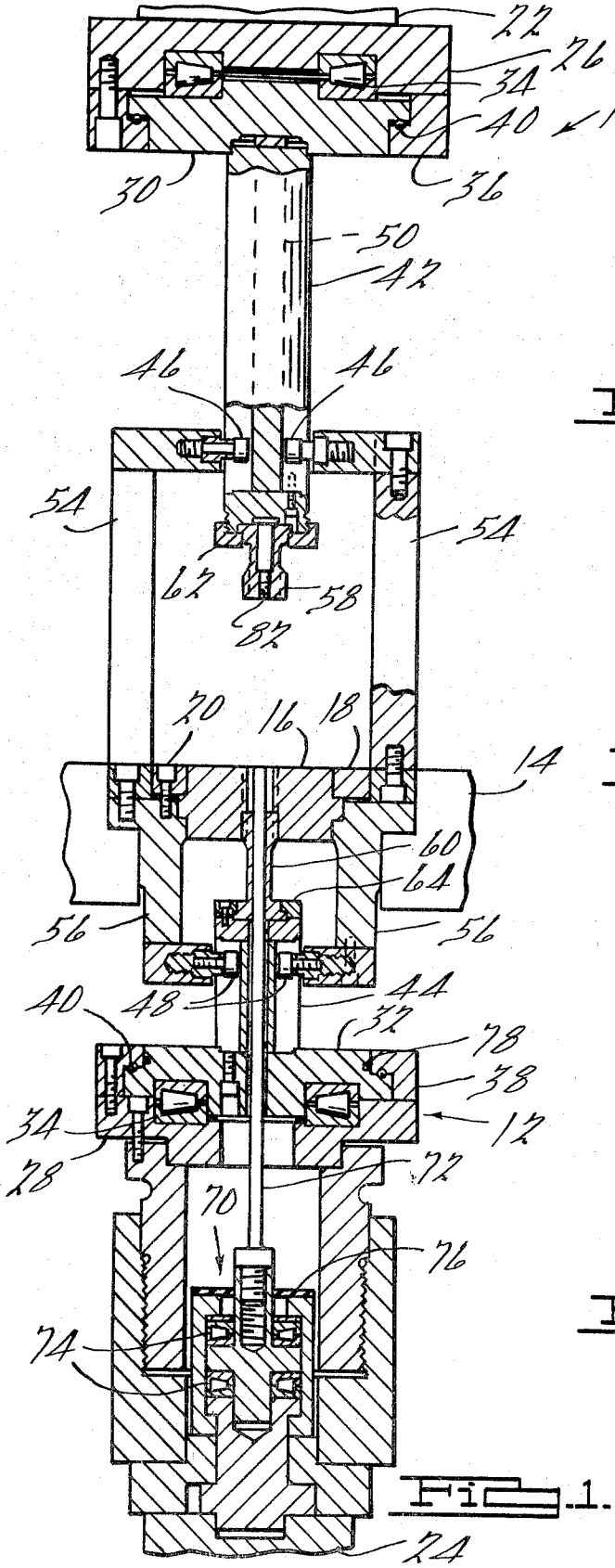


Fig. 1.

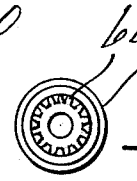


Fig. 4.

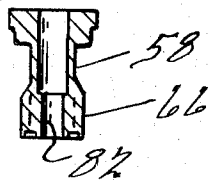
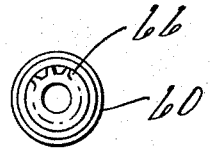


Fig. 5.

Fig. 6.



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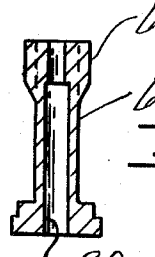

Fig. 8.

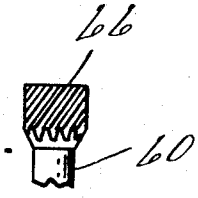

Fig. 9.

