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(72) Inventor; and
(71) Applicant: **BALLEW, Tony** [US/US]; 325 S. Main St. #406, Livingston, MT 59047 (US).

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(54) **Title:** ARTICULATED MAST SECTION FOR CHOP SAWS

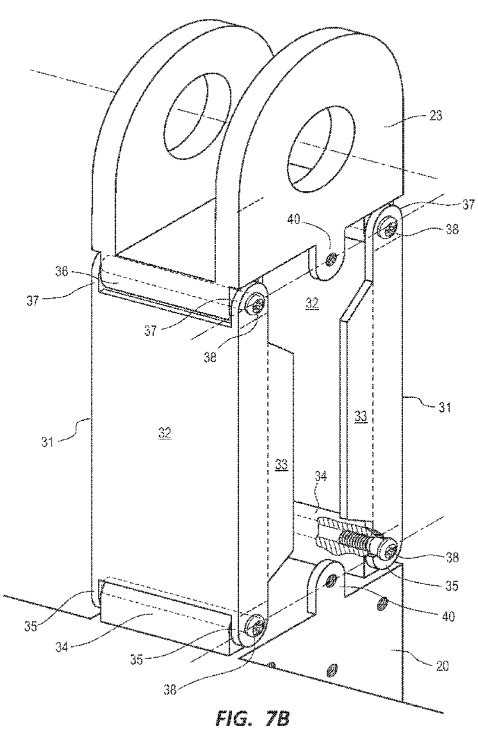

FIG. 7B

(57) **Abstract:** An articulated chop saw mast section (30) replaces a rigid prior art mast section (22) between a chop saw base (20) and a chop saw swing arm assembly (23'). The articulation of mast section (30) provides a front-to-rear longitudinal movement of the swing arm assembly (23') along an axis that is parallel to the longitudinal axis of a chop saw cutting wheel (26), ultimately providing front-to-rear movement of the cutting wheel (26) along its longitudinal axis. The movement of wheel (26) in this fashion provides a means for optimum adjustment to the geometric relationship between wheel (26) and the material to be cut. The ability of the articulated mast to achieve optimum cutting geometry offers greater cutting efficiency by reducing the point or points of contact between wheel (26) and the material's specific profile.

WO 2021/173728 A1

TITLE: ARTICULATED MAST SECTION FOR CHOP SAWS

CROSS-REFERENCE TO RELATED APPLICATIONS -- This application claims the benefit of U.S. provisional patent application, Ser. No. 62,980,445 filed February 24, 2020

FEDERALLY SPONSORED RESEARCH Not Applicable

SEQUENCE LISTING OR PROGRAM Not Applicable

BACKGROUND OF THE INVENTION—FIELD OF INVENTION

The present invention relates to an adjustment mechanism for cutting devices, and more specifically for cutting devices including chop saws, miter saws, sliding compound saws, or a combination thereof.

BACKGROUND OF THE INVENTION—PRIOR ART— Figs 1, 2, 3, 4

In regard to cutting metallic materials with a metal-cutting cut-off or chop saw, it is known that some material profiles cut quickly and efficiently, while others do not. The determinant factor between a fast, efficient cut and a laborious, inefficient cut is specifically linked to the contact point between the saw's abrasive disc and the material to be cut, and more particularly, to the surface area of that contact point. The smaller the point or points of contact between the disc, or cutting wheel, and the material, the more effective the cut. As such and until now, a saw's cutting efficiency has been limited by the geometry of prior art chop saws.

Prior art chop saws (Fig 1) comprise a chop saw base **20**, a rigid mast section **22** joined to base **20,** a jointed end **23** of swing arm assembly **23'** affixed to section **22,** a motor (not shown) with handle **29** fastened to arm **23'**, and an abrasive cutting wheel **24** mounted to the motor. Fig 1 also shows the side-view geometry of a cut being initiated on a narrow steel stud **25** of the three and five-eighths inch to four inch range. Due to the geometric relationship between the cutting wheel and the material, the initial contact point and the two subsequent contact points as the cut progresses are relatively small in comparison to other profiles. These small contact points generate less heat from the abrasive action while the abraded material is separated and spun away in the form of sparks. This scenario lends itself to a rapid, effortless cut.

