

[54] **POWDER COMPACTING DEVICE FOR FORMING HELICAL GEAR COMPACT**

[72] Inventors: Mitsuo Takahashi; Koji Ito; Sadao Kaga, all of Chiba, Japan

[73] Assignee: Hitachi Powdered Metals Co., Ltd., Matsudo-shi, Japan

[22] Filed: Nov. 30, 1970

[21] Appl. No.: 93,712

[30] **Foreign Application Priority Data**

Dec. 1, 1969 Japan44/95699
Jan. 14, 1970 Japan45/3475

[52] U.S. Cl.425/352, 425/78

[51] Int. Cl.B30b 11/02

[58] Field of Search.....18/16 R, 16.5, 16.7; 425/78, 425/352

[56] **References Cited**

UNITED STATES PATENTS

3,394,432	7/1968	Laurent.....	18/16.5
2,767,428	10/1956	Pingl.....	18/16 R X
2,767,438	10/1956	Pingel.....	18/16 R
2,561,735	7/1951	Haller.....	18/16.5
2,499,980	3/1950	Stokes et al.	18/16.7

3,353,215	11/1967	Haller.....	18/16.7
1,467,311	9/1923	Elliott.....	18/16.7 X
3,097,411	7/1963	Gerster et al.	18/16.5 X

Primary Examiner—J. Howard Flint, Jr.
Attorney—Craig, Antonelli, Stewart & Hill

[57] **ABSTRACT**

A powder compacting device for forming a helical gear compact including a die formed with a bore therein, an upper punch adapted to be closely intruded into said bore from one end of said bore, a lower punch closely fitted into said bore from the other end of said bore and, if required, a core rod axially extending through said upper and lower punches, and being adapted to compact a powder material and form it into a helical gear compact within the space defined by said die, said upper and lower punches and said core rod, wherein at least one of said upper and lower punches consists of at least two punch portions, each being contiguous to each other at a coaxially cylindrical surface, and, among these tools inclusive of said die, all of said punch portions and said core rod, each of at least three of selected tools being formed with a helical gear contour, and all but one tool of said selected tools being rotatably secured to the respective plate members.

10 Claims, 14 Drawing Figures

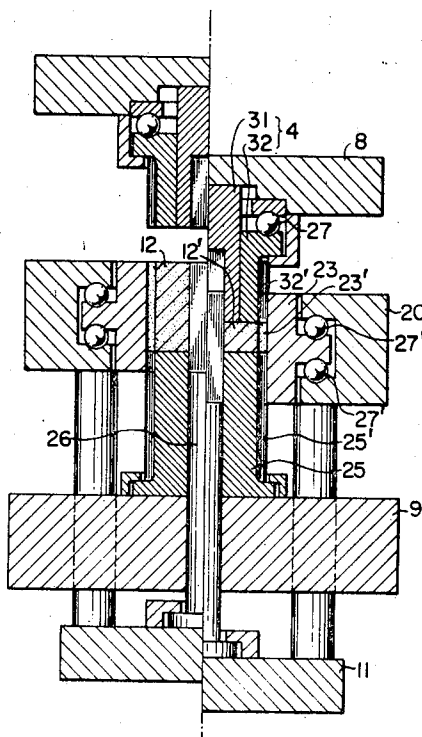


FIG. 1

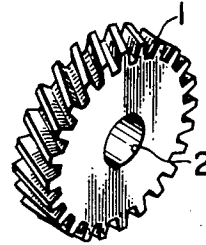
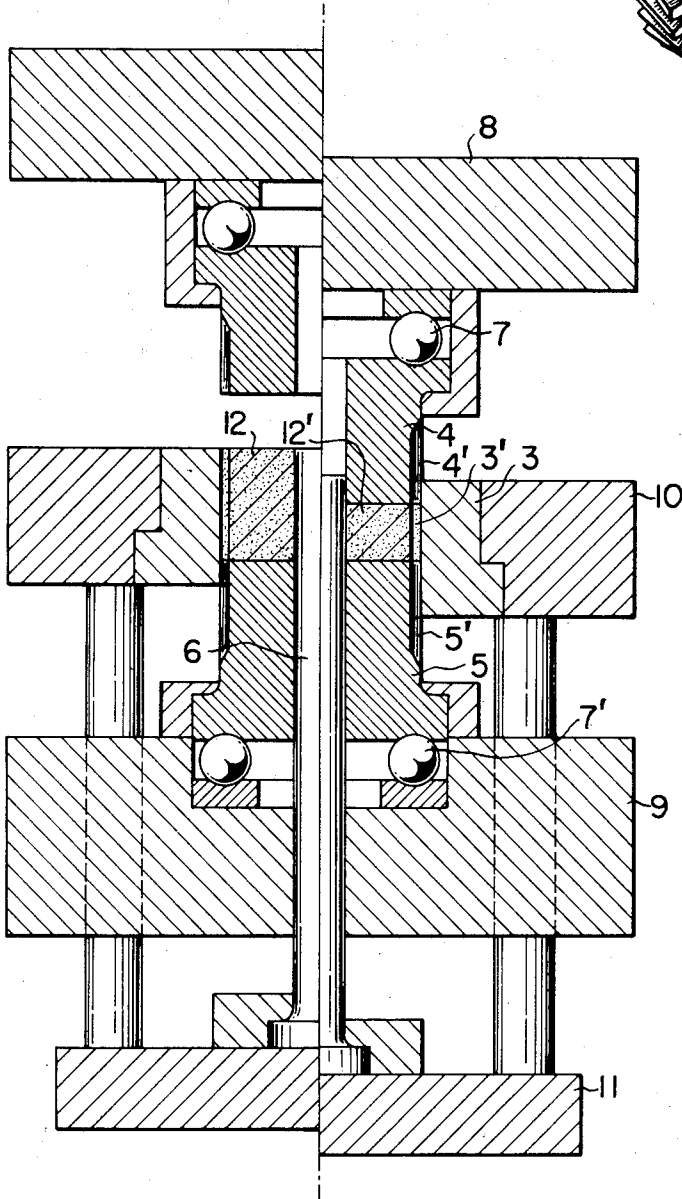