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Patented July 18, 1972 3,677,672

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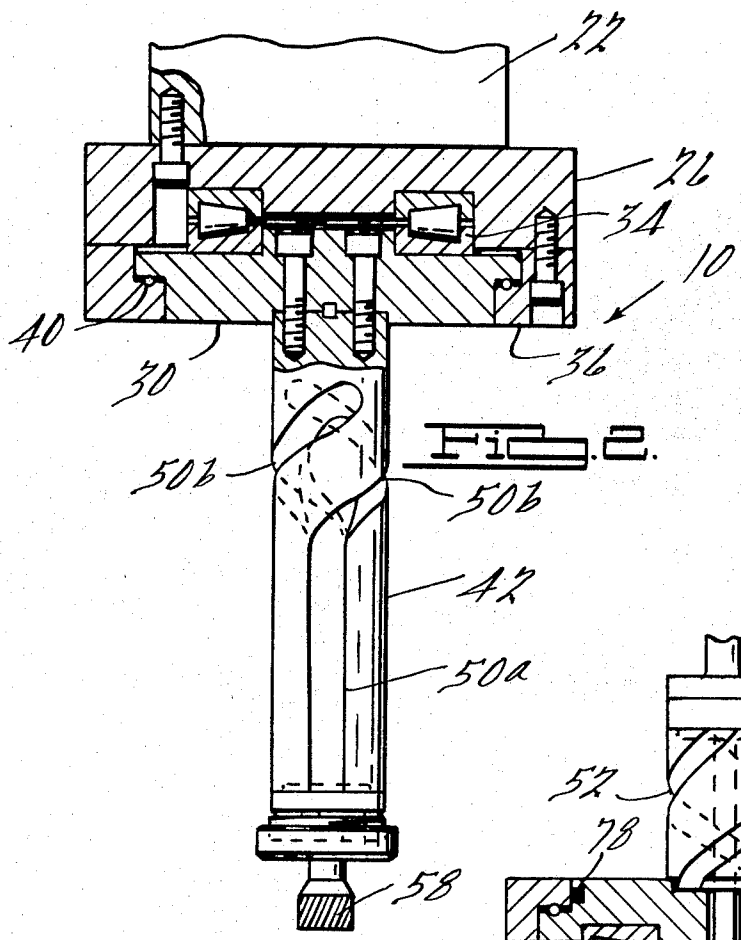

Fig. 2.

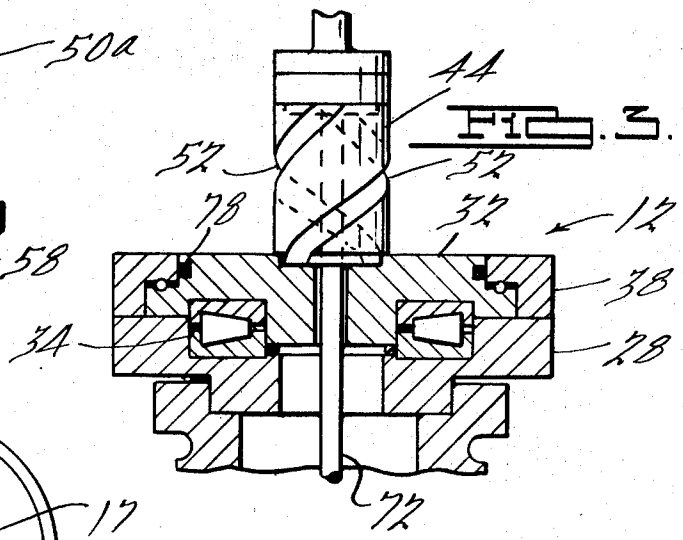

Fig. 3.

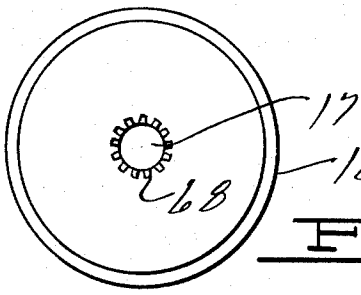

Fig. 10.

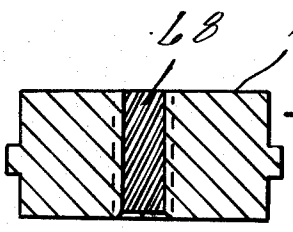

Fig. 11.

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APPARATUS FOR THE MANUFACTURE OF POWDER METAL HELICAL GEARS

BACKGROUND

This invention relates specifically to the pressing of powder metal helical gears. In the conventional pressing of powder metal parts a lower tool punch is fastened rigidly to a lower ram of a press. A die is clamped to a press table. An upper tool punch is clamped rigidly to an upper ram of the press. A center pin or core rod is usually fixed securely to a lower center ram of the press, i.e., a core rod ram if the pressed article is to include a central bore or the like.

With such an arrangement any inner or outer configuration on the article to be formed, such as keys, keyways, gear tooth forms, cam contours or any geometric form, must be on an axis with the vertical motion of the press rams to allow punch entrance into the die for pressing the powder metal and to allow ejection of the pressed article from the die.

