Sept. 10, 1968 F. ARNOLD ET AL 3,400,924

CLAMPING DEVICE

Filed April 6, 1965 2 Sheets-Sheet 1

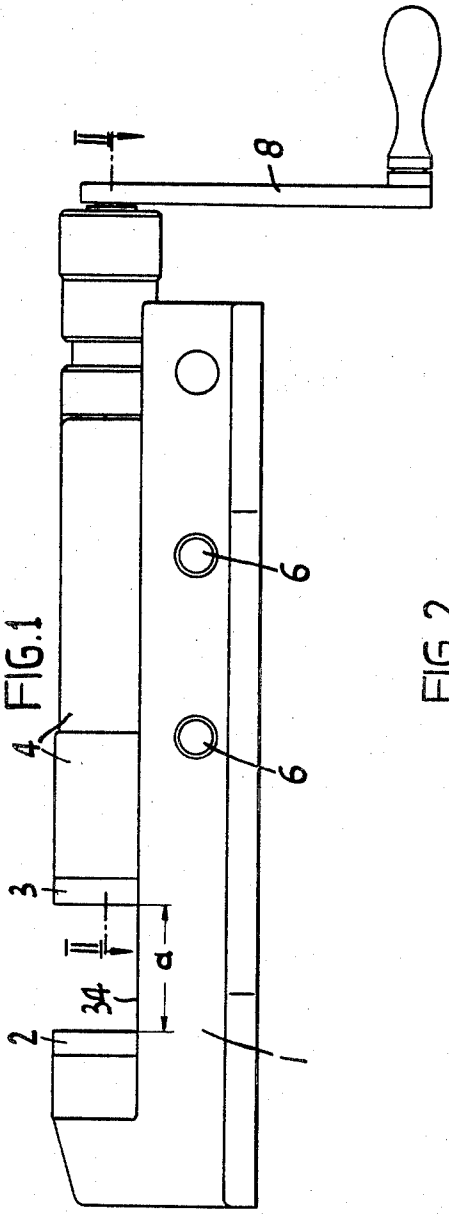

FIG. 1

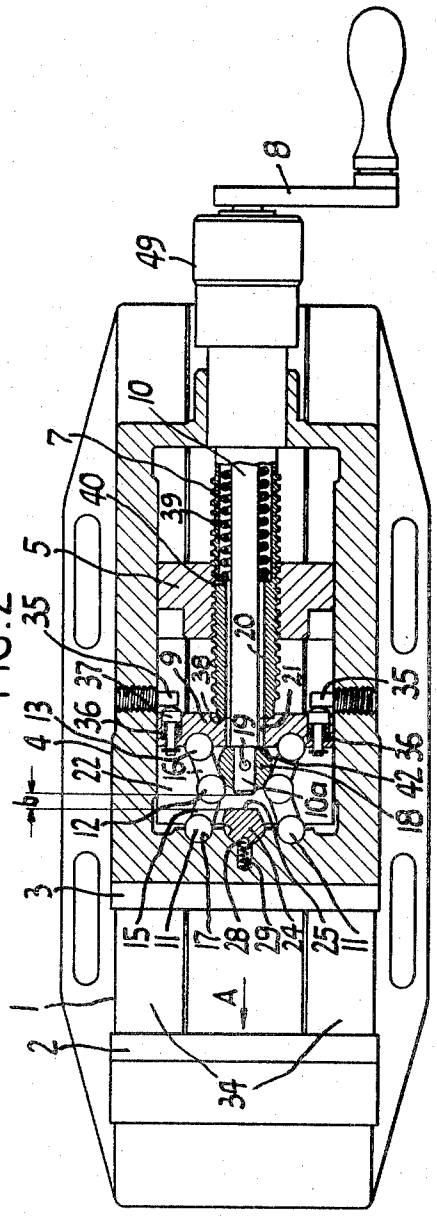

FIG. 2

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FIG.3.

