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(54) Title of the Invention: **Setting unit for a self-piercing rivet device, self-piercing rivet device and method for connecting component parts**
Abstract Title: **Setting unit for a self-piercing rivet device and method for connecting component parts**

(57) A setting unit 70 for a self-piercing rivet device 10 into which a rivet 20 is introducible. The setting unit comprises a vibration system 39 comprising a vibration converter 30, which is connectable to a vibration generator 32, and a sonotrode 15, and with a stamp 80 by means of which a force F can be applied to the rivet. The stamp 80 is distinct from the sonotrode (or ultrasonic horn) and is in, or is moveable into, operative connection to the sonotrode. The setting unit may comprise a guide 16 with bushing (figure 7, 87). The stamp may be held against the sonotrode using a retention device 81, which may be a magnet. The stamp may be cylindrical or have portions of varying diameter, with step or conical transitions (figure 5). Preferably, the stamp is between 50 and 200mm in length, chamfered and/or coated. The setting unit may comprise a rivet feeder 90 and a counterholder 18. The self-pioercing device may have a frame 60 or an X-clamp design (figure 2, 60'). A method for connecting component parts 11, 12 is given.

Fig. 1

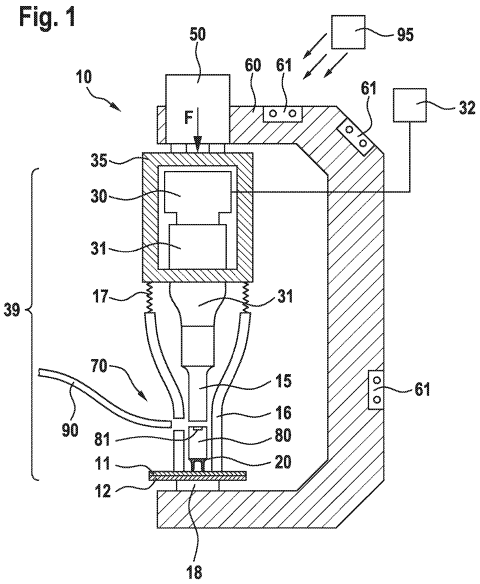

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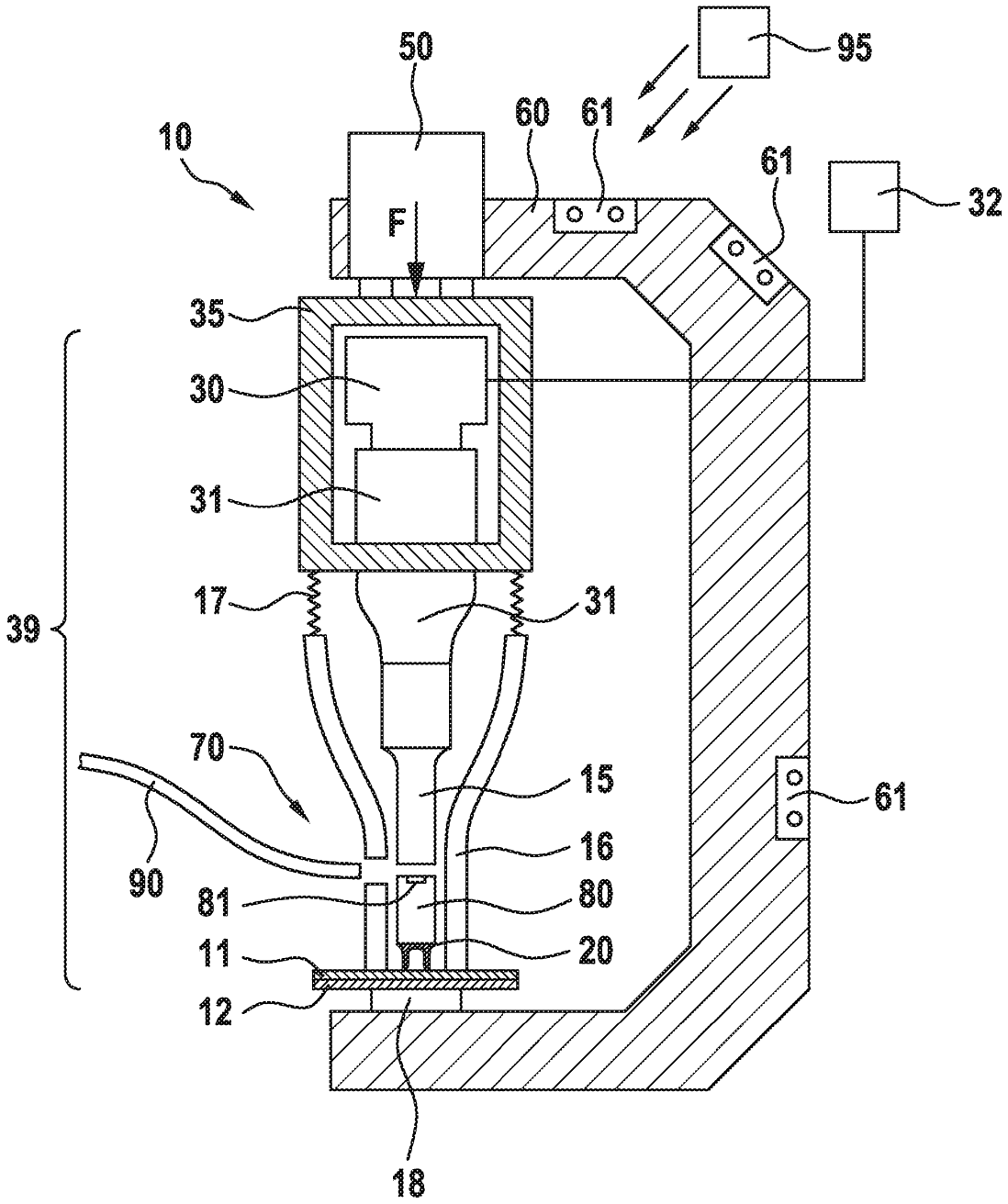
Fig. 1