Fig 2 shows another material profile, an angle iron section **26** in a specific orientation, which also cuts efficiently with the prior art chop saw geometry. As with the narrow steel stud above, the initial point of contact is relatively small, as are its two subsequent points of contact.

Fig 3 shows a wider steel stud **27** (of the six inch and wider width range) prior to cutting. Due to the wheel's diameter and relative position, the contact area between the wheel and the metal (Fig 4) is effectively increased to the degree that the heat generated from added friction causes a much larger area of material to become red-hot. When the temperature of surrounding steel reaches a red-hot point, abrasive cutting action is minimized, as evidenced by a reduction or absence of sparks, and thus leads to a substantial increase in time required per cut. This rapid temperature increase and reduced cutting ability is even more pronounced when the material is of a thicker gauge; where certain thin-gauge, wider profiles allow deflection of the material to the curvature of the wheel, as shown; or when a bundle of material presents a wide profile.

To overcome this reduced cutting action, a typical chop saw operator will increase the downward force of the wheel. Such an action often powers the wheel through red-hot thinner materials. However, thicker materials require even greater time and energy expenditures to accomplish the task, and in some cases, the cutting action simply ceases. One remedy when a material reaches a red-hot state is to release pressure from the wheel to cool the material, and then to reapply pressure, alternating between the two until the material is cut. Thus, the geometry of prior art metal-cutting saws often requires additional time spent per cut, unnecessary physical exertion on the part of the operator, and increased use of electricity, all while subjecting the motor to prolonged, added bearing pressure and potential premature failure.

Even though most metal-cutting saws offer negligible, time-consuming adjustments to the cutting geometry by way of a movable fence **28**, the prior art saws fail to effectively address or overcome the detriments of a largely static geometric relationship between the abrasive wheel's contact point and the material. The only known attempt to address the limitations of metal-cutting chop saw geometry is my own chop saw improvement, a variable-angle cutting deck for metal-cutting chop saws, U.S. application number 16/748,753 to Ballew (2020).

Although geometric limitations have long persisted among prior art metal-cutting chop saws, in the field of wood-cutting chop saws, sliding miter saws effectively alter the geometric relationship between a blade and the wood to be cut in order to increase the span of a cut. Even with an alterable geometry, the smooth shafts of its sliding mechanism and its internal bearings are deemed susceptible to malfunction and damage from sparks and the high volume of abraded metallic debris associated with metal-cutting saws. As such, no sliding mechanisms are known to be used in metal-cutting applications.

OBJECTS AND ADVANTAGES

Accordingly, several objects of the present invention are

(a) to provide an adjustment mechanism for chop saws by which the contact area between a chop saw cutting wheel and a material to be cut may be minimized;

(b) to provide such an adjustment mechanism which is resistant to pitting, contamination, and wear from sparks, and from high volumes of fine, abraded, metallic materials;

(c) to provide such an adjustment mechanism that is quickly and easily readjusted; and

(d) to provide such an adjustment mechanism that may be used with other types of chop saws beyond the metal-cutting type. Additionally, several advantages of the present invention's use over the prior art include

(e) less pressure required for cuts;

(f) less time spent per cut;

(g) reduced operator fatigue;

(h) reduced use of electricity and natural resources; and

(i) reduced wear on chop saw motor and bearings.

Further objects and advantages of my articulated chop saw mast section will become apparent from a consideration of the drawings and ensuing description.