FIG. 2



INVENTORS

MITSUO TAKAHASHI
KOJI ITO AND
SADAO KAGA

BY Craig, Antonelli, Stewart & Hill

ATTORNEYS

FIG. 3

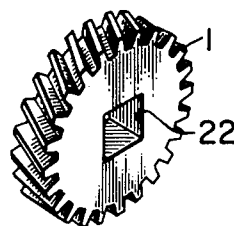
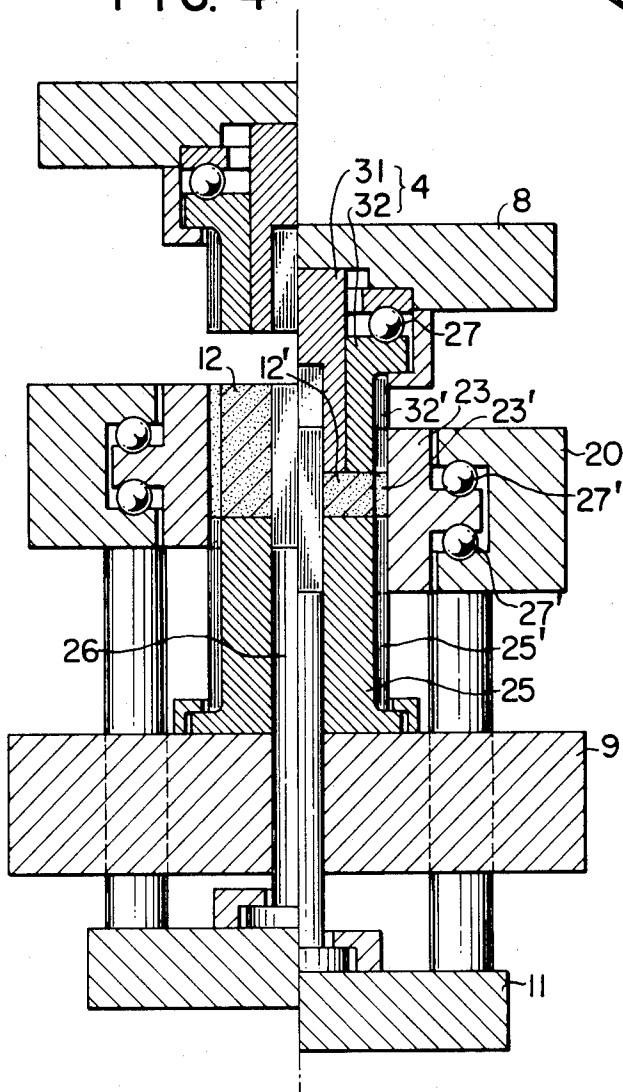


FIG. 4



INVENTORS

MITSUO TAKAHASHI,
KOJI ITO AND
SADAO KAGA

BY Craig, Antonelli, Stewart + Hill

ATTORNEYS

FIG. 5

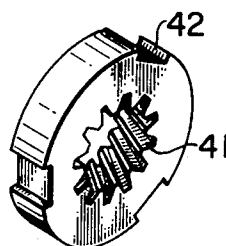
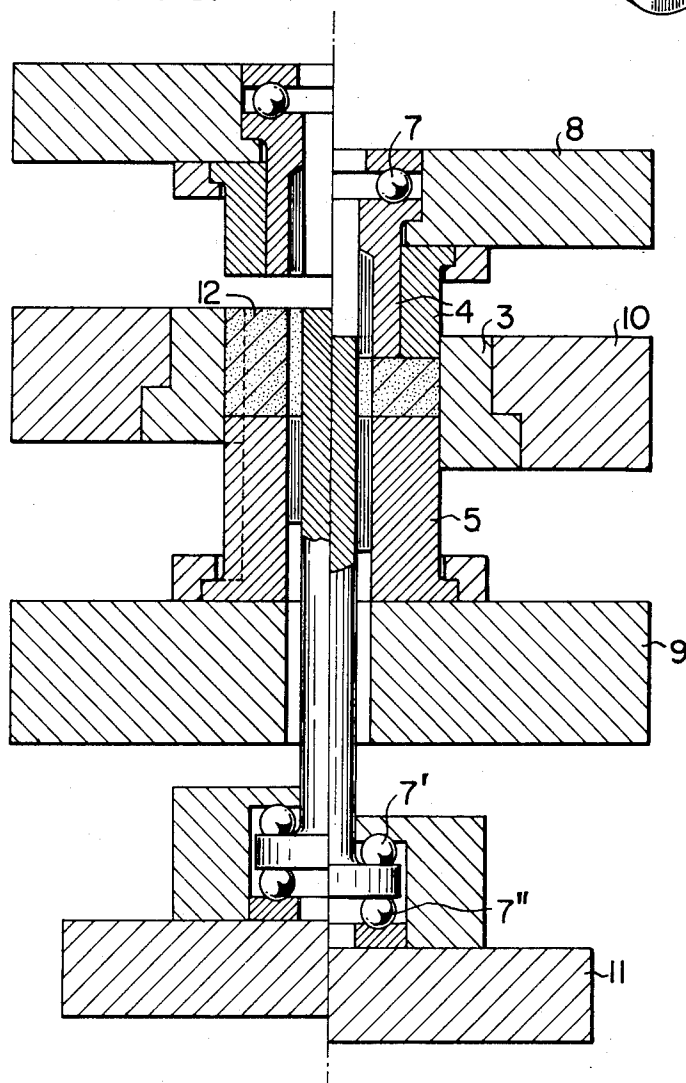


FIG. 6



INVENTORS

MITSUO TAKAHASHI,
KOJI ITO AND
SADAO KAGA

BY Craig, Antonelli, Stewart & Hill

ATTORNEYS

FIG. 7

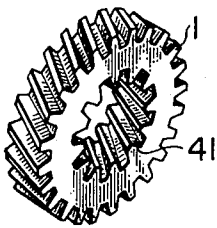
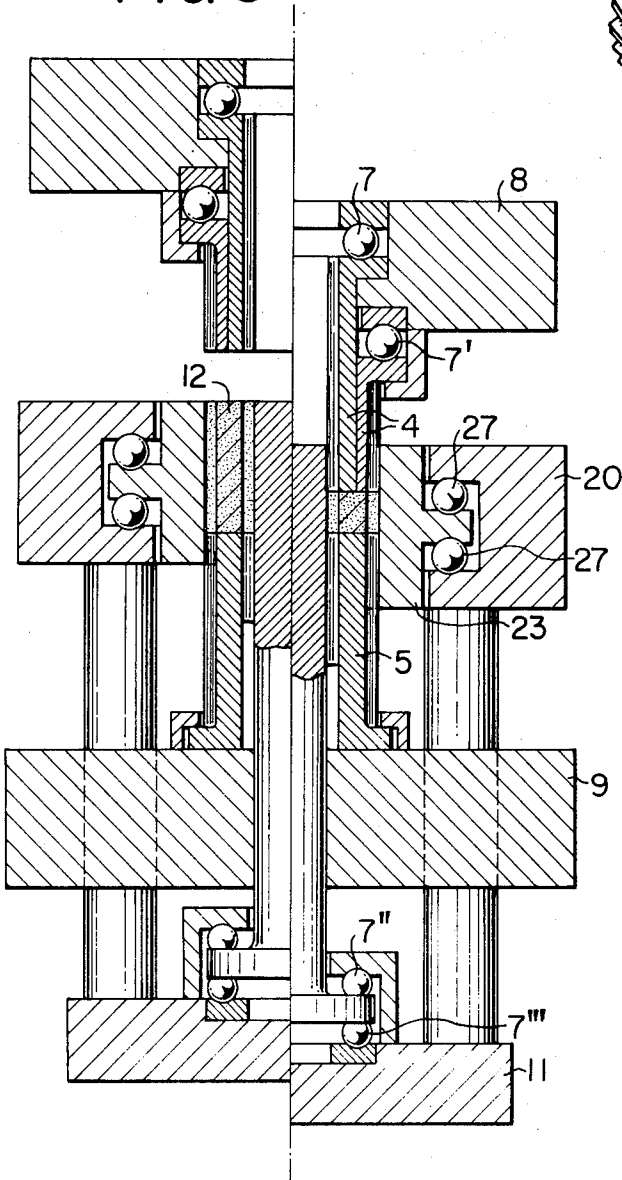