This conventional arrangement for securing tool members to the press members does not allow for any movement of the tools except vertical movement. Also, conventional vertical pressing is limited for the most part to the forming of parts which are not much thicker than around one-fourth inch.

SUMMARY

As a result of an investigation of various techniques for pressing powder metals it has been discovered that the application of a twisting or rotary motion to the powder while pressing it allows the fabrication of larger parts then heretofore possible and provides moreover, parts of more uniform and higher density. Furthermore, the rotary motion shifts the powder about in the die causing the powder to fill it better and settle into the die while also allowing for the fabrication of complex shapes having off-axis inner and outer configurations of the type described above.

The invention will be specifically described in connection with apparatus for manufacturing powder metal helical gears although it is not intended to be limited thereto and finds application elsewhere. For example, it is readily applicable to the pressing of plastic powder and may be used to fabricate a wide variety of off-axis configurations.

It is then an object of this invention to provide apparatus for pressing various powders into shapes having off-axis configurations.

It is a specific object of this invention to provide tool motion which enables the pressing of steep helical angle tooth forms from powder metal using the basic vertical motion of conventional compacting presses. This object is accomplished by rotating or twisting the tools as they press the powder metal. In the case of helical gears, the tool punches have helical lands and the die has corresponding helical grooves into which the punches turn.

BRIEF DESCRIPTION OF THE DRAWING

FIG. **1** is a detailed side view of a preferred apparatus according to the invention which is shown partly in section;

FIG. **2** is a fragmentary elevational view of the apparatus showing the upper punch and cam arrangement partly in section;

FIG. **3** is a fragmentary elevational view of the apparatus showing the lower cam arrangement partly in section;

FIG. **4** is a bottom plan view of the upper punch;

FIG. **5** is a vertical section through the upper punch;

FIG. **6** is a fragmentary view of the upper punch showing the land patterns thereof;

FIG. **7** is a top plan view of the lower punch;

FIG. **8** is a vertical section through the lower punch;

FIG. **9** is a fragmentary view of the lower punch showing the land pattern thereof;

FIG. **10** is a plan view of the die, and

FIG. **11** is a vertical section through the die showing the groove pattern therein.

BRIEF DESCRIPTION OF THE PREFERRED EMBODIMENTS

The invention, contemplates in its preferred embodiment the pressing of powder metal in a die by subjecting the powder to a compacting pressure from two substantially oppositely disposed punches while simultaneously twisting or rotating the punches. In the case of helical gears it is desirable to provide male helical punches and a female helical die and to rotate the punches in opposite directions during pressing as the punches move into the die from opposite directions.

The invention will be better understood after an explanation with reference to a specific preferred embodiment of an apparatus for practicing the invention as described in the accompanying drawing.

Referring to the drawing, particularly FIGS. **1**, **2** and **3**, the novel apparatus shown therein includes upper and lower tool members, generally indicated at **10** and **12** respectively, disposed on opposite sides of a die table **14**. A die **16** having a powder receiving bore **17** is secured to the die table by a clamping ring **18** and bolt **20** as shown.

Upper and lower tool members **10** and **12** are respectively fastened to the upper and lower rams **22** and **24** of a conventional vertical press (not shown) by means of fixed pressure plates **26** and **28** as shown. These plates are fixed in the sense that they are not free to rotate but are only capable of reciprocating movement according to the movement of the rams of the press. Rotary movement of the tool members with respect to plates **26** and **28** is provided by means of rotary pressure plates **30** and **32** which are positioned against pressure plates **26** and **28** respectively by clamping means such as clamping rings **36** and **38**, which are shown bolted to plates **26** and **28** respectively. The clamping rings are preferably positioned against the rotary plates in combination with sets of ball bearings **40** as shown. Interposed between the plates are bearing assemblies **34** which may consist of precision taper roller bearings as shown. With this arrangement, the tool members are free to rotate with respect to the press rams. The pressure plates, including the fixed and rotary plates, also transfer the vertical movement of the rams to the punches.

Securely fastened to rotary plates **30** and **32** respectively are upper and lower tool members **42** and **44** which form, along with upper and lower cam follower means such as rollers **46** and **48**, a cam arrangement associated with the apparatus punch means for imparting a pre-determined twisting or rotary motion to the upper and lower tool members when they are raised and lowered relative to the die for insertion therein. Of course, the arrangement may consist of a pair of oppositely disposed assemblies as shown or only one assembly or more than two if necessary.