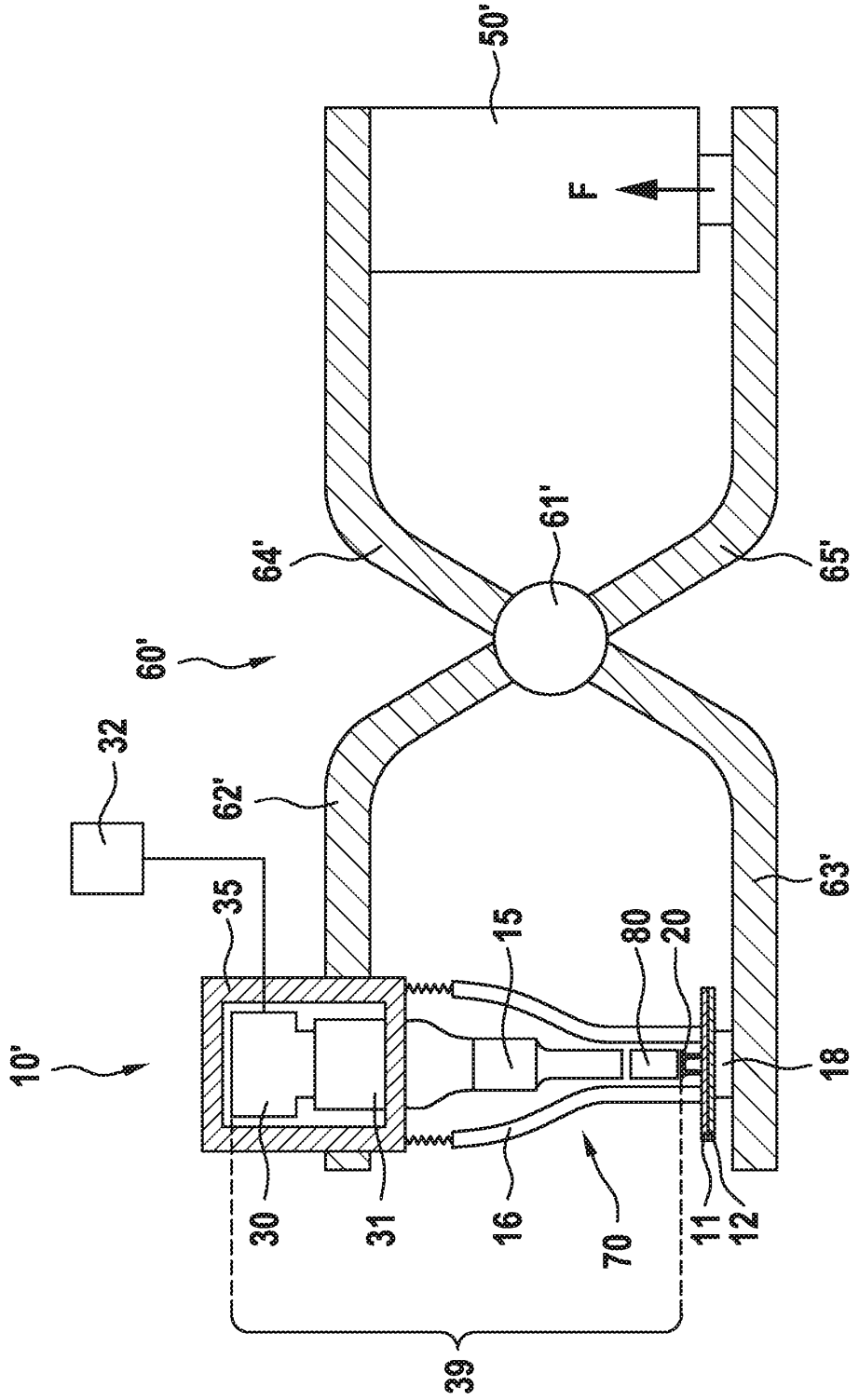


Fig. 2

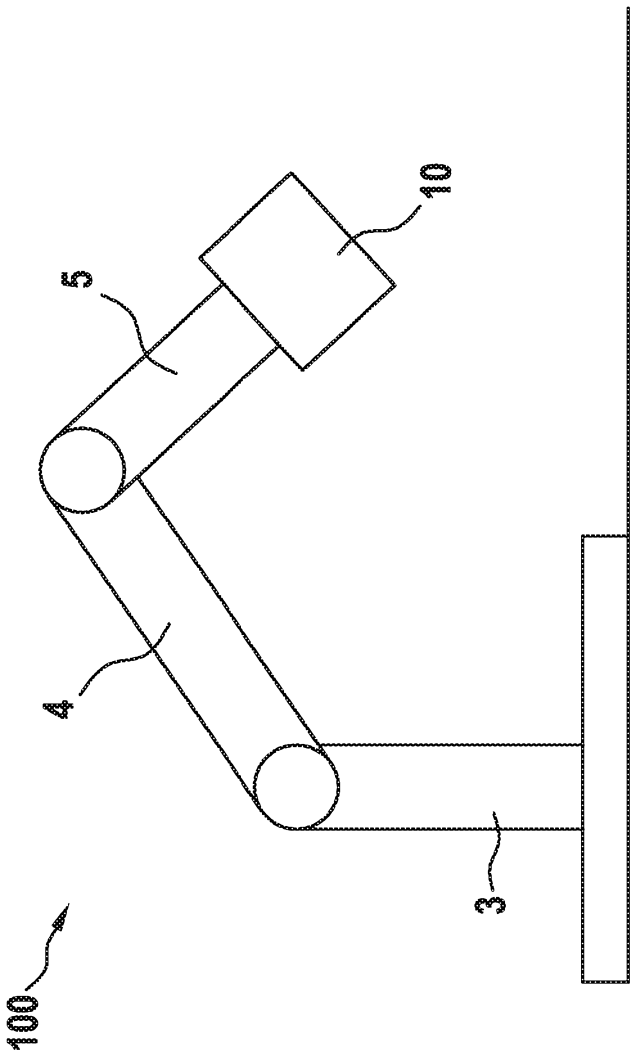


Fig. 3

Fig. 4(a)

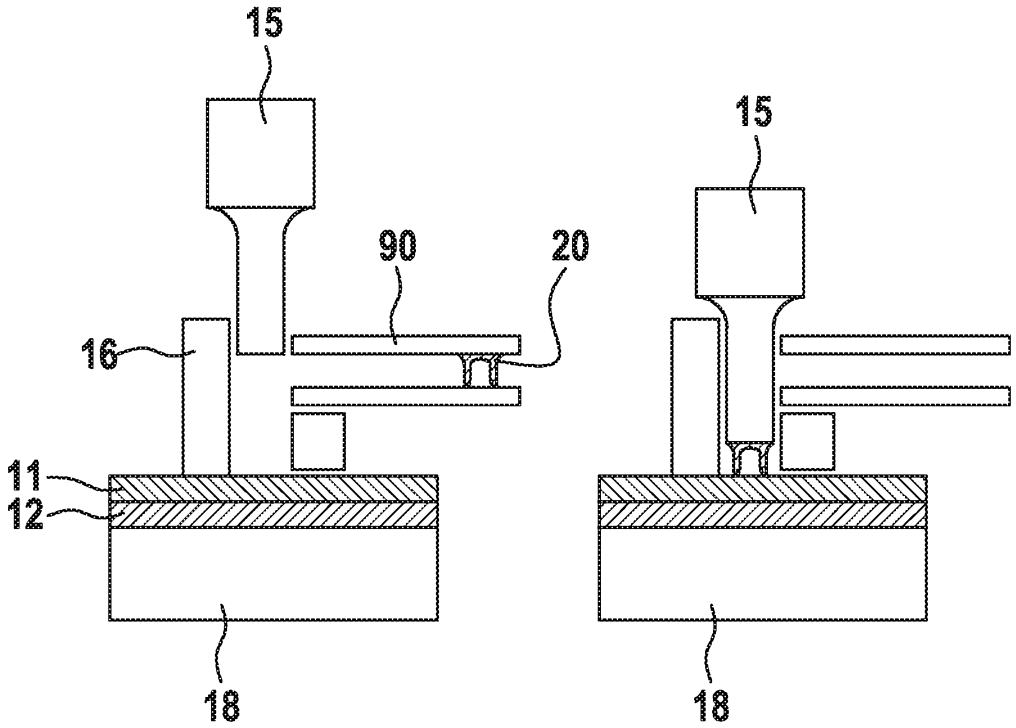


Fig. 4(b)