FIG. 8



INVENTORS

ITSUO TAKAHASHI,
KOJI ITO AND
SADAO KAGA

BY Craig, Antonelli, Stewart & Hill
ATTORNEYS

FIG. 9

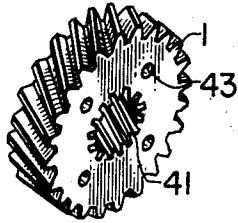
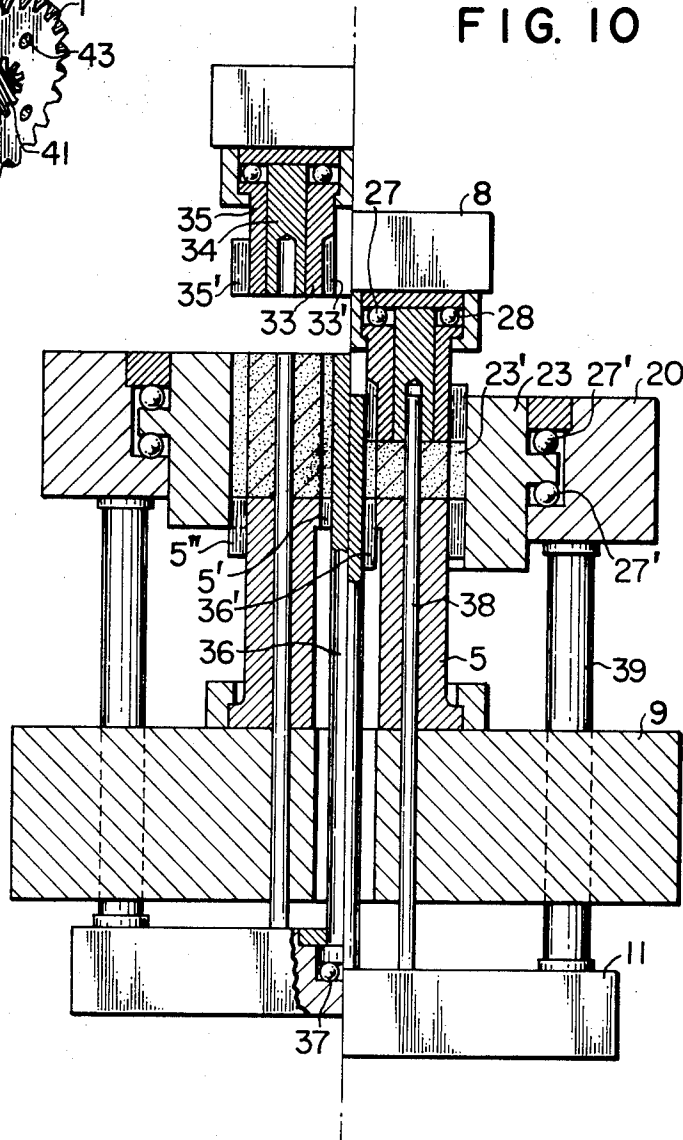


FIG. 10



INVENTORS

MITSUO TAKAHASHI,
KOJI ITO AND
SADAO KAGA

BY Craig, Antonelli, Stewart & Hill

ATTORNEYS

FIG. 11

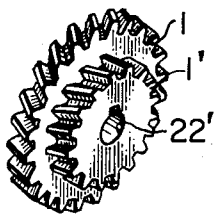
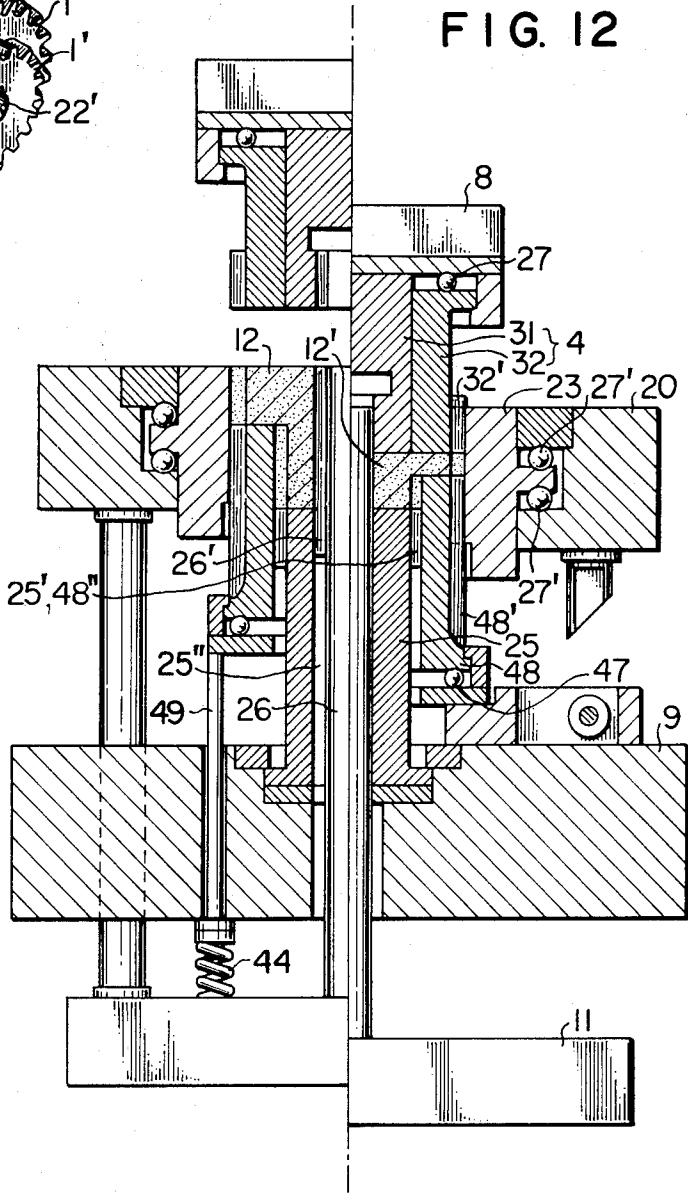