SUMMARY

In accordance with the present invention, an articulated mast section is inserted between a chop saw base and a swing arm assembly and provides a front-to-rear longitudinal swing arm axis that is parallel to the longitudinal axis of a chop saw cutting wheel, thus ultimately allowing front-to-rear movement of the cutting wheel along its longitudinal axis. Movement of the wheel in this manner allows optimum adjustment to the geometric relationship between the wheel and a specific profile of a material to be cut, thereby providing for more efficient cuts.

DRAWINGS—Figures

Fig 1- Prior art chop saw, geometric relationship with narrow steel stud

Fig 2- Prior art chop saw, geometric relationship with inverted angle iron

Fig 3- Prior art chop saw, geometric relationship with wide stud

Fig 4- Prior art chop saw, contact area with wide stud

Fig 5A- Articulated mast section, positioned for wide stud
Fig 5B- Articulated mast section, positioned for narrow stud
Fig 6- Relative dimensions of preferred embodiment
Fig 7A- Riser detail
Fig 7B- Details of preferred embodiment components
Fig 8A- Articulated mast section, detail of self-limiting tabs
Fig 8B- Self-limiting tabs, section in frontward position
Fig 8C- Self-limiting tabs, section in rearward position
Fig 8D- Alternative tab size for section angle adjustment
Fig 9- Exploded view of position lock components
Fig 10- Front view of assembled position lock
Fig 11A- Section locked in frontward position
Fig 11B- Section locked in rearward position
Fig 12- Release lever for the position lock
Fig 13- Alternative risers with barrel joints
Fig 14- Alternative traverse hinges
Fig 15- Alternative individual risers

DRAWINGS—Reference Numerals
20 Chop saw base
22 Rigid mast section
23 Jointed end of swing arm
23’ Swing arm assembly
24 Cutting wheel
25 Narrow steel stud
26 Angle iron
27 Wide steel stud
28 Fence
30 Articulated mast section
31 Riser
32 Planar surface of riser

32’ Riser flange

33 Self-limiting tabs

34 Fixed hinge, lower static part

35 Fixed hinge, lower active part

36 Traverse hinge, upper static part

37 Traverse hinge, upper active part

40 Mounting block

41 Position lock assembly

42 Mounting plate

42’ Mounting plate bores

44 Rod guides

45 Rod

46 Spring retainer

47 Spring

48 Nut

49 Positioning block

49a Position block detent

50 Cable-to-rod knuckle

52 Mounting slot

53 Cable slot

54 Shoulder screw

54’ Threaded bore

60 Cable stop

61 Cable sheath

62 Cable

63 Cable end button

65 Keyhole slot

66 Hinged release lever

67 Cable slot

68 Cable stop

70 Alternative upper static part

DETAILED DESCRIPTION—Preferred Embodiment— Figs 4, 5A, and Figs 6 through 12

For the present invention, mast section **30** (Fig 5A) replaces prior art mast section **22** (Fig 4). Fig 6 shows the relative dimensions of section **30**. Dimensions “x” and “y” define the equilateral nature of section **30**. Dimension “a” defines an equidistant position of blocks **40**.

Figs 7A shows risers **31** of predetermined size sufficient to support the weight and functions of the chop saw components above it. Risers **31** comprise identical rigid plates having planar surfaces **32** oriented parallel and symmetrically to one another, with flanges **32’** located at right angles to planar surfaces **32** along the surfaces’ outer vertical edges, as shown. Self-limiting tabs **33**, detailed below, extend from the flanges. At the risers’ lower and upper ends, hinge sections **35** and **37** (described below) are joined to risers **31**, extending from flanges **32’**.

Fig 7B shows a two-part, fixed riser hinge at the lower end of each riser **31**. Each fixed hinge comprises lower active parts **35** movably joined to a lower static part **34.** Each lower static part **34** comprises a mounting block of predetermined size capable of receiving a riser **31**, and has a central pivot axis through which a threaded bore is formed. Static parts **34** are welded to base **20** at the location of prior art section **22** beneath jointed end **23**. The central pivot axis of each static part **34** is oriented at a right angle, or perpendicular, to the longitudinal, front-to-rear axis of the cutting wheel **26** (Fig 5A). The center-to-center distance between the central pivot axes of static parts **34** (Fig 6, dimension “x”) is predetermined for structural stability.