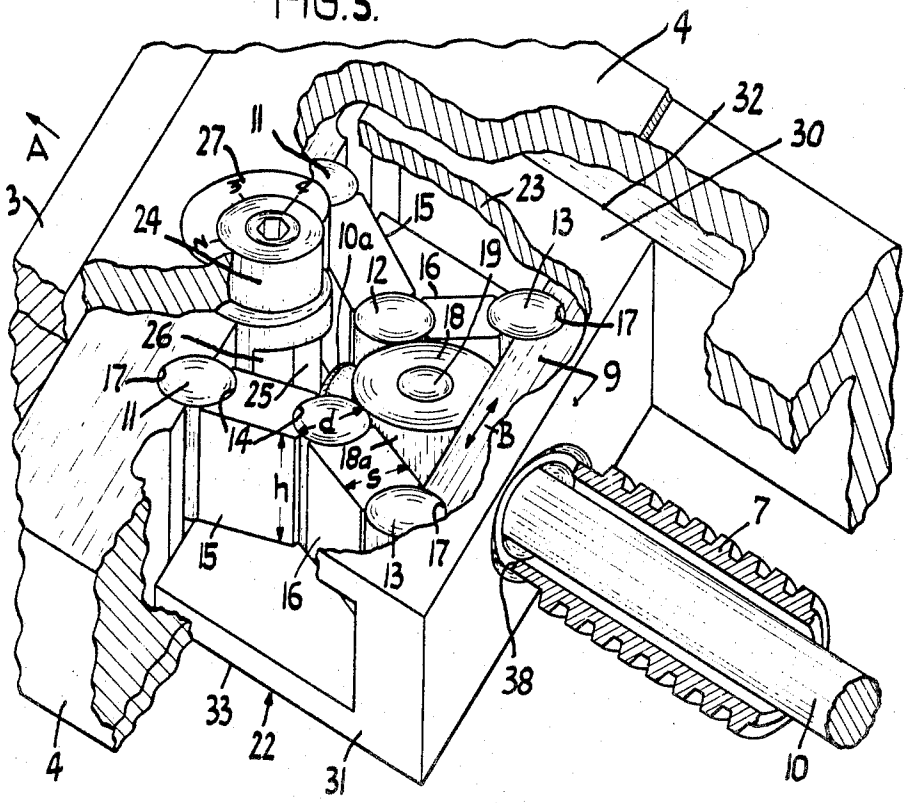
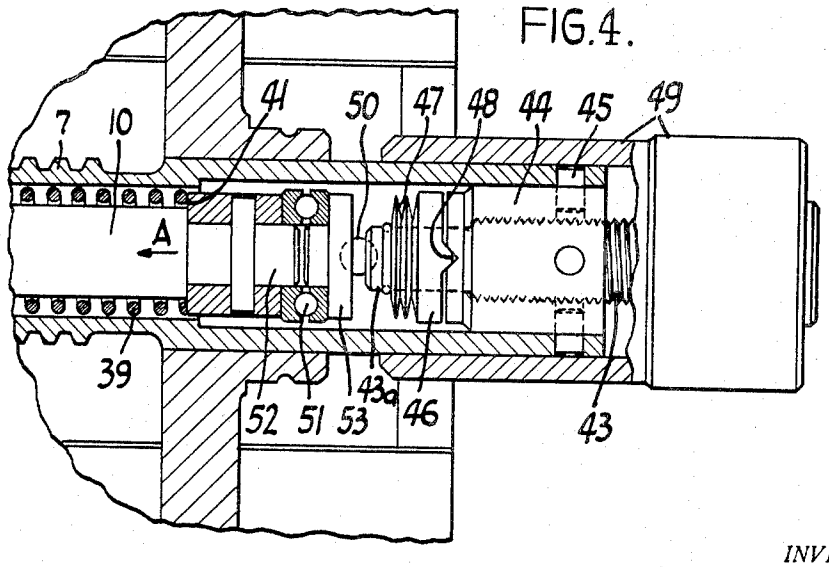


FIG.4.



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CLAMPING DEVICE

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ABSTRACT OF THE DISCLOSURE

A clamping device having a fixed and a movable jaw, the movable jaw being actuated and moved by a rotatable spindle, the spindle being connected to a handcrank and being driven through an overload release clutch. The movable jaw is moved into engagement with the workpiece by simultaneous rotation of the handcrank and the spindle. Upon engagement of the workpiece by the movable jaw, the overload clutch releases whereby further rotation of the handcrank causes a pushrod coaxially mounted within the spindle to axially extend. The pushrod has a pressure member mounted on the end thereof, which member coacts with a pair of toggle mechanisms so as to exert a high clamping pressure onto the movable jaw. Each toggle mechanism comprises a pair of links and three cylindrical pressure rollers, each of the links being provided with partial cylindrical recesses on opposite ends thereof for receiving the pressure members therein. The links and the rollers have a large axial length whereby large bearing areas are provided between the respective members of the toggle mechanism to permit transfer therethrough of large clamping pressures. The toggle mechanisms are mounted within a U-shaped frame member comprising the movable jaw whereby the jaw member can withstand the large clamping pressures applied thereto.

