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[54] **METHOD AND APPARATUS FOR SMOOTH-ROLLING OF CYLINDRICAL WORKPIECE SURFACES**

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[51] **Int. Cl.** **B21c 37/30**

[58] **Field of Search** ..... 29/90 R; 72/78, 100, 121

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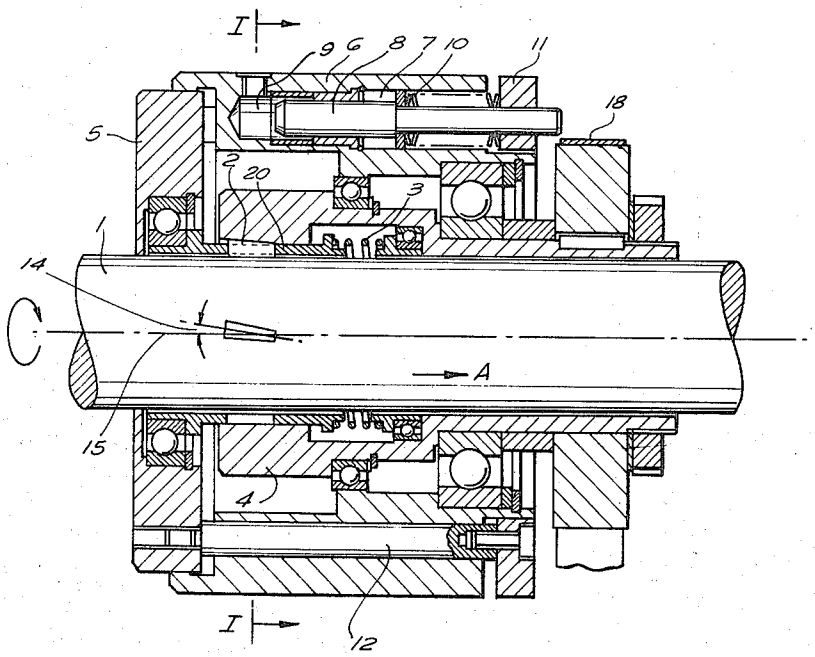
[57] **ABSTRACT**

A tool is provided, having an annulus of rollers which are inclined to the axis of the annulus and which engage the cylindrical surface of a workpiece located cocentrically with respect to the annulus. The inclination of the rollers, which are rotated with reference to the workpiece and which engage the surface thereof over a drop-shaped area inclined to the axis of the annulus, tends to impart to the workpiece a thrust in one axial direction, and the workpiece is forcibly advanced in the opposite direction against this thrust.