FIG. 12



INVENTORS

MITSUO TAKAHASHI,
KOJI ITO AND
SADAO KAGA

BY Craig, Antonelli, Stewart & Hill

ATTORNEYS

FIG. 13

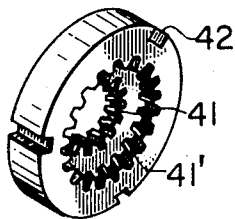
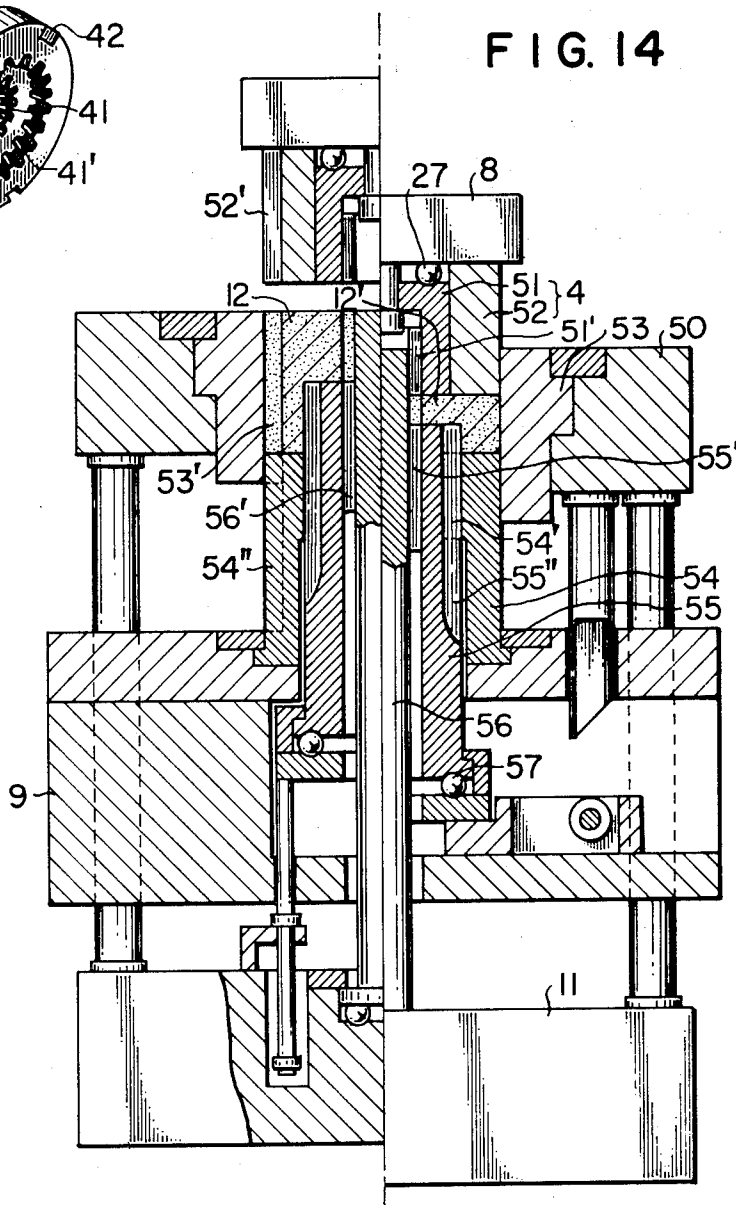


FIG. 14



INVENTORS

mitsuo takahashi,
KOJI ITO AND
SADAO KAGA

BY Craig, Antonelli, Stewart & Hill

ATTORNEYS

POWDER COMPACTING DEVICE FOR FORMING HELICAL GEAR COMPACT

BACKGROUND OF THE INVENTION

Generally, a particular advantage of method of compacting powder material into a compacted article resides in that accurate dimensions of said article may be dimensions without any of additional machine process even though said article has a relatively complex configuration.

However, it is an exception in said powder compacting to form a helical gear compact, in which configurations possibly compacted have been restricted to those of very simple in the prior arts.

In the prior arts, the configurations of helical gear compacts have been restricted to those of very simple, for an example, of such a configuration that has an external helical gear contour on the periphery thereof and a central bore of a circular section. In case of, for an example, a key groove being required to be axially formed on said central bore, this can not be achieved without recourse to another manufacturing step of machine process.

The reason why said key groove can not be formed simultaneously in said powder compacting step is as follows.

While the device operative to compact a helical gear compact within a space defined by an upper punch, a lower punch, a die and a core rod, since said upper and lower punches can not be axially moved into or through said die without being accompanied with relative rotational movements caused by engagements of said helical gear contours therebetween, a kind of core rod provided with a longitudinal projections for forming said key groove and arranged extending through said upper and lower punches is inevitably made twisted to be broken.

Then, said upper and lower punches are required to relatively rotate to said die while said device operative to form a helical gear contour, and, in contrary to this fact, said punches are required to fixedly secured so as not to rotate while said device operative to form such a bore as having a key groove.

It has been impossible to achieve these two of contradictory requirements or functions in a conventional type of powder compacting device.

In the device of this invention, at least one of said upper and lower punches is divided into at least two parts and consists of at least two punch portions, each of which is contiguous to each other at a coaxially cylindrical surface so as to be freely given a relative rotational movement to each other, so that said contradictory requirements as above mentioned can be performed by these punches.

SUMMARY OF THE INVENTION

This invention relates to an advanced construction of powder compacting device, and particularly to a device for forming a compact of helical gear.

According to this invention, there is provided a powder compacting device including a die formed with a bore therein, an upper punch adapted to intrude into said bore from one end of said bore of said die, a lower punch closely fitted into said bore from the other end of said bore and a core rod axially extending through said upper and lower punches, and thus said device

being adapted to compact a powder material and form a helical gear compact in the space defined by metal patterns of said die, said upper and lower punches and said core rod, wherein at least one of said upper and lower punches is divided into at least two parts and consists of at least two punch portions, each of which being contiguous to each other at an coaxially cylindrical surface, and, among these tools inclusive of said die, said punch portions of said upper and lower punches and said core rod, each of at least three of selected tools are formed with a helical gear contour or contours, and all but one tool of said selected tools is rotatably secured to the respective plate members.

Then, an object of this invention is to provide such a functionally advanced powder compacting device that is so constructed as to possibly form in a single step a helical gear compact which has an external helical gear contour on the periphery thereof and a bore having a key groove or of four-cornered section as above mentioned.

Another object of this invention is to provide such various types of functionally advanced powder compacting devices that are so constructed as to possible form in a single step various configurations of relatively complex gear compacts, which have been impossible to be formed without recourse to some other machine process or processes.

A further object of this invention is to provide a more efficient manufacturing process for forming a helical gear compact even in case of said gear having a relatively complex configuration as compared with the prior arts, and thus to achieve as much reduction of manufacturing cost of said gear.

BRIEF DESCRIPTION OF THE DRAWING

FIGS. 1, 3, 5, 7, 9, 11 and 13 are perspective views of various types of helical gear compacts and FIGS. 2, 4, 6, 8, 10, 12 and 14 are schematic views of longitudinal sections of powder compacting devices adapted to compact a powder material into these types of helical gear compacts respectively.