Tool members **42** and **44** each include sets of cam track means or channels, such as grooves **50** and **52** which are better seen in FIGS. **2** and **3** respectively. The grooves are precision ground to the identical helix angle required on the part to be pressed and are peripherally disposed around the members. The grooves and rollers may be of any shape such as cylindrical or tapered as is well known in the cam art. Furthermore, sliding contact or rolling contact may be used although rolling contact is preferred. Upper and lower tool members **10** and **12** are engaged by suitable cam follower means, such as rollers **46** and **48**, which project into grooves **50** and **52** respectively. The rollers project inwardly from and are rotatably secured to their respective cam follower support means such as column assemblies **54** and **56** which are in turn secured to die table **14** as shown. The support means positions the cam follower means for engagement with the cam tracks. The columns are preferably in pairs and spaced on the center line of die **16** as shown, left and right, to permit entrance over the die for powder fill. Upper and lower oppositely disposed support means are preferred.

Upper and lower punch means, such as punches **58** and **60**, are secured to the upper and lower tool members by, for example, bolted clamp rings **62** and **64**. In the embodiment

shown, for the manufacture of helical gears, the punches have several peripheral helical lands **66** as best seen in FIGS. **4** through **6** for upper punch **58** and FIGS. **7** through **9** for lower punch **60**. These lands have a predetermined warp or helix angle depending on the specifications desired in the helical gear to be pressed. Die **16** is correspondingly helically grooved as indicated at **68** in FIGS. **10** and **11** to mate with the lands on punches **58** and **60**. The helix angle tooth form **68** may be machined into the bore wall of die **16** as can be best seen in those Figures.

Lower tool member **12** further includes a core rod assembly generally indicated at **70** comprising an elongated core rod **72** which is rotatably mounted by means of caged tapered bearing race assembly including tapered bearings **74** for free rotation within lower tool member **12** as shown in FIG. **1**. Assembly **70** may be covered by neoprene seal **76** or the like as shown. An additional seal such as O-ring **78** may be included in the upper portion of lower tool member **12** also if desired. The purpose of the seals is to provide protection against the entrance of falling powder metal.

When die **16** is filled with powder metal and lower punch **60** is inserted into the die as shown in FIG. **1**, the upper ram of the press is activated to lower upper tool member **10** into the die. The lower portion **50***a* of tracks **50** are straight and the upper portions **50***b* are curved as shown in FIG. **2** so that as punch **58** is lowered it moves down to the die without turning and then rotates during insertion.

Accordingly, the lands or edges of the punches move in a helical path as the punches rotate and move into and out of the die. The exact configuration and length of the cam tracks is of course dependent upon the particular shape of the tooth pattern or the like desired in the pressed article.

The lower tool member **12** undergoes a similar movement but to less extent as can be seen from the differences in position between the two tool members in the drawing. Core rod **72**, extending through the axial bore **80** of lower punch **60** also extends into axial bore **82** of upper punch **58** during pressing to form a center hole in the helical gear.

It is important to note that the die does not direct the punches through the twisting or rotary motion. Such an approach has been tried unsuccessfully due to the fact that dies are usually made of materials such as tungsten carbide which can absorb extremely high pressures but which are brittle and have little or no resistance to shear. It is therefore an important feature of this invention that the cam arrangement generate the rotary movement during pressing without substantial aid or direction from the die.

The exact configuration and length of the grooves **50** and **52**, the land patterns on the punches and the groove patterns in the die must of course be complementary and match the predetermined configuration of the gear to be fabricated.

To eject the pressed gear, upper punch **58** is raised and lower punch **60** turns upwardly into the die until the piece is ejected. The pressed gear turns freely in the die to permit its ejection therefrom. The punch is then returned to its initial position and the apparatus is ready to press another piece. After ejection the gear may be subjected to a sintering heat treatment or the like to complete its manufacture.

Although the pressing operation of the apparatus disclosed herein has been described as involving the simultaneous downward movement of the upper punch and upward movement of the lower punch, it is contemplated that other modes of operation may be used. For example, the lower punch may be inserted into the die and maintained in a fixed position during pressing by the upper punch. The lower punch would move only to eject the pressed piece.

Any powder material may be pressed in this fashion such as plastic powders, ferrous and non-ferrous metal powders and the like. The reversal of certain parts described above is possible. For example, the cam tracks could be formed in the column supports and the followers could be carried by the upper and lower tool members.