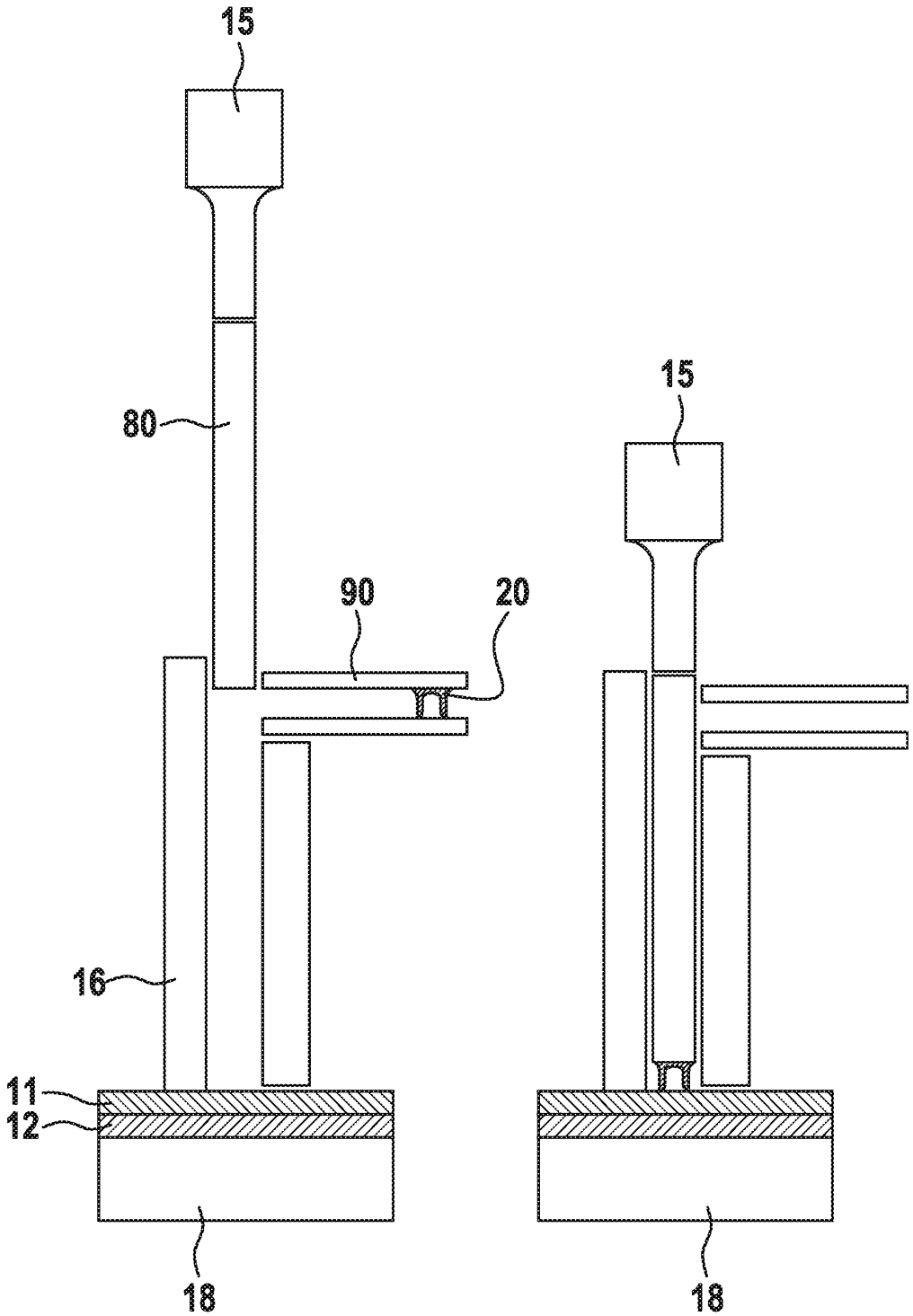


Fig. 5

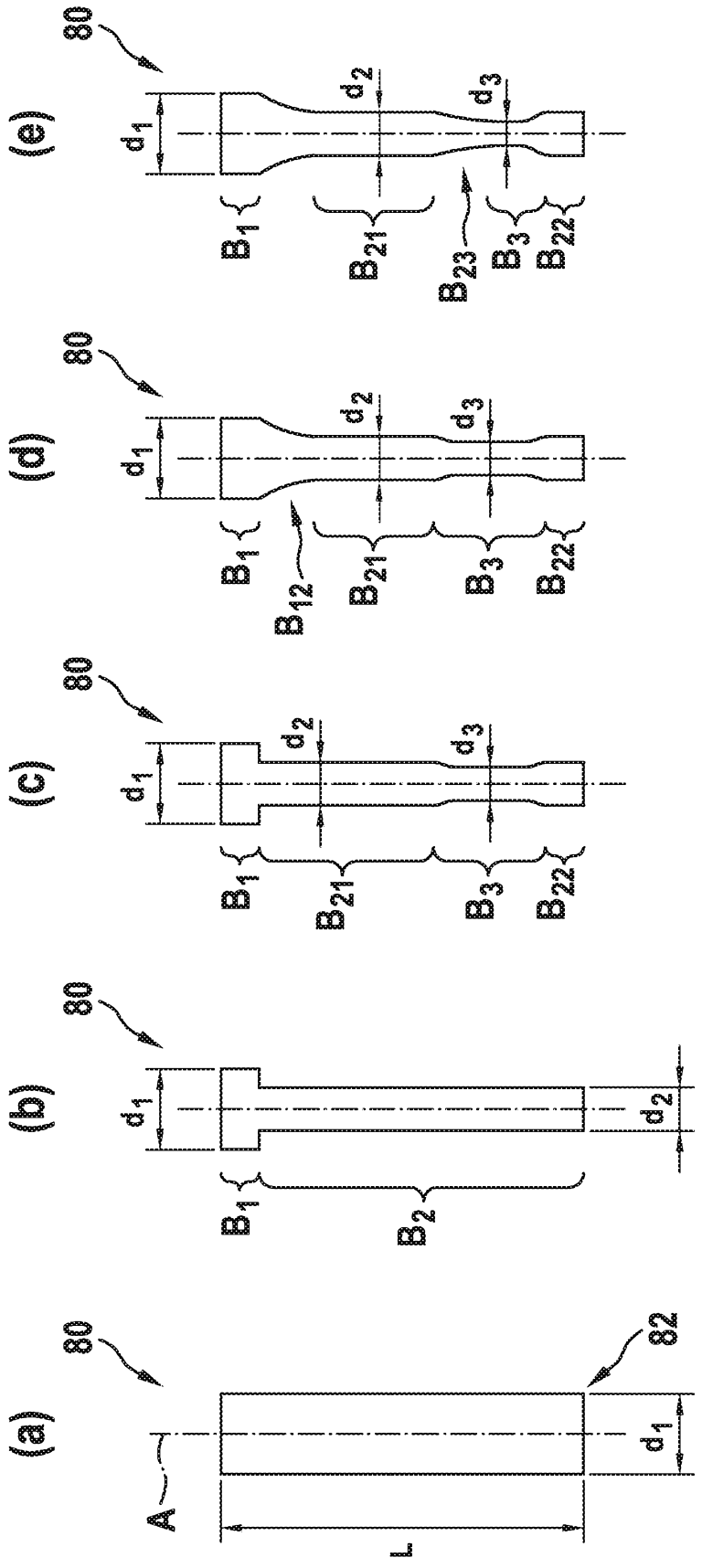

(a)
80
82
A
L
d1
(b)
80
d1
d2
B1
B2
(c)
80
d1
d2
d3
B1
B21
B3
B22
(d)
80
d1
d2
d3
B1
B12
B21
B3
B22
(e)
80
d1
d2
d3
B1
B21
B23
B3
B22

