Innovation, Sciences et Développement économique Canada
Office de la Propriété Intellectuelle du Canada

Innovation, Science and Economic Development Canada
Canadian Intellectual Property Office

CA 2812468 C 2018/10/16

(11)(21) **2 812 468**

(12) **BREVET CANADIEN
CANADIAN PATENT**

(13) **C**

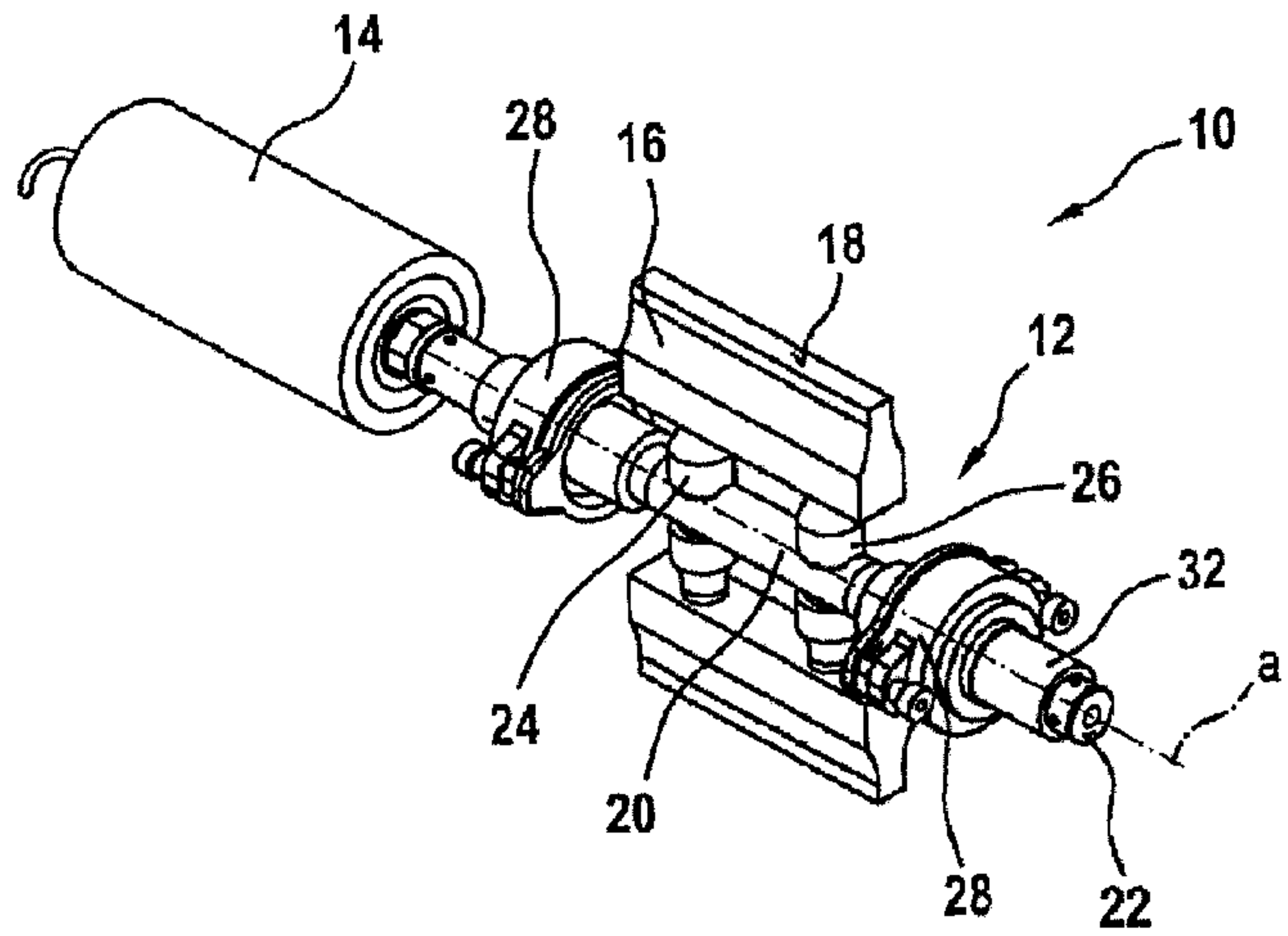
(86) Date de dépôt PCT/PCT Filing Date: 2011/09/09
(87) Date publication PCT/PCT Publication Date: 2012/04/19
(45) Date de délivrance/Issue Date: 2018/10/16
(85) Entrée phase nationale/National Entry: 2013/03/25
(86) N° demande PCT/PCT Application No.: EP 2011/065669
(87) N° publication PCT/PCT Publication No.: 2012/048968
(30) Priorité/Priority: 2010/09/27 (DE10 2010 041 432.8)