The device of FIG. 2 is a conventionally practiced one and the others of FIGS. 4, 6, 8, 10, 12 and 14 are embodiments of this invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

So as to make this invention easily understood in contrast with the prior arts, a conventional construction of a powder compacting device for forming a helical gear compact will be described with reference to FIGS. 1 and 2.

FIG. 1 shows an example of a very simple type of helical gear compact having a helical gear contour 1 on the periphery thereof and a bore of circular section 2 at the center thereof. Such the simple type of helical gear as in FIG. 1 can be formed by means of a conventionally constructed device the section of which is schematically shown in FIG. 2. In this FIG. the left hand side thereof shows a state of said device being filled with a powder material 12 therein, and the right hand side shows a state of said device being operative to compact said powder material into a helical gear compact 12', the configuration of which being as in FIG. 1.

In FIG. 2, the numeral 3 indicates a die provided with an internal helical gear contour 3' on the inner wall thereof, the numeral 4 indicates an upper punch, each of said upper and lower punches being provided with an external helical gear contour 4', 5' respectively at the periphery thereof and also provided with a bore through which a core rod 6 is to be fitted into. Said external helical gear contours 4', 5' are adapted to be engaged with said internal helical gear contours 3' of said die. Said upper and lower punch 4, 5 are rotatably secured to a head plate 8 and a base plate 9 respectively through the medium of respective ball bearings 7, 7'.

The operation of this device is as follows.

At first, the powder material 12 is filled in the space within said die 3 and then said upper punch 4 is forced to move downwardly. After said upper punch 4 is made in contact with the upper surface of said die 3, said punch is intruded into said space filled with said powder material 12, and meanwhile the downward movement of said punch is accompanied with a rotational movement caused by the engagement between said helical gear contour 4' of said punch and said helical gear contour 3' of said die.

On the other hand, said die 3 is also caused to move downwardly to some extent relative to said lower punch 5, this fact causing said lower punch to be rotated relative to said die 3 in the opposite direction to that of said upper punch 4, and thus said powder material 12 is completely compacted into a helical gear compact 12' having the configuration of FIG. 1.

After that, said upper and lower punches 4, 5 and said die 3 is put back in their original places with said helical gear compact 12' taken out by a suitable method, thus one cycle of the compacting step being completed.

By means of a conventional type of powder compacting device of FIG. 2 such the helical gear compact as having a true circular bore at the center thereof may be formed as above mentioned, but such a helical gear compact as having a bore whose section is different from a true circle, for an example a bore of four-cornered section as exemplified in FIG. 3, can not be formed for the following reason.

In case of forming a four-cornered bore, said core rod has to be formed into of four-cornered section corresponding to said bore, and said core rod has to be arranged extending through said upper and lower punches, therefore, when said upper and lower punches are axially moved along said die and caused to rotate relative to said core rod in the opposite directions, said core rod is inevitably twisted to be broken. In case of said core rod having a true circular section, it is obvious that said punches are free to rotate around said core rod and such the problem as above mentioned does not take place.

According to this invention, there can be provided a functionally advanced type of powder compacting device whose construction is adapted to form such a helical gear compact as having an external helical gear contour and a bore of non-circular section, for an example, of a four-cornered section as shown in FIG. 3, also such a helical gear compact as having an internal helical gear contour and an non-coaxially circular shape around said internal helical gear contour as exemplified in FIG. 5, and further also such a helical gear

compact as having both of an internal helical gear contour and an external helical contour as exemplified in FIG. 7, and still further such more complex helical gear compacts as exemplified in FIGS. 9, 11 and 13.

With reference to FIGS. 3 to 14, preferred embodiments of this invention will be described in detail hereinafter.

FIG. 4 is an illustrative sectional view of an embodiment of this invention, whose construction is adapted to form a type of helical gear compact as in FIG. 3.

In FIG. 4, an upper punch is divided into two parts and consists of an inner punch portion 31 and an outer punch portion 32, said inner punch portion 31 being fixedly secured to a head plate 8 and having a four-cornered bore at the center thereof so as to possibly fitted over a core rod 26 of four-cornered section, and said outer punch portion 32 being rotatably secured to said head plate 8 through the medium of a ball bearing 27 and formed with an external helical gear contour 32'.

The numeral 25 indicates a lower punch which is fixedly secured to a base plate 9 and formed with an external helical gear contour 25' at the periphery thereof and a four-cornered bore.

The numeral 23 indicates a die which is rotatably secured to a die plate 20 and has an internal helical gear contour 23', said helical gear contour 23' being adapted to be engaged with said external helical gear contours 32' and 25' of said outer upper punch portion 32 and said lower punch 25.

Powder compacting step of this device thus constructed as above mentioned according to this invention is performed as follows.

While said upper punch consisting of said punch portions 31 and 32 being forced to move downwardly and intruded into said die 23, said inner portion 31 is made axially slidably fitted over said core rod 26 and simultaneously said outer portion 32 is downwardly moved along said helical gear contour 23' of said die 23 in company with a relative rotational movement caused by said helical gear contours 23', 32' engaged together with.

Meanwhile said die 23 is also moved downwardly to some extent relative to said lower punch 25, this downward movement being also accompanied with a rotational movement caused by the helical gear contours 23', 25' engaged together with.

In this embodiment of this invention, among the tools inclusive of said outer punch portion 32, said die 23, and said lower punch 25 each of which is formed with an internal or an external helical gear contour, with one exception, that is said lower punch 25, all the tools are rotatably secured to the respective plate members 8, 20.

On the other hand, each of another group of the tools inclusive of said inner upper punch portion 31, said core rod 26 and said lower punch 25 which is formed with a non-circular shape, that is a four-cornered section, is fixedly secured to the respective plate member 8, 9 or 11.

According to the device thus constructed as above mentioned, such the helical gear compact of FIG. 3 which is integrally formed with a helical gear contour 1 and a four-cornered bore 22 can be formed in a single step of powder compacting.

The embodiment of FIG. 4 is one of the relatively simple application of this invention, in which the idea of this invention being typically and intelligibly disclosed.

In FIG. 5 there is shown such a type of helical gear compact as having an internal helical gear contour 41 and an desired number of grooves or notches 42 on the periphery thereof. This type of helical gear compact can be formed in a single step of powder compacting by means of a suitably constructed device according to this invention as shown in FIG. 6. Since the operation of this device of FIG. 6 will be made naturally known in the description about the embodiment of FIG. 14, there is omitted detail descriptions about FIG. 6 hereupon.

In FIG. 7, there is shown such a type of helical gear compact as having an internal helical gear contour 41 and an external helical gear contour 1. This type of helical gear compact can be formed in a single step of powder compacting by means of a suitably constructed device according to this invention as shown in FIG. 8. Since the operation of this device will be made naturally known in the description about the embodiment of FIG. 10, there is omitted detail descriptions about FIG. 8 hereupon.

Of course, these two types of helical gear compacts shown in FIGS. 5 and 7 have been impossible to be formed by means of a powder compacting device of conventionally practiced as exemplified in FIG. 2.