Fig. 6

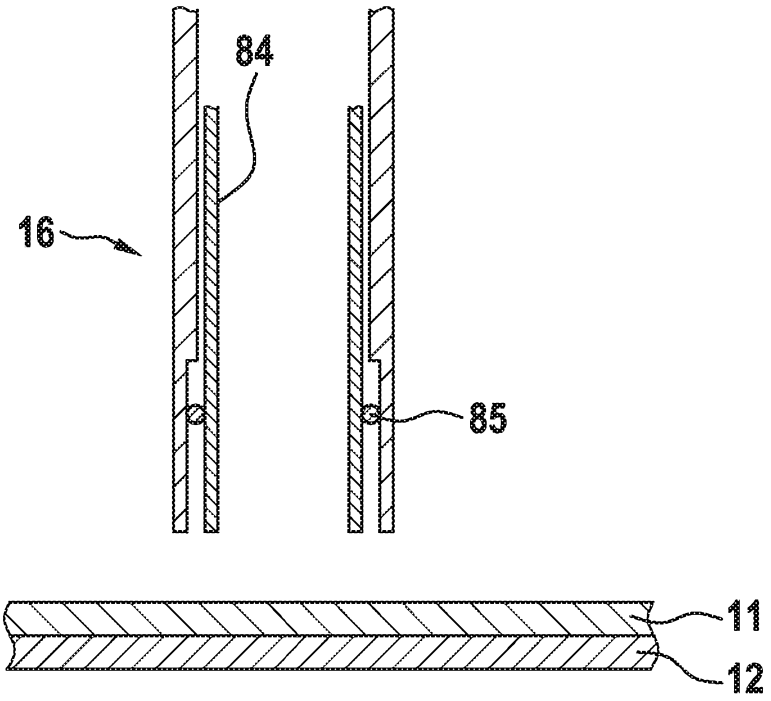
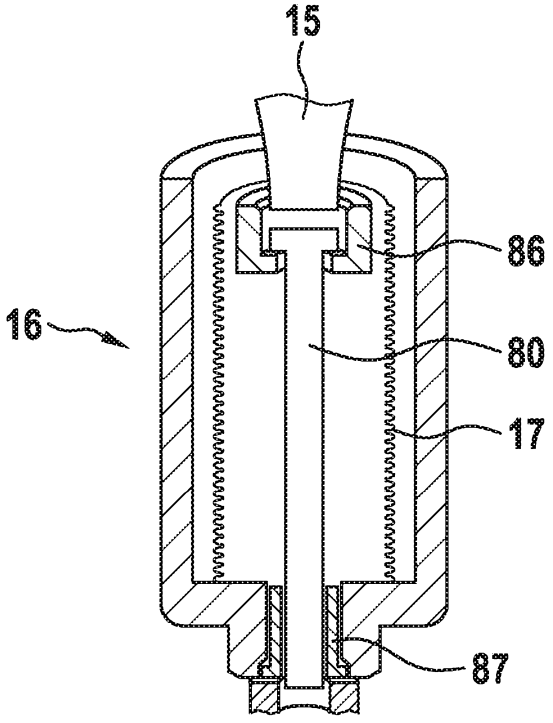


Fig. 7



Setting unit for a self-piercing rivet device, self-piercing rivet device and method for connecting component parts

Description

The present invention relates to a setting unit for a self-piercing rivet device, a self-piercing rivet device with such a setting unit and a method for connecting component parts by means of a rivet.

Prior art

Joining processes, such as riveting processes, are used to connect at least two component parts (joining members), which are in particular formed flat in a connection region. A self-piercing rivet process is characterised, for example in that the component parts to be connected to one another do not have to be pre-pierced. In fact, a rivet is impressed into the at least two component parts as the joining element by means of a joining tool or a setting unit, which comprises a stamp, it being possible to ensure by means of a correspondingly shaped counterholder, for example in the form of a die, which cooperates with the joining tool, that the rivet or the component parts are deformed in a certain manner in order to establish a frictional and positive-locking connection between the component parts.

Furthermore, a so-called ultrasonic self-piercing rivet process is known, for example from EP 2 318 161 B1 in the case of which a vibration generator, such as for example an ultrasonic generator is used to vibrate one or a plurality of components when connecting the component parts. This vibration reduces, for example the force to be exerted to impress the rivet.

A self-piercing rivet device with vibration support is, for example known from DE 10 2014 224 596 A1, which is designed in the shape of a so-called X-clamp or in a so-called X-design.

Disclosure of the invention

According to the invention, a setting unit, a self-piercing rivet device and a method for connecting component parts are proposed having the features of the independent claims. Advantageous configurations are the subject-matter of the dependent claims and the following description.

The invention proceeds from a setting unit for a self-piercing rivet device into which setting unit a rivet is introducible and which has a vibration system comprising a vibration converter, which is connectable to a vibration generator, and a sonotrode and a stamp by means of which (generally using a suitable drive) force can be applied to the rivet and the rivet is introducible into at least two component parts during a riveting operation.

In the case of such setting units or their use in a self-piercing rivet device, vibrations can be generated by the vibration system, which, in addition to the vibration converter (for example in the form of a piezo converter) and the sonotrode, can preferably also comprise a booster (between the vibration converter and the sonotrode) and the vibrations can be coupled into the rivet via the stamp. To this end, the vibration converter is connected to a vibration generator, for example an ultrasonic generator. In this manner, not only will the force required to impress the rivet be reduced, but, by means of the vibrations, the rivet connection per se can also be improved, for example by improved positive-locking connection or undercutting, which leads to improved formation of joining points.

It has so far been customary in the case of such setting units for the sonotrode to be used directly as the stamp (or as the joining tool or part of such), i.e. the free end of the sonotrode is used to transmit the force and also the vibrations directly to the rivet. Due to the special configuration of such sonotrodes, in order to achieve the greatest possible amplitude for the vibrations at the free end of the sonotrode, only a relatively short piece with a small diameter now remains, as is common for a stamp in the case of conventional self-piercing rivet devices. Accessibility to the component parts to be connected is thus sometimes significantly restricted, for example in the case of narrow or thin flanges. The fact that feeding of the rivet must take place between the free end of the sonotrode and the component parts also in particular contributes to this. The other part of the sonotrode, in contrast, has a notably larger diameter, which is largely caused by the self-resonating design and a required transmission or amplification of the output amplitude.

According to the invention, the stamp is now designed as a component distinct from the sonotrode and it is arranged in the setting unit such that it is in or is moveable into operative connection with the sonotrode. Such an operative connection is in particular understood as the stamp being capable of contacting the sonotrode at least while the rivet is impressed, then expediently also only temporarily, such that vibrations can be transmitted. In this manner, the accessibility is notably increased since the separate stamp allows the region with small diameter to be notably extended, the stamp head can preferably have the same diameter here as the sonotrode at its free end. In particular, a diameter of the stamp shaft can or should, however, be smaller than a diameter of the rivet so that the rivet element can be guided properly. This also in particular enables feeding of the rivets further away from the component parts, as will be explained later in greater detail on the basis of the figures.

A further advantage of this separate stamp is that a kind of hammering effect can be generated on the stamp and thus on the rivet by the vibrating sonotrode and the stamp, which is operatively connected to the sonotrode, but still loose, whereby the overall force to be applied to impress the rivet can be reduced even further.

The setting unit also preferably has a guide in which the stamp is arranged and is guidable. Such a guide can preferably also be used as a hold-down device by means of which the component parts, together with a counterholder, can be held during the riveting operation, i.e. while the rivet is impressed into the component parts.

It is particularly preferred here for the guide to have a guide bushing for the stamp in which or by means of which the stamp is centerable. A symmetric formation of joining points can therefore, in particular be ensured.