This invention relates to a clamping device for achieving high clamping pressures. More particularly, the present invention relates to a clamping device which is adapted to chuck workpieces and which can be used as a machine vise.

More specifically, the present invention relates to a clamping device wherein two opposite pairs of toggle means are arranged between an abutment and a slide which carries the clamping jaw, while a movable pressure element for forcing the two pairs of toggle means apart and hence for stretching said pairs is provided between said pairs.

In a known device of the aforesaid type the pairs of toggle means consist of laminar members, while all toggle links are formed in a usual manner by hinge bolts extending through said laminar members. Since only relatively small pressures can be achieved by toggle means of this type, this known structure is unsuited for machine vises wherein clamping pressures of at least 4 tons must be achieved. Besides, said previously known toggle means are subject to considerable wear.

The problem underlying the present invention is to provide a clamping device provided with pairs of toggle means by which it is possible to achieve very high clamping pressures and which are virtually not subject to wear. Furthermore, the toggle lever system shall have a simple structure and it shall be easy to manufacture; in particular, it shall be of small dimension so as to occupy a minimum of space in a machine vise or the like.

This problem is solved substantially in that each pair of toggle means embodying the present invention consists of three press rollers and two support levers which

are positioned between said rollers and which are supported on said rollers by partial cylindrical bearing surfaces of said levers. Furthermore, substantially semi-cylindrical recesses which receive said two rollers are provided in said slide and in said abutment. Since these elements of the pairs of toggle means are very compact and sturdy and since they have very large pressure surfaces, it is possible to achieve very high clamping pressures by such pairs of toggle means. All components of these pairs of toggle means as well as the pressure element are made advantageously of hardened steel so that—also in view of the presence of large pressure surfaces—any wear is practically out of the question.

The pairs of toggle means in this novel structure can be disposed in as small spaces as possible and they can be advantageously mounted for free displacement between two horizontal parallel bearing plates which are integral with said abutment and which together form a U-profile piece.

Further details and advantages of the clamping device embodying the present invention will become apparent from the following detailed description of an exemplary embodiment in connection with the appended drawings in which:

FIG. 1 is a side elevation of a machine vise;

FIG. 2 is the corresponding top plan view partially in section taken along line II—II of FIG. 1;

FIG. 3 is a diagrammatic illustration of the slide of said screw vise including the toggle lever system with parts broken away;

FIG. 4 is an enlarged section of one component of the system of FIG. 2.

Referring now to the drawings, **1** represents the substructure of a machine vise, **2** represents the immovable clamping jaw, and **3** represents the movable clamping jaw secured to a slide **4**. To the substructure **1** is connected a spindle nut **5** which is secured to the structure **1** by means of a bolt **6** inserted therethrough and which can be arranged in different positions on the substructure **1** in order to achieve different stretch widths *a*. A hollow quick acting spindle **7** which can be rotated by a crank handle **8** and which is connected to an abutment **9** is screwable in said spindle nut **5**. As is described hereinafter, said crank handle **8** is designed so that not only the slide **4** carrying the jaw **3** can be moved by way of the quick acting spindle **7** in the clamping direction A toward the workpiece, but also the desired high clamping pressure can be achieved by way of two pairs of toggle means by displacing a push rod **10** in the direction A when said crank handle **8** is further rotated. As shown in the drawing and more particularly in FIG. 3, each pair of toggle means comprises three cylindrical press rollers **11**, **12** and **13** and two support levers **15**, **16** which are positioned between said rollers and which are supported on said rollers by partial cylindrical bearing surfaces **14** on said levers. The roller **12** constitutes an intermediate cylindrical roller member of the toggle linkage, while the other two rollers **11** and **13** constitute end partial cylindrical bearing members. Substantially semi-cylindrical recesses which receive the rollers **11** and **13** are provided in said slide **4** and in said abutment **9**.

As is apparent from the drawings, the support levers have a thickness *s* which is approximately equal to the diameter *d* of the press rollers.