(51) Cl.Int./Int.Cl. *B29C 65/08* (2006.01), *B06B 3/00* (2006.01)
(72) Inventeur/Inventor:
THAERIGEN, JAN, CH

(73) Propriétaire/Owner:
ROBERT BOSCH GMBH, DE

(74) Agent: BORDEN LADNER GERVAIS LLP

(54) Titre : UNITE EMETTRICE D'ULTRASONS
(54) Title: ULTRASONIC VIBRATION UNIT



(57) Abrégé/Abstract:
The invention relates to an ultrasonic vibration unit (10) for an ultrasonic welding device for sealing and welding material webs, comprising a sonotrode (12) connected to a converter (14) and having at least one sealing horn (16) radially protruding from an axis of rotation (a) and having a free end forming a sealing surface (18). The sonotrode (12) comprises a sonotrode shaft (20) having the axis of rotation (a). One or both end faces (22) of the sonotrode shaft (20) are connected to a converter (14) and the sealing horns (16) are attached to the sonotrode shaft (20) directly or by means of boosters (24, 26) when vibrational nodes (K_L) of a longitudinal vibration (S_{w1}) of the sonotrode shaft (20) are present.

ABSTRACT

The invention relates to an ultrasonic vibration unit (10) for an ultrasonic welding device for sealing and welding material webs, comprising a sonotrode (12) connected to a converter (14) and having at least one sealing horn (16) radially protruding from an axis of rotation (a) and having a free end forming a sealing surface (18). The sonotrode (12) comprises a sonotrode shaft (20) having the axis of rotation (a). One or both end faces (22) of the sonotrode shaft (20) are connected to a converter (14) and the sealing horns (16) are attached to the sonotrode shaft (20) directly or by means of boosters (24, 26) when vibrational nodes (K_L) of a longitudinal vibration (S_{w1}) of the sonotrode shaft (20) are present.

ULTRASONIC VIBRATION UNIT

TECHNICAL FIELD

The present invention relates to an ultrasonic vibration unit for an ultrasonic welding device for sealing and welding material webs, comprising a sonotrode connected to a converter and having at least one sealing horn protruding radially from an axis of rotation and rotatable about the axis of rotation and having a free end forming a sealing surface.

PRIOR ART

Ultrasonic welding is a method for joining plastics. Ultrasound is a mechanical vibration above the audible limit. The frequency range begins at about 20 kHz and extends up to frequencies of 1 GHz. Such ultrasonic frequencies are frequently generated from electrical energy with the aid of piezoelectric converters. This mechanical vibration energy is applied to the workpiece or the material to be processed via the sonotrode connected to the converter, if appropriate via a booster. The surface of the sonotrode which is provided to come into contact with the material to be processed is also designated a sealing surface.

The ultrasonic vibration unit thus constitutes a structure which vibrates during operation and comprises the converter, if appropriate the booster and the sonotrode.

In order to transfer the ultrasonic vibration effectively with the aid of the ultrasonic vibration unit, it is necessary to bring the ultrasonic vibration unit to resonance. Depending on the construction of the ultrasonic vibration unit, the latter has a multiplicity of natural frequencies. Only if the converter generates a natural frequency of the ultrasonic vibration unit does resonant vibration of the ultrasonic vibration unit occur. Therefore, converter and ultrasonic vibration unit must be matched to each other.

Strictly speaking, the resonant frequency differs somewhat from the natural frequency, since every real system is damped. However - as also frequently in the literature - the terms resonant frequency and natural frequency will be used synonymously below. The most important natural frequency of the ultrasonic vibration unit is generally the natural frequency at which a standing longitudinal vibration with nodes and antinodes is formed in the ultrasonic vibration unit. In this case, an antinode is formed respectively at the ends of the sonotrode.

The converter which generates the appropriate ultrasonic excitation frequency is connected to one of the ends. If appropriate, a booster, which changes the amplitude of the ultrasonic vibration but not the frequency, is connected between converter and sonotrode. As a result of the provision of a booster, the natural frequency of the sonotrode and therefore the position of the vibration nodes of the longitudinal vibration are not affected.