Advantageously, the setting unit also has a retention device configured to apply a retention force by means of which the stamp can be held in and/or is moveable into contact with the sonotrode. On the one hand, this means for example the required operative connection between stamp and sonotrode can be achieved, on the other hand, the stamp can, however, also be particularly easily moved away, i.e. lifted or pulled back from the component parts together with the sonotrode after the rivet has been impressed. The retention device is expediently configured to apply the retention force by means of negative pressure and/or magnetically and/or by means of positive-locking connection and/or by means of mechanical

coupling. The retention device can thus for example have a negative pressure source, one or a plurality of magnets (for example permanent magnets or even electromagnets) or also suitably shaped components in order to at least partially enclose the stamp. A pressure spring or a tension spring are for example considered as the mechanical coupling. A combination of a plurality of the mentioned possibilities is also conceivable. In addition, such a retention device can also form a combination with the guide, i.e. these two components can be part of a larger component. It is also conceivable for the retention device itself, or even only a part thereof, to be arranged on or in the stamp. For example, a magnet can be arranged on or in the stamp.

By means of the positive-locking connection or a positive-locking mounting in the retention device, in particular together with the mentioned guide bushing, the stamp can be operatively connected to the vibrating sonotrode during the joining operation and can be guided back into the starting position when the process has ended in order to be able to feed a new rivet element for the next joining process. In this regard, it is expedient for the stamp to have a collar at the upper end or end region, i.e. the end or end region facing the sonotrode. In this regard, reference is made to the following embodiments below. During the actual joining operation, the retention device is, however, typically not in contact with the collar of the stamp in order to mount the stamp in a positive-locking manner such that wear and cold welding can be avoided at this point.

The stamp is preferably designed rotationally-symmetric in relation to a longitudinal axis and, in particular has a cylindrical shape at least in sections. A pure or completely cylindrical shape, i.e. with continuously uniform diameter, is also expedient. This has the advantage of the stamp then not having a geometric notch and therefore there is no increased risk of breakage when superimposing or coupling in vibrations or ultrasound. The return stroke of the stamp after setting the rivet then cannot take place by means of the positive-locking connection, but for example via negative pressure and/or magnetisation.

It is particularly preferred for the stamp to have a first diameter in a first region, which comprises an end region facing the sonotrode, said diameter being larger than a second diameter in at least one second region, which comprises at least one end region facing away from the sonotrode. An expedient formation here is for the stamp (viewed in the longitudinal direction) to have even only this first region and a second region adjoining thereto. In other words, the shape of the stamp then corresponds to the shape of the two cylinders with different diameter, the transition between the first region and the closest second region being designed in a flowing or gradual or step-like manner. The stamp therefore has an additional

collar at the upper end or at the stamp head, which allows a return stroke of the stamp via a positive-locking connection.

The first region at the upper end expediently comprises, both in the case of this specific embodiment and also generally, only one small longitudinal region, for example between 5% and 10% of the overall length of the stamp. A positive-locking connection can therefore be established particularly easily, as already mentioned above. The first diameter expediently corresponds to the diameter of the sonotrode at the end facing the stamp such that the vibrations can be transmitted in the most optimal manner possible.

Advantageously, the at least one second region also comprises a middle region between the first region and the end region facing away from the sonotrode (there is therefore at least two second regions), the stamp having a third region with a third diameter between the middle region and the end region facing away from the sonotrode, said third diameter being smaller than the second diameter. There is therefore an additional narrowing in the lower stamp region. The preferred function of the reduced third diameter results from the fact that the rivet element is typically guided via two pre-tensioned shell halves (which can form the guide already mentioned above or a part thereof) during the joining operation in order to prevent the rivet from tilting or revolving during the hold-down deflection. However, the third or reduced diameter of the stamp now means that there is no direct contact between the stamp excited with vibrations or ultrasound and the shell halves during the joining process. Otherwise, this could actually lead to increased wear and undesired cold welding during the joining process and therefore the tool life of the stamp and/or shell halves being impaired.

It is expedient here for a transition to be designed in a flowing, in particular conical manner from the middle region to the third region. The third region can, in particular have only a short length here viewed in the longitudinal direction of the stamp, while the transition from the second to third diameter has a longer length.

Alternatively to a step-like transition between the first region and the closest second region, this transition can preferably also be designed in a flowing, in particular conical manner or with a tangential transition. A quick and easy option for designing the transition between the first and the second stamp region to be as low in tension as possible is the so-called tensile triangles method. Sensitivity or susceptibility to notch tears can therefore be reduced, but a positive-locking mounting can still be enabled.

Irrespective of the rest of the shape of the stamp, it is also particularly preferred for the stamp, at the end region facing away from the sonotrode, to have a chamfered portion towards the end facing away from the sonotrode (or towards the lower operative face). The wear with component parts in contact can therefore be kept as low as possible.

The stamp preferably has a length of between 50 mm and 200 mm, preferably between 80 mm and 150 mm, particularly preferably a length of 130 mm. The excitation frequency of the longitudinal mode (longitudinal eigenmode) should, in this case, be equal to or preferably below the exciter frequency of a typical vibration generator or generator. In the case of an exciter frequency of the generator of 20 kHz, the longitudinal mode of the stamp should also be, for example 20 kHz or preferably below this (for example 19 kHz). The stamp length therefore results, in particular from the vibration design of the system.

It is advantageous for the stamp to have steel and/or ceramic and/or hard metal as the material. In general, however, different materials are considered that have sufficient strength and hardness as well as stiffness so as not to plastically deform in the case of forces of up to 50 kN, which typically act on the stamp. These can, for example be different cold work steels such as for example the type 1.2379 or even high-performance ceramics such as zirconium oxide. Hard metal materials such as tungsten carbide are also conceivable.

It is also expedient for the stamp to have a coating, in particular made of hard metal and/or ceramic at least in regions. This represents a further possibility to reduce wear. Tribological wear protective layers are, in particular conceivable here with which the stamp can be coated and which have a high hardness and a low friction coefficient or low adhesion tendency (e.g. to radial contact and/or guide points). Hard metal layer systems or ceramic coatings are, in particular considered here as possible coatings. Furthermore, heat treatment can also be performed in combination with a chemical surface modification of the material of the stamp, such as for example by nitrating, kolsterising, carbonitriding, boriding and the like, in particular in the case of the material, steel.

It is also particularly preferred for the stamp to have a surface, which is polished at least in regions, in particular remelt-polished. This can be carried out by laser- or electron beam-based polishing of the surface, possibly also in addition to a wear protective layer (e.g. a DLC coating such as C2 layer or C3

layer or also a thin, ceramic or ceramic-like coating such as zirconium oxide layer using sol–gel methods).

By remelting a thin edge layer (in particular in a thickness of up to 100 µm) using a laser or electron beam, the surface is smoothened as a result of the interfacial tension. A different operating principle accordingly underlies the laser or electron beam polishing (namely remelting, in the case of which no material is ablated) in comparison to machining methods such as grinding and polishing methods, which are normally used. The remelting process especially leads to smoothing of the surface structures, which result in the case of a preceding milling, rotation or grinding process (e.g. smoothing of machining grooves). In this case, the surface solidifies without tears or pores from the melt, whereby no sharp-edged structures remain on the surface and the mechanical wear of the contact pair is reduced.

As an alternative to laser or electron beam polishing, mechanical polishing or lapping of the stamp surface is conceivable.

The setting unit also preferably has a feeder unit through which the rivet is introducible into the setting unit. Such a feeder unit can, for example be arranged on the mentioned guide, in particular in a region, which is arranged as far as possible away from the end of the guide facing the component parts or from the entire setting unit. The advantage of the present invention then in particular comes into play whereby the accessibility is increased. The feeder unit can, for example comprise a type of recess in the guide or be arranged in such a recess, it being possible to feed rivets in the desired alignment, for example via a profile hose or the like.

The subject-matter of the invention is further a self-piercing rivet device for connecting at least two component parts by means of a rivet, in the case of which a setting unit according to the invention and a counterholder are arranged such that the at least two component parts can be arranged between the setting unit, in particular the stamp, and the counterholder while impressing the rivet by means of the setting unit and with a drive by means of which the force can be applied to the stamp and thereby to the rivet.