7 Claims, 3 Drawing Figures



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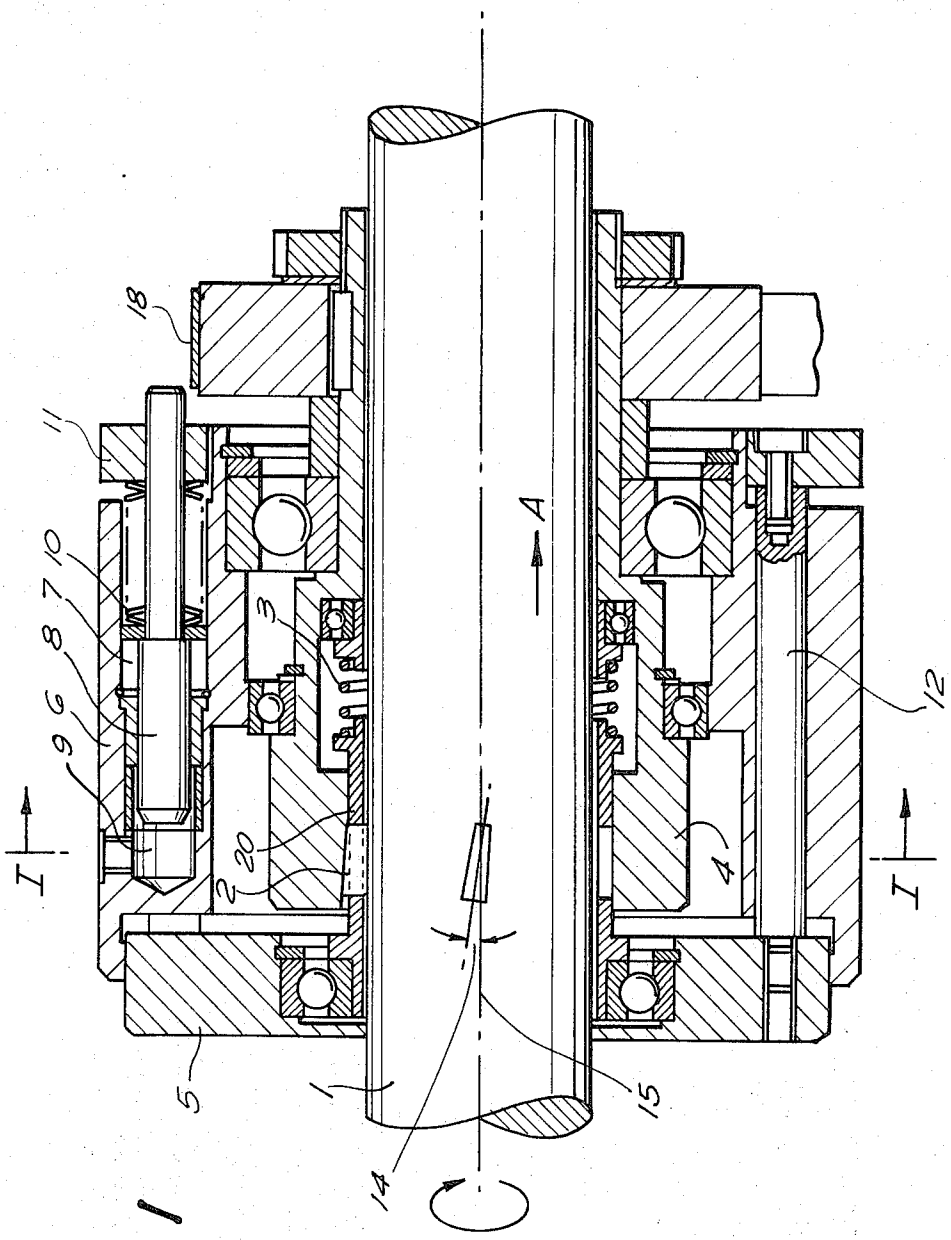