For some applications, the booster and the sonotrode are formed in one piece, i.e. can no longer be differentiated visually. In order therefore to distinguish the sonotrode from the booster, it is necessary to determine the position of the vibration troughs of the pure longitudinal vibration. As a rule, the sonotrode comprises the sealing surface. Each section which reaches from vibration maximum to vibration maximum in the longitudinal direction and which does not affect the natural frequency of the pure longitudinal vibration is not a part of the sonotrode.

If, on the other hand, such a section affects the natural frequency of the pure longitudinal vibration, i.e. it cannot be removed without a substantial change in the natural frequency, then it belongs to the sonotrode.

During the processing of materials with the aid of ultrasound, the material to be processed is generally positioned between the sonotrode and an opposing tool (not belonging to the vibration structure), which is also called an anvil. The sonotrode that is in contact with the material to be processed then transfers the ultrasonic energy to the material to be processed, which, as a result, is welded or separated, for example. The heat needed to plasticize the material web is generated by the conversion of ultrasonic vibrations into frictional energy. On account of the interface and molecular friction, heat thus arises, which causes the plastic to begin to melt.

In the case of most sonotrodes, the longitudinal ultrasonic vibration is used to transmit energy via the sealing surface.

However, there are also sonotrodes having a sealing surface substantially in the form of the surface of a cylinder circumference, which utilize the radial ultrasonic vibration building up transversely with respect to the longitudinal propagation direction of the ultrasonic vibration for the transmission of energy. These sonotrodes frequently comprise a substantially rod-like section, which is followed by the converter and possibly the booster, and a wheel-like or bell-like section projecting radially beyond the rod-like section. The wheel-like or bell-like section has the sealing surface.

These sonotrodes generally have two main natural vibration modes.

One natural vibration mode corresponds substantially to the longitudinal resonant vibration of the rod-like section. This resonant vibration has a relatively large longitudinal vibration amplitude. However, associated with this is also a forced influence on the material in the transverse direction, i.e. perpendicular to the rod axis. This forced influence manifests itself in a thickness vibration which propagates radially with respect to the rod axis. The vibration amplitude of the thickness vibration is relatively small, the consequence of which is that the major part (more than 90%) of the vibration energy absorbed in the vibration system is contained in the longitudinal vibration.

The other natural vibration mode corresponds substantially to the resonance of the radial vibration of the wheel section. Associated with this is a comparatively small (forced) vibration in the longitudinal direction. In this natural vibration mode, the major part (normally more than 90%) of the vibration energy absorbed in the vibration system is contained in the radial vibration.

In the case of rotational welding, the second natural vibration mode is used since, by producing a relatively small longitudinal vibration in the rod-shaped section of the sonotrode, a relatively large radial vibration can be generated in the wheel section of the sonotrode.

Thus, sonotrodes with a sealing surface in the form of a cylinder surface are known, which are employed for the continuous ultrasonic processing of moving material webs. During operation, these sonotrodes are rotated about their longitudinal axis, so that the cylinder surface-like sealing surface is moved substantially at the same speed as the material web to be processed. Thus, in the case of these sonotrodes, only a small part of the sealing surface is always in contact with the material web.

An ultrasonic welding device of the type mentioned at the beginning is known from WO 2007/012917 A1. The device, of multi-vane design, comprises two rotating shafts parallel to each other. The sonotrodes are mounted on one shaft, the anvils on the other shaft. The converters used to feed the sonotrodes are likewise placed on the rotating shaft. The disadvantage with this device is that a converter is needed for each sonotrode. In the case of a four-vane design, for example, four converters are thus needed, which gives rise to high costs. Converter and sonotrode have a relatively large overall height. Therefore, the axial spacing of the two parallel shafts has to be chosen to be large, which needs a great deal of space and has a detrimental effect on the format range. In the event of a format change, for example from three vanes to four vanes, complicated conversion with subsequently difficult adjustment is necessary, the consequence of which is relatively long stoppage and start-up times following the format change.