Lower active parts **35** comprise bores at the lower end of each riser **31**, as shown in Fig 7A, which align with the threaded bores of static parts **34**. The bores of active parts **35** are sized to accept a shoulder portion of shoulder screws **38**, when screws **38** are threaded into static parts **34**. The resultant orientation of risers **31** and fixed hinges **34/35** allows risers **31** to rotate perpendicularly to the shared central pivot axis of hinges **34/35**. This orientation further provides a front-to-rear longitudinal rotation axis for a given point at the top of a given riser **31** throughout the riser’s range of motion that is parallel to the longitudinal axis of wheel **26**.

Fig 7B also shows a two-part traverse riser hinge **36/37** joined to the upper end of each riser **31**. Each traverse hinge comprises upper active parts **37** movably joined to an upper static part **36.** Each part **36** comprises a mounting block of predetermined size capable of receiving a riser **31**, and has a central pivot axis through which a threaded bore is formed. Upper static parts **36** are formed into an underside surface of end **23** so that their central axes are perpendicular to the longitudinal axis of wheel **26**. The center-to-center distance between each riser's upper static parts **36** is equal to the center-to-center distance between each riser's lower static parts **34**.

Upper active parts **37** comprise bores at the upper end of each riser **31** (Fig 7A), which align with the threaded bores of upper static parts **36** to provide a common central pivot axis. The bores of active parts **37** are sized to accept the shoulder part of shoulder screws **38**, when screws **38** are threaded into static parts **36**. The resultant orientation between riser hinges and risers **31** provide a front-to-rear longitudinal axis for section **30** that is parallel to the longitudinal axis of wheel **26**. The parallel axes allow front-to-rear movement of wheel **26** along its longitudinal axis by way of element connectivity between mast section **30** and cutting wheel **26**.

Fig 7B also shows mounting blocks **40** joined to base **20** and to jointed end **23**. Each block **40** has a bore parallel to screws **38** and has a horizontal centerline on the same plane as the plane between the centerline of screws **38** to the left and right of each block **40**. The bores' axis centerlines are also equidistant from the axis centerlines of screws **38** to the left and right of each block **40** (Fig 6, dimension "a"). The bores of block **40** are threaded to accept fasteners for a position lock assembly, detailed below. A total of four blocks with identical bore dimensions and relative positions, two per side, are used for this embodiment.

In Fig 7A through Fig 8D, rotational limit stops, or self-limiting tabs **33**are shown. The width of tabs **33** is determined by the desired angle of rotation of mast section **30**. Figs 8A- 8D illustrate the width calculation and other physical properties.

In Fig 8A, tabs **33** comprise a given width "b," as shown. In Fig 8B, section **30** rotates frontward until each tab **33** contacts its opposing tab, resulting in angle "b-prime" for both the frontward and rearward (Fig 8C) positions. Conversely, if angle b-prime is known, the width of each tab **33** equals one-half the total distance, or width "b", of the dimension across risers at a right angle to risers **31**, as shown, when section **30** is positioned at angle b-prime.

Fig 8D illustrates that a reduction in tab width "c" increases angle of rotation of section **30** and results in angle "c-prime." Greater tab widths reduce riser travel. The shape of the uppermost and lowermost edges of all tabs **33** is also angled, as shown, to prevent the tabs' contact with blocks **40** throughout the range of motion of section **30**.