FIG. 10 shows an another embodiment of a powder compacting device according to this invention, which is adapted to form a helical gear compact having an external helical gear contour 1, an internal helical gear contour 41 and at least one intermediate bore 43 between said external and internal helical gear contours as shown in FIG. 9.

The left hand side of FIG. 10 shows a stage at which the device being filled with a powder material 12 to be formed, and the right hand side thereof shows a stage at which said device being operative to compact said powder material therewithin so as to form a helical gear compact 12'.

In FIG. 10, a die 23 is rotatably secured to a die plate 20 through the medium of ball bearings 27', 27', said die plate being fixedly connected to a yoke plate 11 through connecting rods 39 so as to serve as a frame member of this device.

A core rod 36 formed with an external helical gear contour 36' is rotatably secured to said yoke plate 11. At least one intermediate core rod 38 is fixedly secured to said yoke plate 11.

A lower punch 5 integrally formed with an internal helical gear contour 5', an external helical gear contour 5'' and at least one intermediate bore which is slidably fitted over said at least one intermediate core rod 38 respectively.

An upper punch 4 is divided into three parts and consists of an inner punch portion 33, an intermediate punch portion 34 and an outer punch portion 35, each of which being contiguous to each other at a coaxially cylindrical surface.

Said intermediate punch portion 34 is fixedly secured to said head plate 8 and formed with at least one intermediate bore into which said intermediate core rods 38 being possibly fitted.

Said inner and outer punch portions 33 and 35 are rotatably secured to said head plate 8 through the medium of ball bearings 27 and 28 respectively, said inner punch portion 33 being formed with an internal helical gear contour 33' which is possibly engaged with said external helical gear contour 36' of said core rod 36, and said outer punch portion 35 being formed with an external helical gear contour 35' which is possibly engaged with an internal helical gear contour 23' of said die 23.

The operation of This device thus constructed is as follows.

When compacting a powder material 12 into a helical gear compact 12' with said upper punch 4 forced into said die 23, said inner punch portion 33 is made engaged with said core rod 36 and then downwardly moved in company with a rotational movement relative to said core rod caused by said engagement between said helical gear contours 33' and 36', and meanwhile said outer punch portion 35 is made engaged with said die 23 and further downwardly moved in company with a rotational movement relative to said die.

On the other hand, since said die 23 and said core rod 36 are made downwardly moved to some extent relative to said lower punch 5, said die and said core rod is caused to be rotated relative to said lower punch which is fixedly secured to said base plate 9.

Accordingly, there can be formed such the helical gear compact as shown in FIG. 9 by means of the device of this invention as shown in FIG. 10.

In FIG. 12, there is shown a further another embodiment of this invention, which is adapted to form such a helical gear compact as having two external helical gear contours 1 and 1' and a bore with a key groove 22' as shown in FIG. 11.

In FIG. 12, a die 23 having an internal helical gear contour 23' is rotatably secured to a die plate 20. An upper punch 4 is divided into two parts and consists of an inner punch portion 31 and an outer punch portion 32, each being contiguous to the other at a coaxially cylindrical surface.

Said inner upper punch portion 31 is fixedly secured to a head plate 8 and formed with a bore with a groove, into which bore a core rod 26 having a longitudinal projection 26 being possibly slidably fitted.

Said outer upper punch portion 32 is rotatably secured to said head plate 8 through the medium of a ball bearing 27 and formed with an external helical gear contour 32'.

The numeral 25 indicates an inner lower punch and the numeral 48 indicates an outer lower punch. Said inner lower punch 25 is fixedly secured to a base plate 9 and formed with a longitudinally grooved bore 25'' and an external helical gear contour 25'.

Said outer lower punch 48 is rotatably supported on supporting pins 49 through the medium of a ball bearing 47 and formed with an internal helical gear contour 48'' and an external helical gear contour 48'.

Said core rod 26 having a longitudinal projection 26' is fixedly secured to a yoke plate 11.

The operation of the device thus constructed is as follows.

While said upper punch forced to be moved downwardly, said inner punch portion 31 is made axially slidably fitted over said core rod 26, and simultane-

ously said outer punch portion 32 is engaged with said die 23 in company with a relative rotational movement caused by said helical gear contours 32' and 23' engaged with each other.

Meanwhile said outer lower punch 48 is also forced to move downwardly to a predetermined extent against compression spring 44 upwardly urging said supporting pins 49.

After that said die 23 is also moved downwardly to some extent relative to said outer lower punch 48, and this downward movement is also accompanied with a rotational movement caused by said helical gear contours 23' and 48' engaged together with.

Said downward movement of said outer lower punch 48 relative to said inner lower punch 25 is also naturally accompanied with a rotational movement selective to said inner punch fixedly secured to said base plate 9.

Accordingly, by means of the device of FIG. 10 thus operative as above mentioned, there can be formed such the relatively complex helical gear compact as having two external helical gear contours 1 and 1' and an axially grooved bore 22' as shown in FIG. 11 in a single step of powder compacting.

FIG. 14 shows a still further another embodiment of this invention, by means of which such a helical gear compact as having two internal helical gear contours 41 and 41' and grooves or notches 42 on the periphery thereof as shown in FIG. 13.

In FIG. 14 an upper punch 4 is divided into two parts and consists of an inner punch portion 51 and an outer punch portion 52, each being contiguous to the other at a coaxially cylindrical surface.

Said inner upper punch portion 51 is rotatably secured to a head plate 8 through the medium of a ball bearing 27 and formed with an internal helical gear contour 51'. Said outer punch portion 52 is fixedly secured to said head plate 8 and formed with grooves or notches in the axial direction.

In this device there are provided two lower punches 54 and 55, the inner lower punch 55 being rotatably supported on supporting pins 49 through the medium of a ball bearing 57 and said outer lower punch 54 being fixedly secured to a base plate 9.

Said inner lower punch is formed with an internal helical gear contour 55' and an external helical gear contour 55'', and said outer lower punch 54 is formed with an internal helical gear contour 54' and grooves or notches 54''.

A core rod 56 is rotatably secured to a yoke plate 11 and formed with an external helical gear contour 56' with which both of said internal helical gear contour 51' and 55' of the punch means are to be engaged.

Said die 53 is fixedly secured to a die plate 50 and formed with longitudinal projections each of which is to be made slidably fitted into said grooves 52' and 54'.

The operation of the device thus constructed as above mentioned is as follows.

While the upper punch 4 being forced to be moved downwardly, said outer punch portion 52 is made axially slidably fitted with said die 53, and simultaneously said inner punch portion 51 is engaged with said core rod 56 in company with a relative rotational movement caused by said helical gear contours 51' and 56' engaged with each other.

Meanwhile said inner lower punch 55 is also forced to move downwardly to a predetermined extent.

After that said die 53 is also moved downwardly to some extent relative to said outer lower punch 54.