FIG. 1

FIG. 2

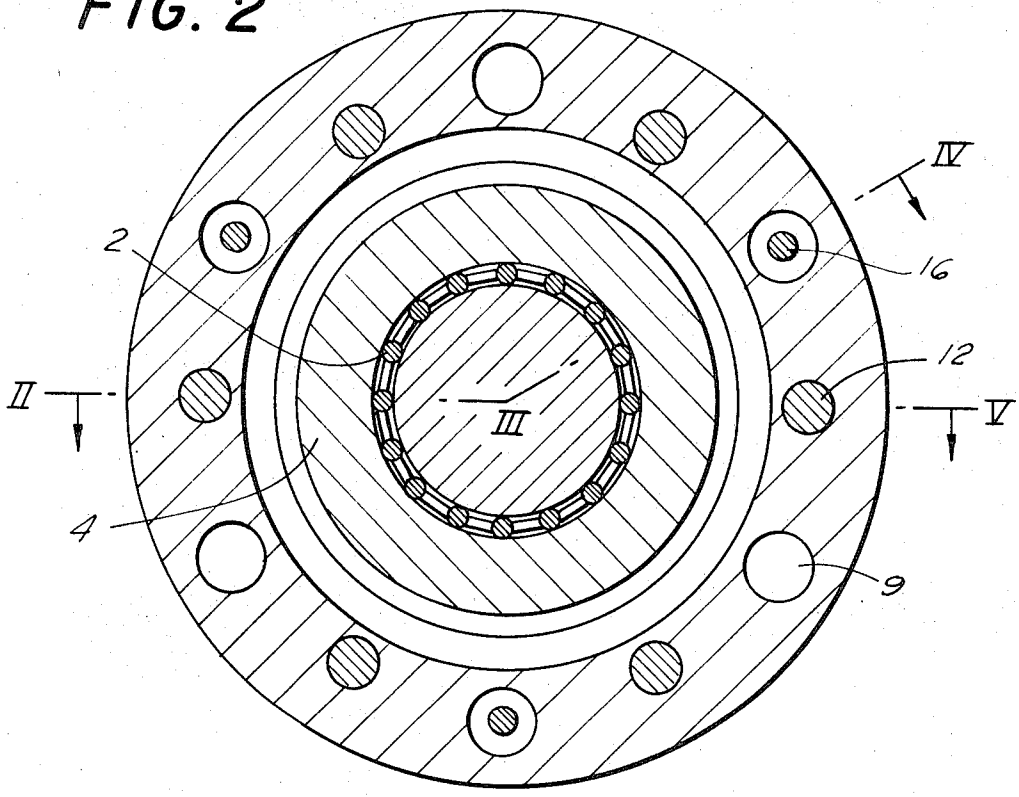
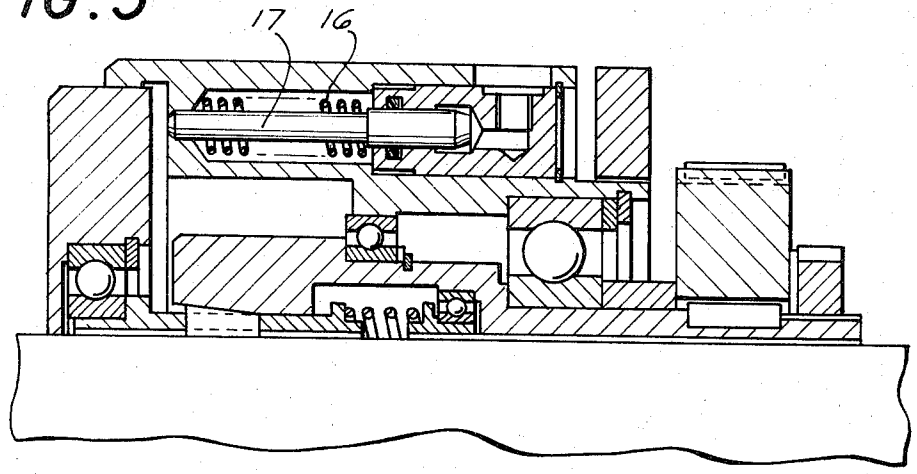


FIG. 3



METHOD AND APPARATUS FOR SMOOTH-ROLLING OF CYLINDRICAL WORKPIECE SURFACES

BACKGROUND OF THE INVENTION

The present invention relates generally to the treating of workpiece surfaces, and more particularly of cylindrical workpiece surfaces. Still more particularly the invention relates to a method of carrying out such treatment and to an apparatus for carrying out the method.

It is already known to improve, that is to smooth, the surface of cylindrical workpieces such as rods or the like by continuous circumferential roller pressure. This is carried out by bringing rollers in contact with the surface of the workpiece, rotating the latter and thus assuring that the rollers which are distributed around the circumference of the workpiece, exert a pressure from opposite directions against the workpiece surface so that the pressures negate one another and a force is transmitted to the workpiece which smoothes the surface thereof. The rollers are guided along the workpiece, the latter being maintained stationary against longitudinal displacement but being subjected to rotation.

A further approach known from the art is to incline the axis of the rollers so as to impart to the workpiece a thrust, thus eliminating the need for separate means which effect relative dispacement between the annulus of rollers and the workpiece. Also, it is not necessary in this second prior-art approach to rotate the workpiece by separate means, because rotation is imparted to it by one or more of the rollers which may be driven. If the workpiece is relatively long, for instance rod-shaped, it is necessary of course to appropriately support it so that it will not flex or whip .

All of the prior-art devices of this type use rollers of very large diameter which consequently exert a very substantial roller pressure on the workpiece surface. In order to be able to withstand these pressures it is necessary to provide very large bearings or journals, and these in the final analysis determine the diameter of the rollers themselves. These constructions are relatively large, due to the number and dimensions of the components involved, and require substantial space, aside from the fact that they are relatively complicated and therefore expensive to produce.