Fig 9 details an embodiment of a position lock assembly **41**. A mounting plate **42** is movably fastened to blocks **40** with shoulder screws **43**. Screws **43** pass through bores **42'** in plate **42** and into threaded bores of blocks **40**. Upper and lower rod guides **44** are located on plate **42** and are bored to accommodate a positioning rod **45**. A spring retainer **46** is formed near the middle of rod **45**. When rod **45** is positioned into guides **44**, a spring **47** is located on rod **45** between retainer **46** and the underside of upper guide **44** by which a downward force is exerted on rod **45**. All position lock components are sized to allow travel of rod **45** into and out of a positioning block **49**. The top end of rod **45** is threaded and passes through a bore **51** of a cable-to-rod knuckle **50**. A nut **48** is threaded onto rod **45**, holding it captive to knuckle **50**.

Knuckle **50** is shaped as shown and comprises an elongated mounting slot **52**, and a cable slot **53**. Knuckle **50** is slidably attached to plate **42** by means of shoulder screws **54** which pass through mounting slot **52** and into threaded bores **54'** in mounting plate **42**.

A cable stop **60** is also located on mounting plate **42**. Cable **62** passes through stop **60** by way of slot **64**. Cable sheath **61** of cable **62** rests against top of stop **60**. The lower end of cable **62** is positioned into slot **53** of knuckle **50** so that button **63** is positioned on the underside of slot **53**. The distance between the underside of the cable stop **60** and the top of the cable-to-rod knuckle **50** when knuckle **50** is in its lowest position is equal to or greater than the distance that the positioning rod **45** projects below the bottom of mounting plate **42**, as in Fig 10.

In Fig 10, the assembled view of the position lock **41** is shown. Although only one lock is seen, the preferred embodiment employs a position lock on each side of section **30**. Positioning blocks **49** with a plurality of detents **49a** are attached to base **20** with screws **49b**. The location of blocks **49**, as well as the size and orientation of detents **49a**, are all predetermined to accept the lower end of positioning rod **45** throughout the section **30** range of motion. Figs 11A and 11B show mast section **30** locked in alternate positions.

Fig 12 shows an embodiment of a position lock release assembly. A release lever **66** is hinged to a cable stop **68**, which is is fastened to handle **29** with screws **68'**. Cable end buttons **63** pass through keyhole slots **65** in release lever **66**. Cables **62** extend from the back of the lever and into cable slots **67** on stop **68**. Cable sheaths **61** rest against the back side of stop **68**. The entire release assembly is of predetermined size to provide a sufficient length of cable **62** to be withdrawn from the cable sheath **63** so that rod **45** (Fig 10) may be withdrawn from detents **49a**.

OPERATION— Preferred Embodiment — Fig 12

To move the cutting wheel to a more efficient orientation, release lever **66** is pulled toward the chop saw operator, thus withdrawing rod **45** from its current detent **49a**. Handle **29** is pushed or pulled in the desired direction of cutting wheel reorientation. When proper wheel orientation is achieved, release lever **66** is released, allowing rod **45** to extend into its chosen detent **49a**.

Alternative Barrel-Joint Hinges and Limit Blocks— Description and Operation—Fig 13

Fig 13 shows alternative fixed hinges **34'/35'** and traverse hinges **36'/37'**comprising barrel joints of the type commonly found in door hinges. Lower static parts **34'** are welded, cast, machined, formed into, or otherwise joined to base **20**. Lower active parts **35'** comprising barrel joints are formed into the lower ends of risers **31'**, as shown. Upper static parts **36'** are joined to the underside of jointed end **23'** in the same fashion as lower static parts **35'** to base **20**. Upper active parts **37'** comprising barrel joints are formed into the upper ends of risers **31'**, as shown. A pin **38'** is inserted into a void throughout the mated hinges' common central pivot axis, as shown. Alternative rotational limit stops are also shown. Limit blocks **33'**, comprising rigid angled surfaces fastened to base **20**, stop movement of section **30** at predetermined angles. Position lock assemblies **41**are added, and operation is identical to the preferred embodiment.