In this device of FIG. 14, among the tools inclusive of said inner upper punch portion 51, said core rod 56, said inner lower punch 55 and said outer lower punch 54, each of these tools being formed with one or two helical gear contours, all but one tool, this is said outer lower punch 54 in this case, are rotatably secured to the respective plate members 8, 9 and 11.

On the other hand, another groups of the tools inclusive of said outer upper punch portion 52, said die 53 and said outer lower punch 54, each of which being formed with a non-circular shape that is a cylindrical wall of longitudinal grooves or projections, are all fixedly secured to the respective plate members 8, 50 and 9.

Accordingly, by using the device thus operative, such the relatively complex helical gear compact as shown in FIG. 13 can be formed in a single step of powder compacting, and this fact is a particular advantage of this invention over the prior arts.

Though some preferred embodiments of this invention have been described in detail heretofore by taking up six types of helical gear compacts as shown in FIGS. 3, 5, 7, 9, 11 and 13 respectively, it is naturally understood from the foregoing descriptions that various other modifications of helical gear compacts may be practicably formed in a single step by means of appropriately modified devices according to this invention, even in case of said modified helical gear compacts having more complex configurations.

We claim:

1. A powder compacting device for forming a helical gear compact having external helical gear teeth and a gear body contour at least a portion of which in transverse section is coaxially noncircular with respect to the gear axis, comprising a first punch means carried by a first plate, a second punch means carried by a second plate, and a die means carried by a die plate and adapted to surround and engage the peripheries of said punch means and define therewith a cavity for the reception of powdered material, said first punch means being divided into inner and outer portions having contiguous coaxial cylindrical surfaces for permitting relative rotational movement therebetween, said inner portion being fixedly secured to said first plate and provided with a surface defining said cavity for forming a contour of noncircular transverse section on said helical gear compact, said outer portion being freely rotatably secured to said first plate and provided with external helical teeth corresponding to the helical gear teeth to be formed on said helical gear compact, said second punch means being fixedly secured to said second plate and provided with external helical teeth corresponding to the helical gear teeth to be formed on said helical gear compact, said die means being freely rotatably secured to said die plate and provided with internal helical teeth adapted to mesh with said external teeth on said outer portion of said first punch means and on said second punch means, whereby movement of said first and second punch means toward each other compresses the powdered material in said cavity to form in a single compacting operation a helical gear

compact having external helical gear teeth on the periphery thereof and a body contour whose transverse section is coaxially noncircular.

2. A powder compacting device for forming a helical gear compact having external helical gear teeth and at least one bore whose transverse section is coaxially noncircular with respect to the gear axis, comprising a first punch means carried by a first plate, a second punch means carried by a second plate, a core carried by a yoke plate and axially extending within said punch means, and a die means carried by a die plate and adapted to surround and engage the peripheries of said punch means and define therewith and with said core a cavity, for the reception of powdered material, said first punch means being divided into inner and outer portions having contiguous coaxial cylindrical surfaces for permitting relative rotational movement therebetween, said inner portion being fixedly secured to said first plate and provided with a bore whose transverse section is coaxially noncircular, said outer portion being freely rotatably secured to said first plate and provided with external helical teeth corresponding to the helical gear teeth to be formed on said helical gear compact, said second punch means being fixedly secured to said second plate and provided with external helical teeth corresponding to the helical gear teeth to be formed on said helical gear compact and further being provided with a bore for receiving said core, said core being fixedly secured to said yoke plate and provided with an outside surface for forming said bore whose transverse section is coaxially noncircular in said helical gear compact, said die means being freely rotatably secured to said die plate and provided with internal helical teeth adapted to mesh with said external teeth of said first and second punch means, whereby movement of said first and second punch means toward each other compresses the powdered material in said cavity to form in a single compacting operation a helical gear compact having external helical gear teeth on the periphery thereof and a bore whose transverse section is coaxially noncircular.

3. A powder compacting device for forming a helical gear compact having internal helical gear teeth and a gear body contour at least a portion of which in transverse section is coaxially noncircular with respect to the gear axis, comprising a first punch means carried by a first plate, a second punch means carried by a second plate, a core carried by a yoke plate, and a die means carried by a die plate and adapted to surround and engage the peripheries of said punch means and define therewith a cavity for the reception of powdered material, said first punch means being divided into inner and outer portions having contiguous coaxial cylindrical surfaces for permitting relative rotational movement therebetween, said inner portion being freely rotatably secured to said first plate and provided with internal helical teeth corresponding to the helical gear teeth to be formed on said helical gear compact, said outer portion being fixedly secured to said first plate and provided with a contour whose transverse section is coaxially noncircular, said second punch means being fixedly secured to said second plate and provided with internal helical teeth corresponding to the helical gear teeth to be formed on said helical gear compact and a contour whose transverse section is coaxially

noncircular, said core being freely rotatably secured to said yoke plate and provided with external helical teeth adapted to mesh with said internal helical teeth of said first and second punch means, said die means being fixedly secured to said die plate and provided with a bore adapted to axially slidably engage said first and second punch means, whereby movement of said first and second punch means toward each other compresses the powdered material in said cavity to form in a single compacting operation a helical gear compact having internal helical gear teeth therein and a contour at least of a portion of which in transverse section is coaxially noncircular.

4. A powder compacting device for forming a helical gear compact having internal and external helical gear teeth coaxially disposed with respect to the gear axis, comprising a first punch means carried by a first plate, a second punch means carried by a second plate, a core carried by a yoke plate, and a die means carried by a die plate and adapted to surround and engage the peripheries of said punch means and define therewith a cavity for the reception of powdered material, said first punch means being divided into inner and outer portions having coaxial cylindrical surfaces for permitting relative rotational movement therebetween, said inner portion being freely rotatably secured to said first plate and provided with internal helical teeth corresponding to the internal teeth to be formed on said helical gear compact, said outer portion being also freely rotatably secured to said first plate and provided with external helical teeth corresponding to the helical gear teeth to be formed on said helical gear compact, said second punch means being fixedly secured to said second plate and provided with internal helical teeth corresponding to said helical gear teeth to be formed and with external helical teeth corresponding to said external gear teeth to be formed, said core being freely rotatably secured to said yoke plate and provided with external helical teeth adapted to mesh with said internal helical teeth of said first and second punch means, and said die means being freely rotatably secured to said die plate and provided with internal helical teeth adapted to mesh with said external helical teeth of said first and second punch means, whereby movement of said first and second punch means toward each other compresses the powdered material in said cavity to form in a single compacting operation a helical gear compact having internal and external helical gear teeth.

5. A powder compacting device as defined in claim 4, wherein said coaxial cylindrical surfaces of said inner and outer portions of said first punch means are contiguous and said second punch means is divided into secondary inner and secondary outer portions having contiguous coaxial cylindrical surfaces, said secondary inner portion being freely rotatably secured to said second plate and provided with the internal helical teeth corresponding to said internal helical gear teeth to be formed on said helical gear compact, said secondary outer portion being fixedly secured to said second plate and provided with external helical teeth corresponding to said external helical gear teeth to be formed on said helical gear compact, and said core being fixedly secured to said yoke plate and provided with external helical teeth adapted to mesh with said internal helical teeth of said first and second punch means.