It can be seen that the apparatus according to this invention provides punches adapted to be rotatably inserted into a die by the vertical motion of the rams of a conventional press. A predetermined rotary motion is provided by a cam arrangement associated with the punches, the arrangement including cam track means and cam follower means which impart the predetermined rotary motion to the punches during insertion into the die. The helix angle generated by the punch rotation permits the punches to enter the die press the part and eject it.

Having described a preferred embodiment of an apparatus, the invention is defined by the following claims:

1. A powder pressing apparatus comprising:

at least one tool member adapted for reciprocating motion, the tool member including peripherally disposed helically configured path cam track means and coacting cam follower means associated with the cam track means for imparting controlled rotary motion to the tool member during its reciprocation,

cam follower support means positioning the cam follower means in engagement with the cam track means,

vertically movable ram means for reciprocating the tool members,

a powder receiving die member positioned to receive an end of the tool member,

punch means disposed at the end of the tool member for insertion into the die when the tool member reciprocates,

the punch means and die including mating lands and grooves which are so shaped relative to the configuration of the cam track means such that when the tool member reciprocates and controllably rotates the punch means into and out of the die member the rotation imparted to the punch means, by the cam track means and cam follower means alone, twists it into and out of the die member in mating fashion.

2. The apparatus of claim **1** including:

a rotary pressure plate connected to the tool member and oppositely disposed thereon with respect to the punch means,

a fixed pressure plate overlaying the rotary pressure plate and adapted for contact with the ram of a press for transmitting pressure therefrom to the rotary pressure plate and the tool body,

a clamping means positioning the rotary plate against the fixed plate but rotatable with respect thereto, and

a bearing assembly positioned between the rotary plate and fixed plate whereby the rotary plate may rotate freely with respect to the fixed plate.

3. The apparatus of claim **1** including:

a pair of oppositely disposed upper and lower tool members,

the punch means comprises upper and lower punches fixed to the inner end of the upper and lower tool members respectively and disposed toward each other, and wherein

the cam follower support means includes oppositely disposed upper supports for receiving the upper tool member therebetween and oppositely disposed lower supports for receiving the lower tool member therebetween, the supports being positioned on the upper and lower sides of a die table carrying the die member,

the cam follower means comprises a pair of spaced inwardly projecting bodies carried by the supports in a position of engagement with the cam track means of the tool members, and

the cam track means on each of the tool members comprises spaced grooves for accommodating the projecting bodies and imparting rotary movement to the tool members when they are moved toward and away from each other.

4. The apparatus of claim **3** including:

upper and lower rotary pressure plates connected to the upper and lower ends of the upper and lower tool members respectively,

upper and lower fixed pressure plates overlaying the upper and lower rotary pressures plates respectively, each being

adapted for contact with the upper and lower rams of a press respectively,

clamping means positioning the rotary pressure plates against the fixed pressure plates, and upper and lower bearing assemblies carried between the upper and lower pressure plates respectively to facilitate rotation of the rotary pressure plates with respect to the fixed pressure plates.

5. Apparatus for pressing helical gears or the like from powder comprising:

a die table

a die having a powder receiving bore extending between opposite major surfaces thereof, the bore walls having a grooved female pattern,

means for holding the die to the table,

upper and lower tool members, each member having a pair of equally spaced helical cam track grooves peripherally positioned thereon, the grooves extending over at least a portion of the length thereof,

support members positioning the tool members on opposite upper and lower sides of the die for axial reciprocating movement into the die bore from opposite directions, vertically movable ram means for reciprocating the tool members,

an upper punch fastened to the lower end of the upper tool member,

a lower punch fastened to the upper end of the lower tool member,

each of said punches having a male pattern complementary to that of the female die pattern,

a pair of oppositely disposed cam followers carried by each of the upper and lower support members, said followers extending inwardly of the support members into the cam track grooves whereby upon axial reciprocating movement of the tool members axial rotation is also provided to them and to the punches,

the cam track grooves being so shaped relative to the patterns of the punches and die such that the rotary motion imparted to the punches, by the cam track grooves and cam followers alone, twists them into and out of the die in mating fashion.

6. The apparatus of claim 5 including:

upper and lower rotary pressure plates connected to the upper and lower ends of the upper and lower tool members respectively,

upper and lower fixed pressure plates overlaying the upper and lower rotary pressure plates respectively, each being adapted for contact with the upper and lower rams of a press respectively,

clamping means positioning the rotary pressure plates against the fixed pressure plates, and

upper and lower bearing assemblies carried between the upper and lower pressure plates to facilitate rotation of the rotary pressure plates with respect to the fixed pressure plates.

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