Alternative Traverse Hinges— Description and Operation—Fig 14

The preferred embodiment shows traverse riser hinges **36/37** having upper static parts **36** that are formed into an underside surface of jointed end **23'**. Fig 14 shows alternative upper static parts **70** that are cast or machined into a vertical outside surface of jointed end **23**. Upper static parts **70** mate with the preferred embodiment's upper active parts **37** at the outside surfaces of active parts **37**. Individually formed static parts 70 may also be joined to end **23** by other means such as welding or by threaded fastener. In a similar fashion to the traverse hinges above, this embodiment's fixed (lower) riser hinges (not shown) may comprise lower static parts that are also mated at the outside surfaces of the risers' lower active parts. Position lock assemblies **41**are added, and operation is identical to the preferred embodiment.

Alternative Independent Risers— Description and Operation—Fig 15

For this embodiment, a plurality of individual risers each comprising an upper active part and a lower active part is mated to its corresponding upper static part and lower static part. Position lock assemblies **41**are added, and operation is identical to the preferred embodiment.

Conclusion, Ramifications and Scope of Invention—

Thus the reader will see that the articulated mast section of the present invention provides a device by which the geometric relationship between a chop saw cutting wheel and the material to be cut may be easily and quickly altered to a more efficient cutting geometry. While my above description contains many specificities, these should not be construed as limitations on the scope of the invention, but as an exemplification of one preferred embodiment thereof. Many other variations are possible. For example:

Fixed riser hinges **34/35** of the preferred embodiment are described as fastened to base **20** by welding. Alternate forms of fastening for this or any hinge component include threaded fastening and rivets. In addition, manufacturer preferences may dictate that hinge components be cast, formed into, stamped, 3-D printed, CNC machined, or otherwise affixed or joined to risers **31**, base **20**, and to arm end **23**.

The position lock release mechanism detailed in Fig 12 is of rudimentary style to draw a cable through its sheath. A bi-lateral, thumb-activated release lever may be desirable. Such a lever would place two levers providing the same function within operational proximity to a right-hand thumb and a left-hand thumb of an operator's hand while the hand is grasping the chop saw handle **29**. Such a bi-lateral release lever would provide ease of cutting wheel repositioning by a single hand without releasing the handle during cutting operations.

Components of the position lock assembly are shown as a particular relative size. More robust components, including a larger rod diameter **45**, may be desired. In addition, multi-directional rods **45** may also be desired, in which rods travel not only downward into detents, but also upwards into detents. Such an embodiment could draw the rod ends toward one another, to then be released into their chosen detents, thus providing four distinct, locking contact points.

Self limiting tabs **33**, limit blocks **33'**, and position lock assembly **41** may be used separately, together in any combination, or eliminated entirely.

Upper active parts **37** and lower active parts **35**for the preferred embodiment's traverse and fixed riser hinges are shown as one-piece with risers **31**. All active parts for any embodiment may be separately formed and joined to the risers.

Accordingly, the scope of the invention should be determined not by the embodiments illustrated, but by the appended claims and their legal equivalents.

CLAIMS—

What is claimed is:

1. An articulating chop saw mast section for altering a geometric relationship between a chop saw cutting wheel and a material resting on a chop saw base, said geometric relationship comprising locations along a longitudinal axis of said cutting wheel, said mast section being positioned between said chop saw base and a jointed end of a swing arm, said swing arm movably supporting a motor to which said cutting wheel is mounted; said mast section comprising a plurality of risers configured to rotate between a plurality of riser hinges, each of said risers being substantially equal in length and oriented substantially parallel to one another, said risers comprising a lower end and an upper end, said riser hinges comprising fixed hinges and traverse hinges,

(a) each of said fixed hinges comprising a lower static part movably joined to a lower active part, said lower static part and said lower active part sharing a central pivot axis,

(1) said lower static part being joined to said chop saw base at a predetermined location below said jointed end of said swing arm so that said central pivot axis is oriented perpendicularly to said longitudinal axis of said cutting wheel