In this manner, between the rollers **11–13** and the support levers **15**, **16** are formed relatively large, nearly semi-cylindrical pressure surfaces **14** extending over the width *h*. This permits the achievement of very high pressing forces by the pairs of toggle means, between which there is arranged a pressure element **18** which is secured to the offset end **10***a* of the push rod **10** by means of a

pin **19**. All members **11–13**, **15**, **16** of the pairs of toggle linkages as well as the pressure member **18** are advantageously made of hardened steel in a distortionless manner due to the simple, compact structure of these members. Only a sliding friction occurs between the aforesaid hardened members when the pairs of toggle linkages are forced apart by moving the pressure element **18** in the direction A, the hardened rollers **11** and **13** being pressed into the softer material of slide **4** and abutment **9** so that said rollers **11** and **13** are securely held and cannot rotate. As is apparent from the drawing, the clearance existing between the push rod **10** and the bore **20** of the hollow spindle **7** as well as the bore **21** of the abutment **9**, respectively, permits free motion of the pressure element **18** inclusive of the push rod **10** relative to the abutment **9** transversely of the longitudinal direction of the push rod **10**—that is to say, in the direction B. This arrangement has the advantage that the pairs of toggle linkages are always in uniform engagement with the pressure element and that, respectively, the pressure element can freely adjust itself when said element is displaced in the direction A so that invariably equally great forces are created between said element and the two pairs of toggle linkages. Thus, due to the fact that said pressure element is mounted for free movement in the direction B, it is possible to avoid any one-sided, unequal forces which would otherwise come into being due to unavoidable dissimilar manufacture and arrangement of both pairs of toggle linkages if said pressure element is immovably mounted.

It will be apparent that said pressure element **18** can either act indirectly upon the pairs of toggle linkages or, advantageously, directly upon the press rollers **12**. Said pressure element **18** has convex pressure surfaces **18***a* which are suitably cylindrically shaped. Due to said convex cylindrical pressure surfaces cooperating with the rollers **12**, it is possible to achieve the force required for displacing the pressure element **18** when the latter is displaced in the direction A—and hence also the torque to be exerted by the crank handle **8**—which force remains nearly unchanged despite the increasing toggle lever pressure.

Furthermore, as is apparent from the drawing and in particular from FIG. 3, the press rollers **11–13**, the support levers **15**, **16** and the pressure element **18** have the same height *h*, and all of these elements are mounted for free movement between two parallel, horizontal bearing plates **22** and **23**. These two bearing plates **22** and **23** are advantageously formed integral with the abutment **9** and together form a U-profile piece. Thus, the legs of this U-profile piece constitute the two bearing plates **22**, **23** for the pairs of toggle linkages and the pressure element **18**, while the web or ridge of this U-profile piece constitutes the abutment **9**. This abutment is subjected to considerable bending stress due to the very high pressure forces exerted by the pairs of toggle linkages. Yet deflection or bending of said abutment **9** is prevented by the long legs **22**, **23** of said U-profile piece.

As is apparent from FIGS. 2 and 3, in the slide **4** is arranged a stop **24** which is rotatable about a vertical axis and which has two (or more) vertical stop faces at **25** for the push rod end **10***a*. In the drawing, the clamping device and in particular the toggle linkage system is represented in the released or expanded condition where a spacing *b* exists between the end **10***a* and the set stop face **25** so that the push rod **10** can only be moved a distance *b* in the direction A. Accordingly, the stop faces **25**, **26** permit selection of different clamping pressures. As is shown in FIG. 3, the upper side of slide **4** includes an indicating scale **27** for adjusting the clamping pressure, said scale being concentrically disposed relative to the rotatable stop **24**. As is apparent from FIG. 2, a detent device (ball catch **28**, compression spring **29**) for arresting the stop **24** in various stop positions is provided between the slide **4** and the rotatable stop **24**.

As is apparent from FIGS. 3 and 1, the U-profile piece **9**, **22**, **23** with its upper side **30** and the two side surfaces **31**, **32** is mounted in the slide **4**, and with its underside **33** it is mounted on the upper side **34** of the substructure **1**, for longitudinal displacement and guidance in the direction A.

FIG. 2 shows stops **35** for the abutment **9**, which are for limiting the displacement of said abutment in the slide **4** in the clamping direction A. Furthermore, compression springs **36** are arranged between said stops and the abutment. In the embodiment shown, these springs **36** which are formed as cup or disk springs are arranged on bolts **37** which are located in the abutment **9** and engage with the stops **35**. The cup springs **36** are effective to constantly urge the abutment **9** in the direction A, in consequence of which the pairs of toggle linkages subjected to this pressure remain movable for free play and are constantly pressed with the rollers **12** against the pressure element **18**.