It is preferred that the self-piercing rivet device has a frame on which the setting unit and the counterholder are arranged opposite one another, the drive, in particular being directly attached to the vibration

system. To this end, the drive can be fastened to the frame, the vibration system, in turn, to the drive. The frame itself can, to this end, expediently be present in the form of a so-called C-frame or C-bracket.

Alternatively, it is preferred for the self-piercing rivet device to be designed as an X-clamp, the setting unit and the counterholder being arranged at two opposing limbs of the X-clamp and the drive, in particular being arranged between two additional limbs of the X-clamp. In other words, the setting unit and the counterholder, on the one hand, and the drive, on the other hand, are thus arranged on two different sides of a joint of the X-clamp.

Depending on the desired use of the self-piercing rivet device, one or the other variant, i.e. the C-frame or the X-clamp, may have advantages, for example with respect to the geometric dimensions.

The subject-matter of the invention is furthermore a method for connecting at least two component parts by means of a rivet, the at least two component parts being arranged between a stamp and a counterholder, and a force being applied to the rivet to impress into the at least two component parts. In addition, when impressing the rivet, the stamp is vibrated by using a vibration system comprising a vibration converter and a sonotrode. In addition, a component, which is designed distinct from the sonotrode and is operatively connected to the sonotrode at least during impression, is now used as the stamp.

A setting unit according to the invention or a self-piercing rivet device according to the invention is expediently used here.

With respect to the advantages and further configurations of the self-piercing rivet device and the method and in order to avoid repetition, reference is, at this point, made to the above embodiments of the setting unit, which apply here accordingly.

Further advantages and configurations of the invention emerge from the description and the accompanying drawing.

It is understood that the features mentioned above and still to be explained below can be used not only in the respectively indicated combination, but also in other combinations or alone, without departing from the scope of the present invention.

The invention is schematically represented in the drawing on the basis of exemplary embodiments and is described in detail below with reference to the drawing.

Description of the figures

Figure 1 schematically shows a self-piercing rivet device according to the invention in a preferred embodiment.

Figure 2 schematically shows a self-piercing rivet device according to the invention in a further preferred embodiment.

Figure 3 schematically shows a manufacturing system with a self-piercing rivet device according to the invention.

Figures 4a and 4b schematically show a setting unit according to the invention in a preferred embodiment in comparison to a setting unit not according to the invention.

Figures 5a to 5e schematically show a stamp of a setting unit according to the invention in different preferred embodiments.

Figure 6 schematically shows a part of a setting unit according to the invention in a further preferred embodiment.

Figure 7 schematically shows a part of a setting unit according to the invention in a further preferred embodiment.

Detailed description of the drawing

A self-piercing rivet device 10 according to the invention is schematically represented in Figure 1 in a preferred embodiment, here as an ultrasonic self-piercing rivet device, which can also be used for a method according to the invention. The self-piercing rivet device 10 has a frame 60, which is preferably present in the form of a C-frame or C-bracket on which the individual components can be arranged in a self-piercing rivet device in order to be able to adopt the desired position in relation to one another.

The self-piercing rivet device 10 can, for example be fastened via the frame 60 on an arm for movement in the space. To this end, three possible flange points 61 on the frame 60 are shown by way of example and at the top of the frame, top right and on the side in the lower region to the right. It is understood that one of these flange points is sufficient, but a plurality of them can also be present such that the desired point can be selected during installation.

The self-piercing rivet device 10 has a setting unit 70 (or a joining tool), which, in turn, has a vibration system 39. The vibration system 39 here comprises a sonotrode 15, which is operatively connected to an electro-mechanical vibration converter 30 via a booster 31, the vibration converter 30 is, in turn, attached to a vibration generator 32, here an ultrasonic generator (in the sense of a signal generator) such that the vibration system 39 can be excited to vibrate. The sonotrode 15 can, however, also be designed such that an (additional) booster can be omitted. The vibration system 39 is arranged so as to be moveable in the longitudinal direction. Using a holder 35, the vibration system 39 is fastened on a drive 50 and thereby to the frame 60.

In particular in this case, ultrasonic vibrations with a vibration width (distance between maximum positive and negative amplitude of a vibration) of between 10 µm and 130 µm, preferably between 10 µm and 110 µm (corresponds to an amplitude of 5 µm to 55 or 65 µm) and a frequency of between 15 kHz and 35 kHz or possibly even higher are generated. The ultrasonic generator 32, as a vibration generator, can be attached to the computer unit 95 and actuated by the same.

Furthermore, the setting unit 70 comprises a stamp 80, for example as well as the sonotrodes at its free end (in the figure below) with a round cross-section. The stamp 80 is designed as a component distinct from the sonotrode 15, i.e. it is not integrally connected here to the sonotrode 15. The stamp 80 is per se a loose component and is guidable inside a guide 16, which is also used here as a hold-down device. The guide or the hold-down device 16 is fastened to the holder 35 by means of spring elements 17 such that it can be pressed against component parts 11, 12.

The stamp 80, which is loose per se, is in contact with the sonotrode 15 under the influence of a retention force, which is applied by means of a retention device 81. For example, the retention device 81 here comprises a magnet and is arranged in the stamp 80. Accordingly, the sonotrode should include magnet-

ic material. In this manner, an operative connection can be established between the sonotrode 15 and the stamp 80 such that vibrations can be transmitted to the stamp 80 and thereby to a rivet 20.

In addition, the stamp 80 can, in this manner, together with the sonotrode 15 or the vibration system 39, be moved away upwards or from the component parts 11, 12. In this regard, the drive 50 is coupled to the vibration system 39, the drive serving not only to apply a force F required to impress the rivet 20 into the two component parts 11, 12, but also to move the vibration system 39 away once again. The drive 50 can, for example be controlled by means of the computer unit 95.

The drive 50 can, for example be a drive with a ball, roller or planetary screw drive or the like, which is suited to applying a force F for impressing a rivet 20 as a joining element into the component parts 11, 12.

It should be noted that the retention device 81 or the magnet can also be correspondingly arranged on the sonotrode or possibly even on the guide 16. Likewise, other types of retention devices are conceivable, as already mentioned.

A counterholder 18 in the form of a die is arranged on the side of the two component parts 11, 12 opposite the stamp 80 or the setting unit 70. The stamp 80 or the setting unit 70 is arranged so as to be moveable in the vertical direction and moveable relative to the die 18. The setting unit or the hold-down device 16 (or the guide) and the die 18 serve to clamp or compress the two component parts 11, 12 between the setting unit 70 and the die 18 during processing by the stamp 80.

The rivet 20, here for example a semi-tubular rivet, preferably consists of a material that is harder than the materials of the two component parts 11, 12, at least in the region of a rivet shaft. The flat upper side of the rivet facing away from the component part 11 is arranged in operative connection to the stamp 80, which abuts extensively on the upper side of the rivet 20.

Furthermore, a feeder unit 90 with a profile hose is arranged on the setting unit 70, which serves to supply the rivets. By means of the profile hose, rivets can be introduced individually into the setting unit 70 when setting unit is not abutting on the component parts such that a new rivet is made available for each new riveting operation.

A self-piercing rivet device 10' according to the invention is schematically represented in Figure 2 in a further preferred embodiment, here also as an ultrasonic self-piercing rivet device, which can also be used for a method according to the invention. The self-piercing rivet device 10', unlike the embodiment according to Figure 1, does not have a frame, but rather it is designed as a so-called X-clamp or in an X-design. To this end, a clamp 60' is provided on which the individual components can be arranged in order to be able to adopt the desired position in relation to one another.