In most of these devices it is necessary that the surface of the workpiece be precisely prepared before it can be subjected to the roller pressure, that is the surface must already be quite smooth if it is desired for the finished surface to have a maximum of roughness and to be within narrow toloerance limits. However, large roller bodies which exert a high pressure on the workpiece have the disadvantage that they can cause a warping of the workpiece, which is particularly true if the workpiece is rather long, for instance in form of rods. This warping can then necessitate a subsequent straightening of the workpiece, that is an additional operating step which is again time consuming and expensive.

Another type of apparatus known for the purposes in question is one in which roller head is provided which rotates about the workpiece. Here, also, large rollers are used which are located oppositely one another and pressed into contact with the surface of the workpiece.

This is a disadvantage, as already pointed out above, aside from the fact that this arrangement has the further problem that the rollers are rather imbalanced and can therefore rotate only at slow speeds. Moreover, they must be advanced manually. Still another type of apparatus used for this purpose utilizes a large number of smaller rollers which contact the workpiece surface and which roll between the workpiece surface and a back-up surface of the tool itself, in contact with both. This type of apparatus exerts a relatively low roller pressure, because the small area of contact between the rollers and the workpiece produces a high specific surface pressure which alone is determinative and sufficient for the plastic deformation of the surface of the workpiece. A warping of the workpiece does not occur in this type of apparatus. It is known that these rollers can be made conical, in which case the operative diameter of the annulus in form of which they are arranged is varied by axially displacing the rollers on the back-up surface. The rollers can, however, also be cylindrical in which case the device cannot be adjusted for more than a single workpiece diameter. These devices also require great care in the initial production of the workpiece surface, because otherwise the result after rolling will not be as good and as precise within the tolerancce variations, as is desired.

However, there are many applications in which tolerance variations are quite large and can be for instance permitted to fluctuate within 0.2 millimeters or more, as long as an absolutely smooth surface can be provided on the workpiece. For instance, in the case of piston rods these situations exist, because the proper operation of seals cooperating with the surface of the piston rod, and chromiumplating of the surface depend upon great smoothness of the surface, whereas tolerance variations in the diameter are of secondary consideration. The difficulty here is that workpieces with such large tolerances (relatively speaking) cannot be treated with the apparatus known from the art, because either the roller pressure is to small and produces an insufficient smoothness of the surface if the workpiece diameter is at the lower tolerance limit, or else the roller pressure is too large and the workpiece surface is destroyed or damaged if the workpiece diameter is at the upper tolerance limit.

The prior art has provided no approach and no apparatus for properly treating workpieces of this type.

SUMMARY OF THE INVENTION

It is, accordingly, a general object of the present invention to provide an improvement in the state of the art.

More particularly it is an object of the present invention to provide a method of continuously smooth-rolling the cylindrical surfaces of workpieces of the type mentioned above.

Another object is to provide an apparatus for carrying out the method.

In pursuance of these objects, and of others which will become apparent hereafter, one feature of the invention resides, briefly stated, in an apparatus comprising in combination of a hollow cylindrical support, and an annulus of workpiece-engaging rollers mounted in and supported by an inner circumferential surface of the support. The rollers are each inclined to the axis of the annulus and a roller cage retains the rollers in predetermined relative positions. Biassing means exerts an

axial biassing force upon the roller cage and rotating means rotates the rollers about the axis. Force-transmitting means acts upon the rollers for urging the same into engagement with a workpiece surface.

With this construction the workpiece may either be stationary or it may itself rotate. This is a particular advantage in the case or very long workpieces because they can be maintained fixed, that is need not be rotated, which avoids the disadvantage of having the free end of the workpiece perform whipping movements, or of having to provide relatively complicated and expensive arrangements for retaining the free end against such movement.