WO 2009/156207 A1 discloses a rotating sonotrode which has a roll-like active surface (sealing surface). The sonotrode is of wavy form and optionally provided with boosters. The sealing surfaces are formed as radial elevations in the form of wheels or bells. The sonotrode is supplied with ultrasonic energy axially by a converter. The sonotrode of wavy form is designed as a unit and as such must be designed as an overall system with respect to its vibration properties. If, then, in the case of a sonotrode for a tube bag-making machine, what are known as vanes are formed instead of a roll-like sealing surface, this configuration must also be designed as an overall system. In addition, restrictions with regard to the number of vanes result. For instance, the system must be built up symmetrically, which permits only an even number of vanes. Changing the sonotrode on account of maintenance work or else during initial installation is possible only as a whole and is therefore complicated. In addition, changing the number of vanes on account of format adjustment makes dismantling of the entire sonotrode with subsequent complicated adjustment necessary.

From WO 02/060674 A1 it is known to feed the ultrasonic energy axially from both sides in the case of a rotating sonotrode. On account of the conical shape and a corresponding cavity in the sonotrode, the vibration is deflected through 90° into the radial direction. The advantage of this sonotrode is the possibility of two-sided mounting, which means that a higher sealing pressure can be generated. Likewise, the distribution of the vibration to the sealing surface can be implemented more uniformly as compared with the conventional conversion of the axial into radial vibration energy by means of transverse contraction. Because of the cavity, only cylindrical shapes are possible for the sonotrode. Sonotrodes having a plurality of vanes, such as are needed for a tube bag-making machine, cannot be implemented on account of the thin conical walls restricting the stability of the sonotrode but necessary for deflecting the waves. A further disadvantage is the restricted sealing width and energy distribution on the active surface. The result is a restricted format range and also an inadequate sealing quality in the case of wide sealing seams.

SUMMARY OF THE INVENTION

The invention is based on the object of devising an ultrasonic vibration unit of the type mentioned at the beginning which has a small overall shape with the largest possible sealing surface with a uniform energy distribution over the sealing surface.

The achievement of the object according to the invention leads to the sonotrode comprising a sonotrode shaft with the axis of rotation, sealing horns and optional boosters, one or both ends of the sonotrode shaft being connected to a converter and the sealing horns being fixed to the sonotrode shaft at vibration nodes of a longitudinal vibration via boosters or directly to the sonotrode shaft.

As a result of the configuration of the ultrasonic vibration unit according to the invention, multi-vane designs with a free choice of the number of vanes (sealing horns) are possible. Therefore, whilst avoiding the disadvantages of the known solutions, the greatest possible flexibility and a high output range are ensured. Likewise, simple replacement of the sealing horns can be achieved with the shortest possible machine stoppage times and simple adjustment.

The ultrasonic vibration unit according to the infringement is suitable in particular for the production of transverse sealing seams on a tubular packaging film in a vertical or horizontal tube bag-making machine.

In the following text, the term sonotrode is used as a composition of the sonotrode shaft, the optional boosters and the sealing horns, separate vibratory waves being generated in the sonotrode shaft and in the sealing horns and the sealing surface being present only on the sealing horns. By contrast, a conventional sonotrode as a rule comprises only one vibratory wave and includes the sealing surface.

The ultrasonic vibration unit can have a multiplicity of sealing horns - also called vanes - fixed so as to project radially from the axis of rotation. The fixing can be implemented by various techniques. Sealing horns with a large width can also be fixed so as to project radially from the axis of rotation at different vibration nodes.

Each sealing horn can have an individual fixing point. A multiplicity of sealing horns can be arranged so as to project radially from the axis of rotation at one and the same vibration node or at different vibration nodes - that is to say offset laterally with respect to one another in the direction of the axis of rotation.

Each sealing horn can have at least two fixing points, the spacing of the fixing points preferably respectively being a multiple of the wavelength of the longitudinal vibration. A multiplicity of sealing horns can be arranged so as to project radially from the axis of rotation at the same vibration nodes or at different vibration nodes - that is to say offset laterally with respect to one another in the direction of the axis of rotation.

BRIEF DESCRIPTION OF THE DRAWINGS

Further advantages, features and details of the invention can be gathered from the following description of preferred exemplary embodiments and by using the drawing, which serves merely for the purpose of explanation and is not designed to be restrictive. In the drawing, in schematic form, fig. 1 shows an oblique view of an ultrasonic vibration unit;

fig. 2 shows a side view of the ultrasonic vibration unit from fig. 1.