6. A powder compacting device as defined in claim 4, wherein said first punch means is divided into an inner, an intermediate and an outer portion, each of said portions having contiguous coaxial cylindrical surfaces for permitting relative rotational movement therebetween, said intermediate portion being fixedly secured to said first plate and provided with at least one bore in the axial direction for receiving an intermediate core rod, said core rod being fixedly secured to said yoke plate and extending through said second punch means for entry into said bore of said intermediate portion whereby upon movement of said first and second punch means toward each other, there is formed in addition to said external and internal helical gear teeth at least one bore in said helical gear compact between said external and internal gear teeth thereof.

7. A powder compacting device as defined in claim 6, wherein said intermediate portion is provided with a plurality of bores, each bore receiving an intermediate core rod fixedly secured to said yoke plate and extending through said second punch means.

8. A powder compacting device for forming a helical gear compact having external helical gear teeth of two different pitch diameters and a gear body contour at least a portion of which in transverse section is coaxially noncircular with respect to the gear axis, comprising a first punch means carried by a first plate, a second punch means carried by a second plate, and a die means carried by a die plate and adapted to surround and engage the peripheries of said punch means and define therewith a cavity for the reception of powdered material, said first punch means being divided into inner and outer portions having contiguous coaxial cylindrical surfaces for permitting relative rotational movement therebetween, said inner portion being fixedly secured to said first plate and provided with a surface for forming the gear body contour whose transverse section is coaxially noncircular, said outer portion being freely rotatably secured to said first plate and provided with external helical teeth corresponding to the helical gear teeth of larger pitch diameter to be formed on said helical gear compact, said second punch means being divided into a secondary inner portion and a secondary outer portion which are coaxially disposed, said secondary inner portion being fixedly secured to said second plate and provided with external helical teeth corresponding to the helical teeth of smaller pitch diameter to be formed on said helical gear compact and provided with a surface for forming said body contour whose transverse section is coaxially noncircular, said secondary outer portion being freely rotatably secured to said second plate and provided with internal helical teeth meshing with said external teeth of said secondary inner portion and with external helical teeth corresponding to the external gear teeth of larger pitch diameter to be formed on said helical gear compact, said die means being freely rotatably secured to said die plate and provided with internal helical teeth adapted to mesh with said external helical teeth of said first punch means and said secondary outer portion respectively, whereby movement of said first and second punch means toward each other compresses the powdered material to form in a single compacting operation helical gear compact having external helical gear teeth of two different pitch diameters.

9. A powder compacting device for forming a helical gear compact having external helical teeth of two different pitch diameters and a bore whose transverse section is coaxially noncircular with respect to the gear axis, comprising a first punch means carried by a first plate, a second punch means carried by a second plate, a core carried by a yoke plate, and a die means carried by a die plate and adapted to surround and engage the peripheries of said punch means and define therewith and with said core a cavity for the reception of powdered material, said first punch means being divided into inner and outer portions having contiguous coaxial cylindrical surfaces for permitting relative rotational movement therebetween, said inner portion being fixedly secured to said first plate and provided with a bore whose transverse section is coaxially noncircular and adapted to receive said core in fitted relation, said outer portion being freely rotatably secured to said first plate and provided with external helical teeth corresponding to the helical gear teeth of larger pitch diameter to be formed on said helical gear compact, said second punch means being divided into secondary inner and secondary outer portions which are coaxially disposed, said secondary inner portion being fixedly secured to said second plate and provided with a bore whose transverse section is coaxially noncircular and adapted to receive said core in fitted relation and also the external helical teeth corresponding to said helical gear teeth of smaller pitch diameter to be formed on said helical gear compact, said secondary outer portion being rotatably secured to said second plate and provided with internal helical teeth meshing with said external helical teeth of said secondary inner portion and also with external helical teeth corresponding to said helical gear teeth of larger pitch diameter to be formed on said helical gear compact, said core being fixedly secured to said yoke plate to axially extend within said bores in said first and second punch means and provided with an outside surface for forming on said helical gear compact a bore whose transverse section is coaxially noncircular, said die being rotatably secured to said die plate and provided with internal helical teeth meshing with said external helical teeth of said first punch means and said secondary outer portion respectively, whereby movement of said first and second punch means toward each other compresses the powdered material to form in a single compacting operation a helical gear compact having external teeth of two different pitch diameters and a bore whose transverse section is coaxially noncircular.

10. A powder compacting device for forming a helical gear compact having two sets of internal helical gear teeth whose pitch diameters are different and a gear body contour at least a portion of which is coaxially noncircular in transverse section with respect to the gear axis, comprising a first punch means carried by a first plate, a second punch means carried by a second plate, a core carried by a yoke plate, and a die carried by a die plate and adapted to surround and engage with said first and second punch means and define therewith and with said core a cavity for the reception of powdered material, said first punch means being divided into an inner portion and an outer portion having contiguous coaxial cylindrical surfaces for permitting relative rotational movement therebetween, said inner por-

tion being rotatably secured to said first plate and provided with internal helical teeth corresponding to said internal helical gear teeth of smaller pitch diameter which is to be formed on said helical gear compact, said outer portion being fixedly secured to said first plate and provided with a contour whose transverse section is coaxially noncircular, said second punch means also being divided into a secondary inner portion and a secondary outer portion which are contiguous to each other at their coaxial cylindrical surfaces for permitting relative rotational movement therebetween, said inner portion being rotatably secured to said first plate and provided with internal helical teeth corresponding to said internal helical gear teeth of smaller pitch diameter which is to be formed on said helical gear compact, said outer portion being fixedly secured to said first plate and provided with a contour at least a portion of which is coaxially noncircular in transverse section, said second punch means also being divided into the secondary inner portion and the secondary outer portion which are coaxially disposed, said secondary inner portion being rotatably secured to said second plate and provided with internal helical teeth corresponding to said internal helical gear teeth of smaller pitch

diameter which is to be formed on said helical gear compact and also provided with external helical teeth, said secondary outer portion being fixedly secured to said second plate and provided with internal helical teeth corresponding to said internal helical gear teeth of larger pitch diameter to be formed on said helical gear compact and also with a contour whose transverse section is coaxially noncircular, said core being rotatably secured to said yoke plate and provided with external helical teeth meshing with said inner helical teeth of said first punch means and said secondary inner portion respectively, and said die means being fixedly secured to said die plate and provided with an inner surface adapted to receive the peripheries of said first and second punch means in closely fitted relation, whereby movement of said first and second punch means in closely fitted relation, whereby movement of said first and second punch means toward each other compresses the powdered material to form in a single compacting operation a helical gear compact having two sets of internal helical gear teeth of different pitch diameters.

* * * * *

25

30

35

40

45

50

55

60

65