Advantageously, the workpiece utilizes a roller head in which the rollers are arranged in form of the aforementioned annulus, the arrangement being such that they contact the workpiece surface over a drop-shaped area, exerting upon the workpiece an axial force tending to displace the workpiece in one direction, with an advancing force being exerted on the workpiece which advances it counter to this axial force in the opposite direction. Because a great number of rollers can be distributed around the circumference of the workpiece any warping of the latter is avoided, because the very small contact area between the rollers and the workpiece surface result in the exertion on the latter of only a small absolute roller pressure which, however, is nevertheless sufficient to produce the specific surface pressure required for plastic deformation of the surface. The conical rollers are so inclined in contact with the workpiece surface as to obtain the best smoothing effect.

The rollers themselves do not require any complicated journalling, but instead roll directly in contact with the driven conical support and the workpiece surface, being guided in the aforementioned roller cage which prevents the rollers from falling out or shifting their relative positions when the workpiece is changed. This is a very simple arrangement which will rotate without imbalance and therefore permits high rotational speeds,which makes it possible to produce very economically at very high speeds of workpiece advancement.

The roller head is essentially composed of an inner rotating component and two outer stationary components, one of which is here configurated as a pressure ring and is displaceable axially with reference to the other. The stationary component of the roller head is provided with a plurality of hydraulic cylinder and piston units which extend in parallelism with the axis of the workpiece and which can be selectively operated so that some of them exert via the pressure ring and the conical support pressure upon the rollers to press the same against the advancing workpiece, whereas others counterbalance this force, that is relieve the rollers of the roller pressure.

The inner rotating component is completely surrounded by the outer stationary components so that any danger of accidents due to contact with movable parts is avoided.

In fact, except for a suitable drive component which can be covered in known manner, no moving parts exteriorly of the roller head exist. The hydraulic force transmission is continuous, so that any desired roller pressure can be selected. The inclination of the rollers in the roller cage with respect to the workpiece axis in the plane of roller pressure is so selected that an axial force exists which tends to displace the workpiece towards the larger opening of the conical support. This arrangement assures that under all circumstances a movement of the rollers into the conical support — caused by manufacturing tolerances — is avoided, because this could result in an uncontrolled increase of the roller force and in a destruction of the workpiece surface. The workpiece itself can be rotated or stationary as desired.

The novel features which are considered as characteristic for the invention are set forth in particular in the appended claims. The invention itself, however, both as to its construction and its method of operation, together with additional objects and advantages thereof, will be best understood from the following description of specific embodiments when read in connection with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS:

FIG. 1 is a section taken on lines II–III–IV of FIG. 2, showing an embodiment of the invention in which a non-rotating workpiece is being treated;

FIG. 2 is a section taken on line I—I of FIG. 1; and

FIG. 3 is a section taken on line III–V of FIG. 2.

DESCRIPTION OF THE PREFERRED EMBODIMENTS:

Discussing the drawing in detail it will be seen that the illustrated embodiments in FIGS. 1–3 shows the treating of a workpiece that is maintained stationary, that is which is not rotated although it is axially advanced, such as a rod. The direction of axial advancement of the workpiece 1 is designated by the arrow A. The outer circumferential surface of the workpiece 1 is engaged by the rollers 2 which are mounted and guided in a roller cage 20, the latter being subjected to an axial force exerted by a spring 3. The rollers 2 form an annulus surrounding the workpiece 1 and roll between the surface of the workpiece 1 and the inner surface of a conical roller support 4; they can be axially shifted by the pressure ring 5 in direction of the support 4, the purpose being to push the rollers into the support 4 and therefore to push them from engagement with the surface of the workpiece, or in opposite direction in order to release them from contact with the workpiece. The necessary pressure is exerted by three equiangularly spaced cylinder and piston units having a cylinder 7 and a piston 8, respectively, with these units being at equal radial distance from the axis of rotation of the annulus of rollers 2 and being mounted in the stationary portion 6 of the roller head in axial parallelism with the axis of the workpiece. By simultaneously activating the pistons 8 in the cylinders 7, by admitting fluid into the chambers 9, the pistons 8 are advanced against the action of a spring 10 which abuts against a ring 11 which is connected via bolt 12 with the pressure ring 5. Thus, the rings 5 and 11 are maintained at a fixed distance from one another.