DESCRIPTION OF PREFERRED EMBODIMENTS

An ultrasonic vibration unit 10 illustrated in figures 1 and 2 for an ultrasonic welding device for producing transverse sealing seams on a tubular packaging film in a tube bag-making machine comprises a sonotrode 12 having a sonotrode shaft 20 which can be rotated about an axis of rotation a and one end 22 of which is connected axially to a converter 14. It should be noted here that both ends 22 of the sonotrode shaft 20 can each be connected to a converter 14, i.e. the ultrasonic energy can be introduced into the sonotrode shaft 20 simultaneously from both sides. The sonotrode shaft 20 is mounted in bearings 28 arranged on both sides of the sonotrode shaft 20 such that it can be rotated about the axis of rotation a and connected to a drive, not reproduced in the drawing. Fixed to the sonotrode shaft 20 via two boosters 24, 26 each are two sealing horns 16 with a width B with a sealing surface 18 at the ends. Boosters 24, 26 and sealing horns 16 project radially from the axis of rotation a, the sealing surfaces 18 lie parallel to the axis of rotation a.

In fig. 2 the longitudinal vibrations (running in the direction of the axis of rotation a) and transverse vibrations (running at right angles to the direction of the axis of rotation a) occurring in the sonotrode shaft 20 are shown. Likewise shown are the vibrations generated in the boosters 24, 26 and in the sealing horn (vane) 16.

The following designations are used for the vibrations:

S_{Wl} longitudinal vibration in the sonotrode shaft 20
S_{Wt} transverse vibration in the sonotrode shaft 20
S_{Bl} longitudinal vibration in the boosters 24, 26
S_{Fl} longitudinal vibration in the vane 16
K_L vibration node of the longitudinal wave in the sonotrode shaft 20
K_T vibration node of the transverse wave in the sonotrode shaft 20

By using figures 1 and 2, the functioning of the ultrasonic vibration unit 10 will be explained in more detail below.

Via the converter 14, a longitudinal vibration S_{Wl} is excited in the direction of the axis of rotation a of the sonotrode shaft 20 and kept operating. The longitudinal vibration S_{Wl} generates a standing longitudinal wave, which leads to defined vibration nodes K_L of the longitudinal wave. A longitudinal vibration results in material expanding in length and compressing endwise. During endwise compression of the material, the sonotrode shaft 20 becomes thicker at the compressed point; during the expansion it becomes thinner at the expanded point. This thickness fluctuation leads to a transverse vibration S_{Wt}, which generates a transverse wave with defined vibration nodes K_T. The transverse wave has a phase shift Δ with respect to the longitudinal wave.

The fixing of the sonotrode shaft 20 on both sides to a machine stand is implemented in a known way at vibration nodes K_L of the longitudinal wave. Sleeves, for example, are suitable as fixing parts 32. Between these two fixing points 30, at least three further vibration nodes K_L are necessary. At these vibration nodes K_L, the longitudinal displacement is equal to zero and the thickness fluctuation is the greatest. The thickness fluctuation is used as an actuator for one or more sealing horns 16, it being possible for boosters 24, 26 to be connected between them for the purpose of amplification. The boosters 24, 26 or the sealing horns 16 are respectively fixed at those vibration nodes K_L which increase and decrease synchronously in thickness. A new standing longitudinal vibration S_{F1}, which is perpendicular to the longitudinal vibration S_{W1} of the sonotrode shaft 20, is formed in the sealing horn 16 with or without boosters 24, 26. In addition, a new standing longitudinal vibration S_{B1}, which is perpendicular to the longitudinal vibration S_{W1} of the sonotrode shaft 20, is formed in the boosters 24, 26.

The shape of the sealing horn 16 with one or more optional boosters 24, 26 can be formed independently of the sonotrode shaft 20. It is therefore possible to generate a uniform amplitude distribution on the sealing surface 18, which leads to higher quality of the sealing seam. Likewise, a broader sealing surface of the transverse sealing seam can therefore be produced.

A plurality of sealing horns 16 - with or without boosters 24, 26 - can be mounted over the circumference of the sonotrode shaft 20 and can be formed individually independently of one another in terms of their shape. As a result, as opposed to conventional rotating sonotrodes, any desired number of sealing horns 16 with or without boosters 24, 26 can be mounted on the sonotrode shaft 20, restricted only by the space available.

CLAIMS:

1. An ultrasonic vibration unit for an ultrasonic welding device for sealing and welding material webs, comprising a sonotrode connected to a converter and having at least one sealing horn protruding radially from an axis of rotation and rotatable about the axis of rotation and having a free end forming a sealing surface,

wherein

the sonotrode comprises a sonotrode shaft with the axis of rotation, one or both ends of the sonotrode shaft being connected to a converter and the sealing horns being fixed at vibration nodes of a longitudinal vibration in the sonotrode shaft via boosters, and the boosters and the sealing horns project radially from the axis of rotation.