This clamp 60' has four limbs 62', 63', 64' and 65' here, of which each two (63' and 64' or 62' and 65') are part of one arm. Two of these arms are accordingly rotatably connected to one another via a joint 61'. The setting unit 70, which can be designed per se as already described in relation to Figure 1 (retention device and feeder unit are not shown here for the sake of clarity), is now arranged on the left, upper limb 62' (in the figure), the counterholder 18 on the left, lower limb 63'.

The drive 50', which can also be designed as already described in relation to Figure 1 possibly except for the geometric dimensions, is accordingly arranged between the two right-sided limbs 64' and 65' (in the figure) such that a force F can be exerted via the limbs on the setting unit 70 and thereby on the rivet 20 in the manner of a scissor movement.

Otherwise, reference may also be made to the embodiments on the self-piercing rivet device 10 according to Figure 1 for the explanation of the functioning of the self-piercing rivet device 10'.

A manufacturing system 100 with a self-piercing rivet device 10 is represented in Figure 3 in a simplified and schematic manner in a preferred embodiment as an example of a use of the self-piercing rivet device. The manufacturing system can, for example be an industrial robot, for example for automotive body construction.

The manufacturing system 100, in this case, has a support structure 3 arranged on a floor and two moveable arms 4 and 5 arranged thereon and connected to one another. An ultrasonic self-piercing rivet device 10, as is shown in more detail for example in Figure 1, is arranged at the end of the arm 5. It is understood that the self-piercing rivet device 10' according to Figure 2 can also be used here.

A setting unit not according to the invention is now schematically represented in Figure 4a, in contrast, in Figure 4b, a setting unit 70 according to the invention is shown in a preferred embodiment in comparison thereto.

As shown in Figure 4a, the sonotrode 15 or its free (in the figure, lower) end is conventionally used to transmit vibrations and force to the rivet 20. The rivet 20 itself is, as shown on the left, firstly introduced into the guide or the hold-down device 16 via the feeder unit 90 and then impressed into the component parts 11, 12 by means of the sonotrode 15.

Owing to the geometry of the sonotrode, which is required in this shape in order to be able to generate vibrations accordingly, the accessibility is notably restricted, which, as seen here, manifests itself in that the guide 16 or the distance of the feeder unit 90 to the lower end of the guide 16 is very small since otherwise the sonotrode 15 would no longer fit into the guide due to the larger diameter in the upper region. The guide cannot be expanded or it can be expanded but only with difficulty since then the rivet could no longer be guided properly. This would also be detrimental to accessibility.

In Figure 4b, a stamp 80 is, in contrast, provided, which is arranged at the lower end of the sonotrode 15 and is operatively connected thereto, as already explained. The guide 16 or the distance of the feeder unit 90 to the lower end of the guide 16 can now be designed to be notably greater here since the thin stamp can be guided along in the guide 16.

In this manner, a notably smaller interfering contour can thus be present such that the area of application for a setting unit or a self-piercing rivet device with such a setting unit can be notably increased. For example, tight conditions occur precisely in automotive bodywork construction, which are more easily accessible using the proposed solution.

The stamp of a setting unit according to the invention is schematically represented in different preferred embodiments in Figures 5a to 5e, as it can be used, for example in the setting units explained in more detail above. For the sake of simplicity, the stamp is provided with the reference numeral 80 throughout.

A simple stamp geometry is shown in Figure 5a, in the case of which the stamp with the length L is rotationally-symmetric in relation to its longitudinal axis A, i.e. it has a round cross-section and a cylindrical shape at all times (i.e. a constant cross-section). This geometry with uniform diameter has the

advantage that it does not have any geometric notch and therefore there is no increased risk of breakage when the ultrasound is superimposed or coupled in.

A chamfered portion is designated with the reference numeral 82, which is provided on the end region facing away from the sonotrode (at the bottom of the figure) towards the end facing away from the sonotrode, i.e. the underside of the stamp. Such a chamfered portion, which runs in particular over the entire circumference, serves to keep the wear with the component parts that are in contact as low as possible since the contact surface is reduced. Such a chamfered portion can also be provided in the case of the geometries of the stamp that are still to be explained below, even though it is no longer explicitly designated.

A stamp geometry is shown in Figure 5b, which has an additional collar on the stamp head. In other words, there is a first region B_1, which comprises the end region of the stamp facing the sonotrode (i.e. the upper end region), with a first diameter d_1, which is larger than a second diameter d_2 of the second region B_2, which comprises the rest of the stamp 80. The transition between the first region B_1 and the second region B_2 is designed step-like here. A return stroke of the stamp can therefore take place via a positive-locking connection (using a suitable stamp receiving portion).

In comparison to the geometry in Figure 5b, the stamp geometry shown in Figure 5c has an additional narrowing in the lower stamp region, namely a third region B_3, which is located between two second regions B_{21} and B_{22} and has a third diameter d_3, which is smaller than the diameter d_2. The function of the reduced diameter d_3 will be explained in greater detail below in relation to Figure 6.

The length of the third region B_3 in the longitudinal direction of the stamp can, for example be between 20% and 50% of the entire length of the stamp, the lower, second region B_{22} in particular being able to have a length in the longitudinal direction of the stamp, for example between 5% and 30%, in particular between 10% and 20% of the entire length of the stamp. The transitions between the upper second region B_{22} (or the middle region) and the third region B_3 as well as between the third region B_3 and the lower second region B_{22} can be designed step-like or slightly flowing.

The stamp geometry, as it is shown in Figure 5d, in comparison to the geometry according to Figure 5c, also has a flowing or conical transition between the first region B_1 and the upper second region B_{21} or their respective diameters. The notch tear sensitivity in this transition B_{12} can therefore be reduced. The

length of the transition B_{12} can, for example be between 5% and 15% of the entire length of the stamp. It is understood that the embodiment according to Figure 5b can also have such a flowing transition.

The stamp geometry shown in Figure 5e has a pronounced transition region B_{23} between the region B_{21} and the region B_3, the transition being formed by a tapering portion from the diameter d_2 in the upper second region B_{21} towards the diameter d_3 in the third region B_3. This tapering portion can, in particular also be designed conically. The length of the transition region B_{23} can, for example be between 5% and 15% of the entire length of the stamp.

A part of a setting unit according to the invention is schematically represented in Figure 6 in a further preferred embodiment, and indeed a lower region, i.e. a region of the guide 16 facing the component parts 11, 12. In this case, it can be seen that a shell half 84 is, inter alia, provided in the guide 16 (or as a part thereof), which is pre-tensioned by means of an O-ring 85 in order to hold the rivet in position, which is also guided in the guide 16 alongside the stamp.

The shell half 84 is pressed slightly inwards by this O-ring such that without the tapering portion shown in Figures 5c to 5e or the third region, contact between the stamp, which is moved along inside the guide and inside the shell half, and the shell half could occur. In order to avoid contact between the stamp 80, vibrating in the process, and the shell halves 84, the stamp geometries, as they are shown in Figures 5c to 5e, can be used, if necessary.

Another part of a setting unit according to the invention is schematically represented in Figure 7 in a further preferred embodiment, and indeed an upper region, i.e. a region of the guide 16 facing the drive or the sonotrode 15. It should be noted that the guide 16 is constructed somewhat differently, for example with respect to the spring elements 17, than the guide shown in Figure 1. In this case, it can be seen that a guide bushing 87 is, inter alia, provided in the guide 16 (or as a part thereof) by means of which the stamp 80 can be centred and guided.