It will be apparent from the drawings that the quick acting spindle **7** is rotatably mounted at **38** with one end thereof on the abutment **9**. In this spindle is arranged a compression spring **39** which has one end thereof bearing against the spindle at **40**, and has the other end thereof bearing against the push rod **10** at **41**. Under the force of this spring, the spindle end **38** is pressed against one side of the abutment **9**, while the transverse face **42** of the pressure element **18** is pressed against the other side of the abutment **9**.

For the drive of the above described clamping device a driving spindle **43** is provided which is rotatable by the crank handle **8** and the end **43***a* of which is rotatably mounted on the push rod **10**. This driving spindle **43** is screwable in a nut **44** which is securely connected to the hollow spindle **7** by means of, e.g., pins **45**. A torque coupling or clutch is provided between the nut **44** and the driving spindle **43**. By way of example, the torque coupling can consist of a coupling member **46** which is slidable on but rotatable with the spindle end **43***a* and which has wedge-like ribs **48** which engage in corresponding depressions in the nut **44** under the pressure of the cup springs **47**.

The driving spindle **43** can be securely connected to a sleeve **49** rotatably mounted on the hollow spindle **7** so that the driving spindle **43** can be rotated not only by the crank handle **8** but also manually by means of the sleeve **49**.

In order to ensure an unconstrained transmission of the pressure forces exerted by the driving spindle **43** in the direction A to the push rod **10**, the end **43***a* of the driving spindle is advantageously supported by means of a bearing ball **50** and an axial ball bearing **51** on the end **52** of tht push rod **10**, while also a bearing plate **53** is interposed between the ball **50** and the bearing **51**.

The mode of operation of this drive is as follows:

Upon rotation of the crank handle **8**, the nut **44** and hence the hollow spindle **7** are rotated by the driving spindle **43** via the coupling **46–48**. Due to the threaded connection between the spindle **7** and the fixed nut **5**, the hollow spindle **7**, the abutment **9**, the pairs of toggle linkages and the slide **4** (in the condition of the individual members as shown in FIG. 2) are moved in the direction A whereby the jaw **3** comes into engagement with the workpiece. In this position, spindle **7** is restrained from further axial movement. Thus, upon further rotation of the crank handle **8**, the coupling member **46** will be released whereby the spindle **43** will be moved in the direction A relative to the nut **44**. As a result, the push rod **10** will be moved in the direction A so that the pairs **15**, **16** of toggle levers will be forced apart by the pressure element **18** causing a small displacement of the slide **4** in the direction A so that the clamping pressure will be considerably increased.

A reversal of this order of succession of these movement steps will take place when the crank handle **8** is turned backwardly, in consequence of which the moved members will be returned into the represented starting

or initial position under the pressure of the springs 36 and 39.

The present invention is not limited to the illustrative embodiment of a machine vise as is described and represented herein but is applicable to clamping devices of all types.

What is claimed and desired to be secured by Letters Patent is:

1. A clamping device for exerting high clamping pressures on a workpiece, said device comprising:

a pair of clamping members adapted to receive a workpiece therebetween, and frame means mounting said pair of clamping members for relative movement therebetween;

drive means connected to one of said clamping members for movement relative to the other said clamping member, said drive members comprising an abutment member and a slide, toggle means interconnecting said abutment member and said slide for causing said relative movement, said slide being fixedly connected to said one clamping member;

said toggle means comprising a pair of toggle mechanisms, each of which comprises a pair of links having partial cylindrical recesses in each end thereof, a first partial cylindrical bearing member being received in the recess in one end of one of said links and being connected to said abutment member, a second partial cylindrical bearing member being received in the recess in one end of the other of said links and further being connected to said slide, a substantially cylindrical roller member being received in the recesses at the other ends of said pair of links, said pair of links and said first and second partial cylindrical bearing members and said cylindrical roller member all being of substantially the same width;

said drive means further including a movable pressure element having convex pressure surfaces thereon, said pressure surfaces being adapted to contact and actuate each of said toggle mechanisms;

a pair of parallel bearing plates connected to said abutment member, said plates being positioned closely adjacent to and on opposite sides of said toggle mechanisms;

whereby said toggle mechanisms are mounted for free displacement between said parallel bearing plates and are capable of transmitting large clamping forces therethrough.

2. A clamping device according to claim 1, wherein said abutment member has an opening therethrough, and said drive means further includes a pushrod extending through said opening and having said pressure element fixedly connected to the end thereof, means mounting said pushrod for free movement relative to said abutment member in a direction substantially transverse to the longitudinal axis of said pushrod.