2. The ultrasonic vibration unit as claimed in claim 1, wherein each sealing horn has an individual fixing point.

3. The ultrasonic vibration unit as claimed in claim 2, wherein a multiplicity of sealing horns are arranged so as to project radially from the axis of rotation at one and the same vibration node.

4. The ultrasonic vibration unit as claimed in claim 2, wherein a multiplicity of sealing horns are arranged to project radially from the axis of rotation at different vibration nodes.

5. The ultrasonic vibration unit as claimed in claim 1, wherein each sealing horn has at least two fixing points, the

spacing of the fixing points respectively being a multiple of the wavelength of the longitudinal vibration.

6. The ultrasonic vibration unit as claimed in claim 5, wherein a multiplicity of sealing horns are arranged to project radially from the axis of rotation at the same vibration nodes.

7. The ultrasonic vibration unit as claimed in claim 5, wherein a multiplicity of sealing horns are arranged to project radially from the axis of rotation at different vibration nodes.

8. The ultrasonic vibration unit as claimed in claim 1, characterized in that the sealing surfaces lie parallel to the axis of rotation.

Fig. 1

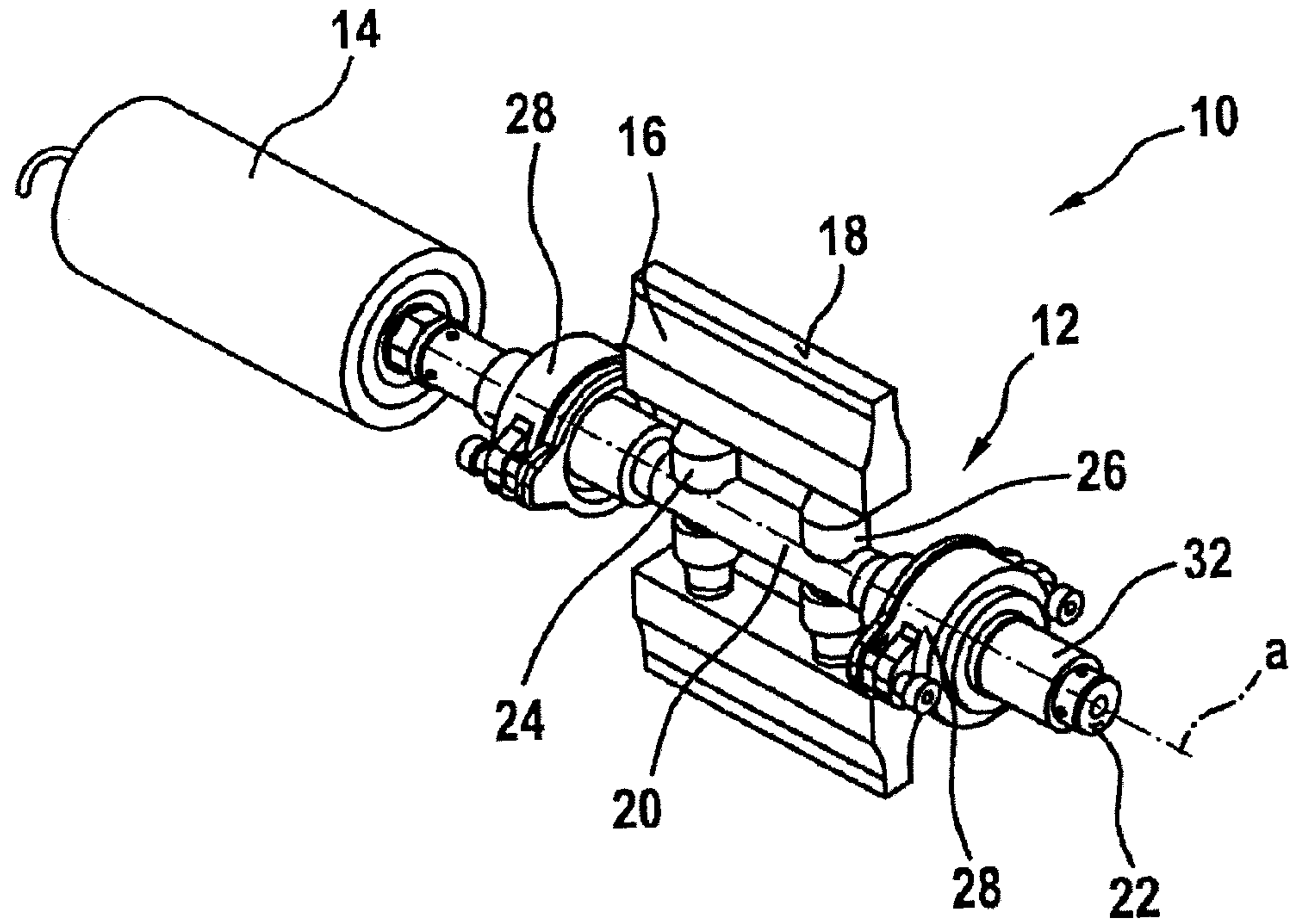
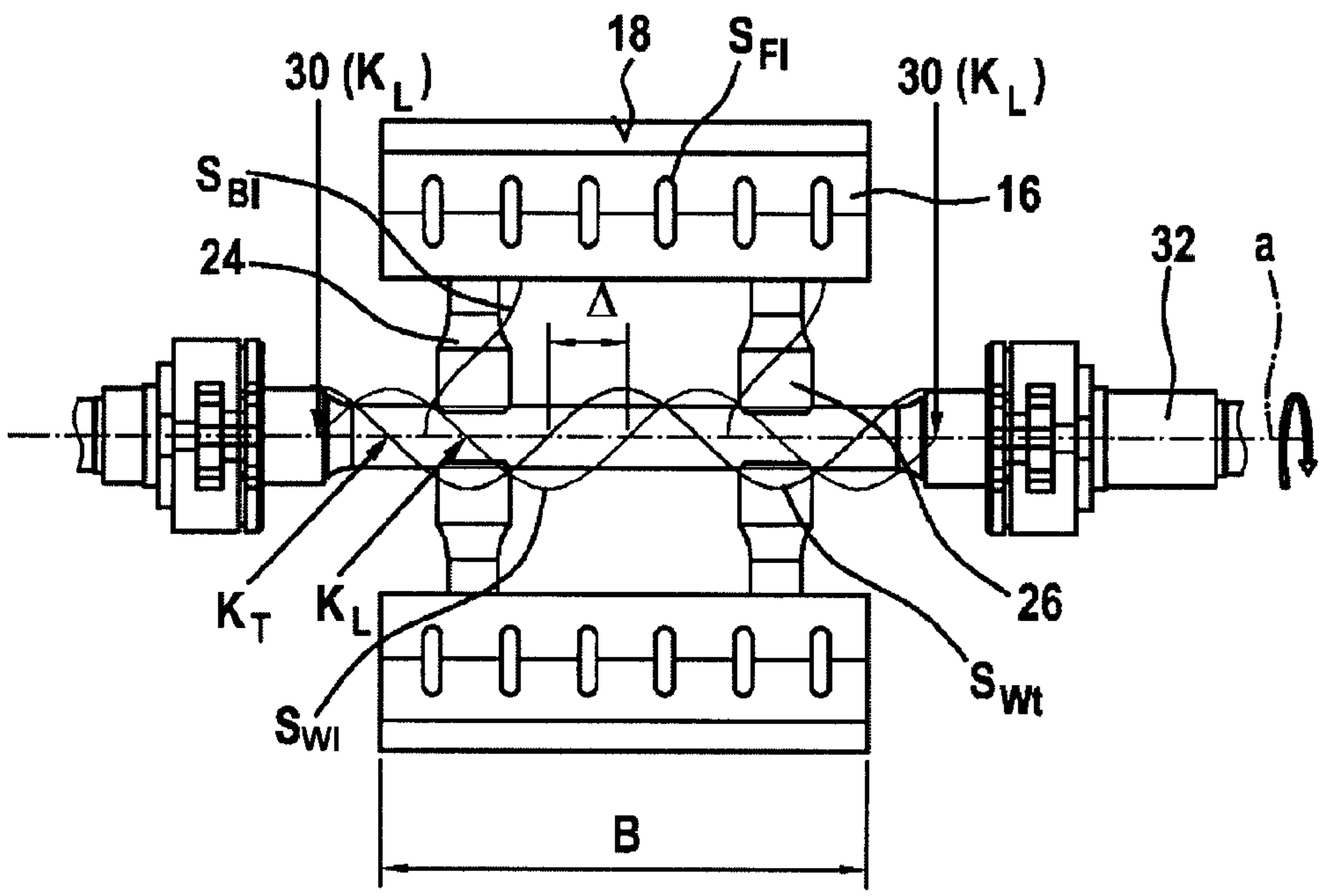
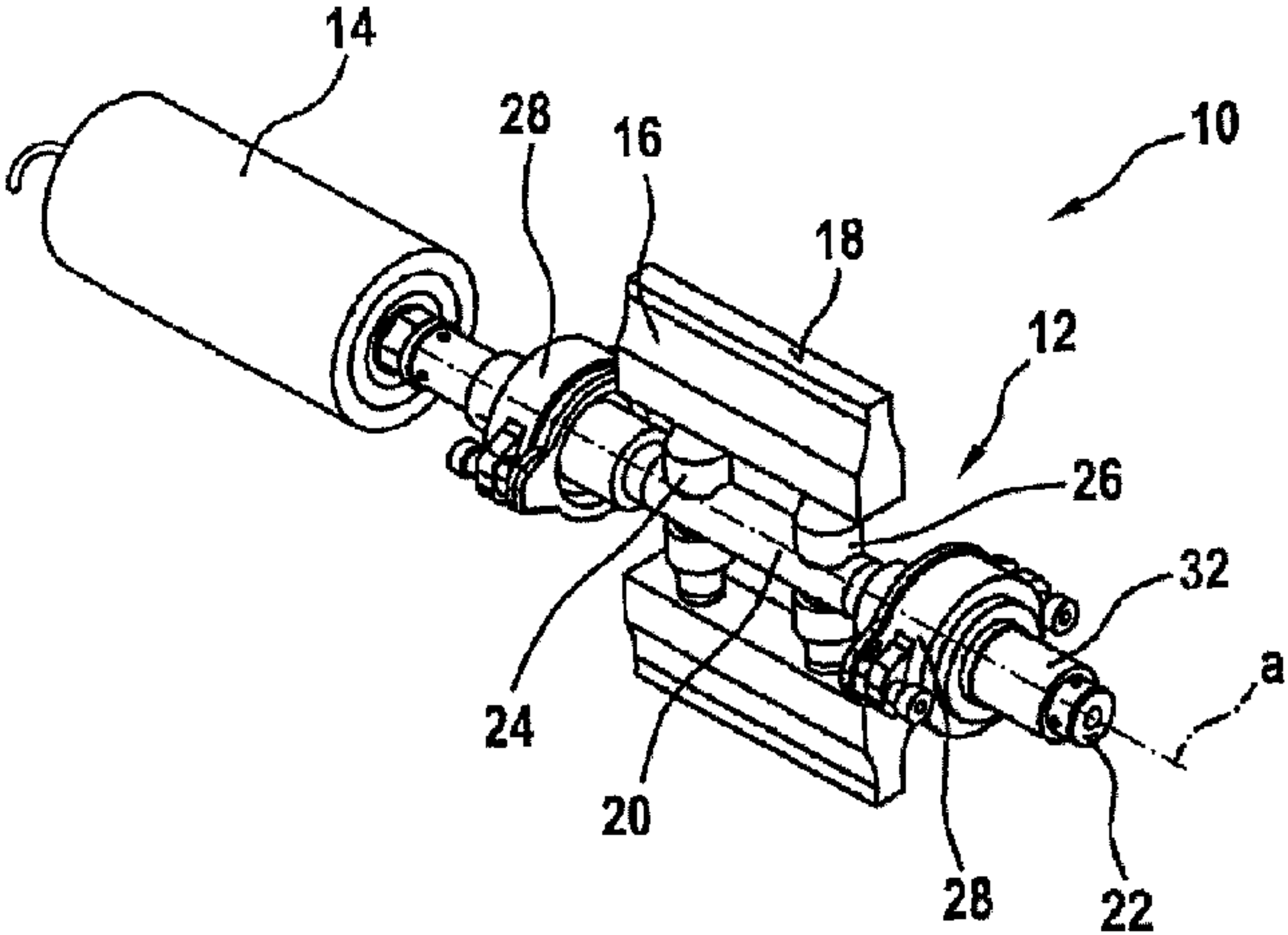


Fig. 2




14
28
16
18
10
12
26
32
a
24
20
28
22