The stationary portion of the roller head 6 is displaceable on the bolt 12 so that the action of the hydraulic pressure exerted by the cylinder and piston units, and the action of the springs 10 is such that the ring 5 is pressed against the rollers 2 and in turn forces the same into contact with the outer circumferential surface of the workpiece 1.

As the drawing clearly shows, the rollers 2 mounted in the cage 4 contact the surface of the workpiece 1 at an angle 14 which is inclined to the workpiece axis 15. Thus, axial forces develop which tend to counter the direction of advancement A of the workpiece. As a result, the rollers 2 always have the tendency to counteract the movement imparted to them by the ring 5.

When the operation is completed, the rollers 2 are released from tight contact with the workpiece surface in fully automatic manner, that is their inherent tendency will release them from the workpiece when the latter is no longer forcibly advanced in direction of the arrow A. However, this requires a certain small time lag which can be avoided if the three release cylinders 16 which are also equiangularly spaced about the workpiece circumference and located intermediate the cylinders 7, are activated with hydraulic fluid so that their piston rods 17 engage the ring 5 and move it away from the stationary component 6 of the roller head. This causes the spring 4 to shift the roller cage 20 and therefore the rollers 2 in the direction towards the larger open end of the roller support 4. The stationary component 6 and the ring 5 together with ring 11 constitute the roller head, in which the roller support 4 rotates with the rollers 2. This rotating component is driven in the illustrated embodiment by a drive belt 18, although a gear drive or another drive can be used and is intended to be encompassed within the concept of the invention.

It will be understood that each of the elements described above, or two or more together, may also find a useful application in other types of constructions differing from the types described above.

While the invention has been illustrated and described as embodied in an apparatus for rolling deformation of cylindrical workpiece surfaces, it is not intended to be limited to the details shown, since various modifications and structural changes may be made without departing in any way from the spirit of the present invention.

Without further analysis, the foregoing will so fully reveal the gist of the present invention that others can by applying current knowledge readily adapt it for various applications without omitting features that, from the standpoint or prior art fairly constitute essential characteristics of the generic or specific aspects of this invention and, therefore, such adaptations should and are intended to be comprehended within the meaning and range of equivalence of the following claims.

What is claimed as new and desired to be protected by Letters Patent is set forth in the appended

1. A method of continuously smooth-rolling cylindrical workpiece surfaces in a tool having an annulus of rollers which are inclined to the axis of the annulus, comprising the steps of effecting concentric positioning of a workpiece and the annulus of rollers, so that the latter each engage the workpiece under pressure over a drop-shaped area which is inclined to said axis; causing said rollers to orbit about said axis in rolling contact with said workpiece to which they tend to impart a thrust in one axial direction; and forcibly advancing said workpiece in an opposite direction against the thrust exerted by said rollers.

2. A method as defined in claim 1; and further comprising the step of rotating said workpiece about said axis.

3. A method as defined in claim 1; and further comprising the step of preventing said workpiece from rotating about said axis.

4. In an apparatus for smooth-rolling cylindrical workpiece surfaces, a tool head comprising a combination of a hollow conical support; an annulus of workpiece-engaging rollers mounted in and supported by an inner circumferential surface of said support, said rollers each being inclined to the axis of said annulus; a roller cage retaining said rollers in predetermined relative positions; biassing means exerting an axial biassing force upon said roller cage; rotating means for rotating said rollers about said axis; and force-transmitting means acting upon said rollers for urging the same into engagement with a workpiece surface.

5. A combination as defined in claim 4, wherein said tool head includes an inner rotatable component and two outer non-rotatable components one of which is displaceable axially with reference to the other.

6. A combination as defined in claim 5, wherein said force-transmitting means comprises a plurality of hydraulic cylinder-and-piston units arranged in said other components in parallelism with said axis and selectively operable so that some of said units urge said rollers into engagement with the workpiece surface and that others of said units exert a relief pressure on said rollers.

7. A combination as defined in claim 4, said annulus being conical and having a wider and a narrower open end; and wherein said rollers are so inclined to said axis as to exert upon the workpiece an axial force in direction towards said wider open end.

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