Furthermore, a retention device 86 is provided by means of which the stamp 80, which has a collar here at the upper end, can be held in a positive-locking manner.

Claims

1. Setting unit (70) for a self-piercing rivet device (10, 10') into which setting unit (70) a rivet (20) is introducible, with a vibration system (39) comprising a vibration converter (30), which is connectable to a vibration generator (32), and a sonotrode (15), and with a stamp (80) by means of which a force (F) can be applied to the rivet (20) and the rivet (20) is introducible into at least two component parts (11, 12) during a riveting operation,
characterised in that the stamp (80) is designed as a component distinct from the sonotrode (15) and is arranged in the setting unit (70) such that it is in or is moveable into operative connection with the sonotrode (15).

2. Setting unit (70) according to claim 1, also with a guide (16) in which the stamp (80) is arranged and is guidable.

3. Setting unit (70) according to claim 2, wherein the guide (16) has a guide bushing (87) by means of which the stamp (80) is centerable.

4. Setting unit (70) according to any one of the preceding claims, also with a retention device (81, 86) configured to apply a retention force by means of which the stamp (80) can be held and/or moved into contact with the sonotrode (15).

5. Setting unit (70) according to claim 4, wherein the retention device (81, 86) is configured to apply the retention force by means of negative pressure and/or magnetically and/or by means of positive-locking connection and/or by means of mechanical coupling.

6. Setting unit (70) according to any one of the preceding claims, wherein the stamp (80) is designed rotationally-symmetric in relation to a longitudinal axis (A) and, in particular has a cylindrical shape at least in sections.

7. Setting unit (70) according to claim 6, wherein the stamp (80), in a first region (B_1), which comprises an end region facing the sonotrode (15), has a first diameter (d_1), which is larger than a sec-

ond diameter (d_2) in at least one second region (B_2, B_{21}, B_{22}), which comprises at least one end region facing away from the sonotrode (15).

8. Setting unit (70) according to claim 7, wherein the at least one second region (B_2, B_{21}, B_{22}) comprises a middle region (B_{21}) between the first region (B_1) and the end region (B_{22}) facing away from the sonotrode (15), and wherein the stamp, between the middle region (B_{21}) and the end region (B_{22}) facing away from the sonotrode (15), has a third region (B_3) with a third diameter (d_3), which is smaller than the second diameter (d_2).

9. Setting unit (70) according to claim 8, wherein a transition (B_{23}) from the middle region (B_{21}) to the third region (B_3) is designed in a flowing manner, in particular conically.

10. Setting unit (70) according to any one of claims 7 to 9, wherein a transition (B_{12}), between the first region (B_1) and the closest second region (B_2, B_{21}), is designed step-like or in a flowing manner, in particular conically or with a tangential transition.

11. Setting unit (70) according to any one of claims 6 to 10, wherein the stamp (80), at the end region (B_{22}) facing away from the sonotrode (15), has a chamfered portion (82) towards the end facing away from the sonotrode (15).

12. Setting unit (70) according to any one of the preceding claims, wherein the stamp (80) has a length (L) between 50 mm and 200 mm, preferably between 80 mm and 150 mm, particularly preferably a length of 130 mm, and/or steel and/or ceramic and/or hard metal as the material.

13. Setting unit (70) according to any one of the preceding claims, wherein the stamp (80), at least in regions, has a coating, in particular made of hard metal and/or ceramic, and/or has a surface that is polished, in particular remelt-polished at least in regions.

14. Setting unit (70) according to any one of the preceding claims, also with a feeder unit (90) through which the rivet is introducible into the setting unit.

15. Self-piercing rivet device (10, 10') for connecting at least two component parts (11, 12) by means of a rivet (20), in the case of which a setting unit (70) according to any one of the preceding claims and a counterholder (18) are arranged such that the at least two component parts (11, 12) can be arranged between the setting unit (70) and the counterholder (18) while the rivet (20) is impressed by means of the setting unit (70), and with a drive (50, 50') by means of which the force (F) can be applied to the stamp (80) and thereby to the rivet (20).

16. Self-piercing rivet device (10) according to claim 15, also with a frame (60) on which the setting unit (70) and the counterholder (18) are arranged opposite one another, wherein the drive (50) is in particular attached directly to the vibration system (39).

17. Self-piercing rivet device (10') according to claim 16, which is designed as an X-clamp, wherein the setting unit (70) and the counterholder (18) are arranged on two opposing limbs (62', 63') of the X-clamp and wherein the drive (50') in particular is arranged between two additional limbs (64', 65') of the X-clamp.

18. Method for connecting at least two component parts (11, 12) by means of a rivet (20), wherein the at least two component parts (11, 12) are arranged between a stamp (80) and a counterholder (18) and wherein a force (F) is applied to the rivet (20) to impress it into the at least two component parts (11, 12), wherein, when impressing the rivet (20), the stamp (80) is vibrated by using a vibration system (39) comprising a vibration converter (30) and a sonotrode (15),
characterised in that a component, which is designed distinct from the sonotrode (15) and is operatively connected to the sonotrode (15) at least during the impression, is used as the stamp (80).

19. Method according to claim 18, wherein a setting unit (70) according to any one of claims 1 to 14 and/or a self-piercing rivet device (10, 10') according to any one of claims 15 to 17 is used.

Intellectual Property Office

Application No:	GB1820181.4	**Examiner:**	Dr Kathryn Willett
Claims searched:	1-17	**Date of search:**	3 June 2019

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
X,Y	1, 2, 4, 6, 12-16 Y:17	EP 3120951 A1 (BOSCH) A rivet device comprising a holding device 35, a vibration system 39, which has a vibration generator 30, for example an ultrasonic generator, a booster 31, a sonotrode 32 and a punch 15 [0042]. The punch is in operable connection with a sonotrode [0014] and figure 4a shows a frame 60.
X	1, 4, 6, 7, 10-16	CN 105081181 A (UNIV NANJING) Figure 3 shows self-piercing rivet device comprising a setting unit and the ultrasonic riveter of figures 1 and 2. The ultrasonic riveter comprises the vibrating device which is connected to a generator (not shown). Horn 17 is connected to die 16 by a screw thread.
X	1, 2, 3, 6, 12-16	JP 2013010144 A (MITSUBISHI) The figures show a setting unit suitable for a self-piercing rivet device. Horn 102 of ultrasonic vibration apparatus 100 is connected to anvil 5. An operator has apparatus 100 in a hand, and presses the horn 102 against anvil 5 [0019]. Figure 5 shows hydraulic cylinders drive and guide
X	1, 4, 6, 12-15	JP 2013252648 A (FUKUI BYORA) The figures show a self-piercing rivet device. The ultrasonic vibration from an ultrasonic pressurization apparatus is provided to the rivet 10 through the press part 40 [0021]. So press part 40 (the stamp) is in operational connection with the sonotrode.
X	1, 4, 6, 11-13	US 9321099 B1 (BOEING) A setting unit, suitable for a self-piercing rivet device, into which a rivet 10 is introducible. The vibration system includes ultrasonic transducer 32 to generate the vibration, the other parts are implicit. Sonotrode (horn 38a) and stamp (acoustic anvil 34) are threadably attached.
Y	17	GB 2533854 A (BOSCH) X-type punch rivet pliers with ultrasonic vibration device.

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.

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Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC[X] :

Worldwide search of patent documents classified in the following areas of the IPC

B06B; B21J; B29C

The following online and other databases have been used in the preparation of this search report

EPODOC, WPI

International Classification:

Subclass	Subgroup	Valid From
B21J	0015/02	01/01/2006
B06B	0003/00	01/01/2006
B21J	0015/12	01/01/2006