3. A clamping device according to claim 1, wherein said parallel bearing plates are integrally connected to said abutment member so as to form a generally U-shaped member.

4. A clamping device according to claim 3, wherein one of said bearing plates is mounted in slideable engagement with said slide and the other bearing plate is mounted in slideable engagement with said frame means, said U-shaped member being movable relative to said frame means and said slide in the same longitudinal direction as said slide.

5. A clamping device according to claim 1, wherein a rotatable stop means is mounted on said slide for permitting adjustment of the clamping pressure, said stop means having a plurality of stop faces thereon, one of said faces being adapted to coact with said pressure member for limiting the movement thereof.

6. A clamping device according to claim 5, wherein spring detent means are positioned between said slide and said stop means for releasably holding said stop means in a selected position.

7. A clamping device according to claim 6, wherein a scale is provided on the upper side of said slide in concentric relationship to said rotatable stop means for providing a visual indication of the selected clamping pressure.

8. A clamping device according to claim 1, wherein a nut is fixedly connected to said frame means, and said drive means further includes a hollow spindle threadedly received in said nut and having a pushrod positioned within said spindle, said abutment member having an opening therein, said pushrod having an end thereof extending through said opening and having said pressure element fixedly secured thereto, spring means coacting between said spindle and said pushrod for urging one end of said spindle into engagement with one side of said abutment member, said one end of said spindle being rotatably mounted on said abutment member, said spring means also urging said pushrod and the pressure element mounted thereon against the other side of said abutment member.

9. A clamping device according to claim 8, wherein said drive means further includes rotatable crank means having a driving spindle fixedly secured thereto, said driving spindle having an end thereof aligned with and rotatably supported on the pushrod, a coupling member securely connected to said hollow spindle, and releasable clutch means interconnecting said driving spindle and said coupling member.

10. A clamping device according to claim 9, wherein said driving spindle is threadedly connected to said coupling member and is supported on the pushrod by means of antifriction bearings.

11. A clamping device according to claim 1, wherein said first and second partial cylindrical bearing members are each cylindrical roller members and said abutment member and said slide are each provided with partial cylindrical recesses therein for receiving said cylindrical roller members.

12. A clamping device for applying a clamping force to a workpiece, said device comprising:

frame means having a stationary clamp jaw fixedly secured thereto;

slide means mounted on said frame means for linear movement relative thereto, said slide means including a clamp jaw fixedly secured thereto and movable toward and away from said fixed clamp jaw;

abutment means mounted on said frame means for slideable linear movement with respect to said frame means and said slide means, said abutment means being movable in a direction substantially parallel to said slide means;

toggle means comprising a pair of toggle mechanisms connecting said slide means and said abutment means, actuation of said toggle mechanisms causing relative movement between said slide means and said abutment means;

rotatable driven means connected to said abutment means for causing linear movement thereof;

crank means for actuating said rotatable driven means whereby said abutment means and said slide means are simultaneously moved relative to said frame means;

releasable clutch means drivingly connecting said crank means and said rotatable driven means, said clutch means automatically releasing upon application thereto of a predetermined torsional resistance;

reciprocal driven means operatively connected to said crank means and driveable thereby when said clutch means is released, said reciprocal driven means being adapted to engage and actuate said toggle mechanism;

whereby actuation of said crank means causes said abutment means and said slide means to move rela-

tive to said fixed jaw until said movable jaw contacts the workpiece causing said clutch means to release, said crank means then linearly moving said reciprocal driven means to actuate said toggle mechanism for causing the application of a large clamping pressure to the workpiece by moving the movable jaw relative to the abutment means.

13. A clamping device according to claim 12, wherein said rotatable driven means includes a hollow spindle and said reciprocal driven means includes a pushrod freely mounted within said hollow spindle, a pressure element being mounted on one end of said pushrod and being adapted to engage said pair of toggle mechanisms.

14. The clamping device according to claim 12, wherein said rotatable driven means includes a hollow spindle having a portion thereof threadedly received in said frame means with one end of said spindle bearing against and being rotatably supported on said abutment means, and resilient means urging said hollow spindle into engagement with said abutment means.

15. The clamping device according to claim 14, wherein said reciprocal driven means includes a pushrod positioned within said spindle, one end of said pushrod extending beyond said spindle and having a pressure member connected thereto for engaging said pair of toggle mechanisms, the other end of said pushrod being in bearing engagement with said crank means, and spring means for urging said other end of said pushrod into bearing engagement with said crank means.

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