(2) said lower active part being joined to said lower end of each of said risers so that said upper end of said risers rotate along a longitudinal rotation axis that is perpendicular to said central pivot axis and parallel to said longitudinal axis of said cutting wheel,

(b) each of said traverse hinges comprising an upper active part movably joined to an upper static part, said upper static part and said upper active part sharing a central pivot axis,

(1) said upper static part being joined to said jointed end of said swing arm at a predetermined location so that said central pivot axis is oriented perpendicularly to said longitudinal axis of said cutting wheel,

(2) said upper active part being joined to said upper end of each of said risers so that said risers rotate along a longitudinal axis parallel to the longitudinal axis of said cutting wheel.

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2. The mast section of Claim 1, wherein said fixed hinges and said traverse hinges comprise barrel hinges, pivot hinges, butt hinges, case hinges, piano hinges, concealed hinges, butterfly hinges, flag hinges, or strap hinges.

3. The chop saw of Claim 1, wherein said mast section further comprises rotational limit stops, said rotational limit stops providing rigid structure against which an opposing rigid element of said mast section contacts said rigid structure at a predetermined angle of rotation, thereby limiting movement of said mast section along said longitudinal rotation axis.

    4. The mast section of Claim 3, wherein said rotational limit stops comprise a first self-limiting tab extending from a first vertical edge of a first riser toward a second self-limiting tab extending from a second vertical edge of a second riser along a plane of said longitudinal rotation axis between said first riser and second riser.

    5. The mast section of Claim 3, wherein said rotational limit stops comprise limit blocks joined to said chop saw base, said limit blocks comprising rigid angled surfaces adjacent to said mast section when said mast section is at a predetermined limit of travel.

6. The chop saw of Claim 1 wherein said mast section further includes a position lock assembly configured to lock said mast section at a specific rotation angle relative to said chop saw base.

    7. The mast section of Claim 6 wherein said position lock assembly comprises position lock components configured to apply force to a spring-loaded rod into one of a plurality of detents that align with said rod throughout said mast's range of motion, and a release mechanism configured to unlock said position lock by applying a force to a lever to cause retraction of said spring-loaded rod from said detent to allow free movement of said mast section.

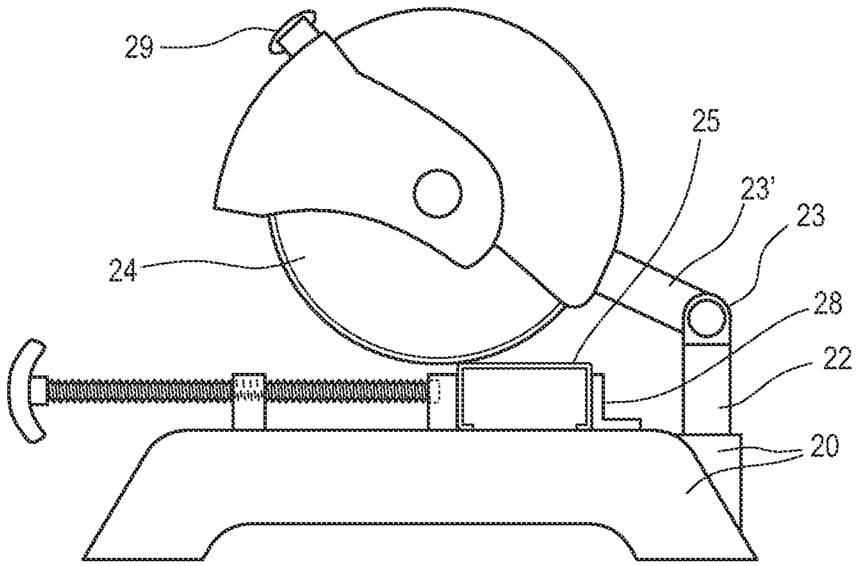

FIG. 1
(Prior Art)

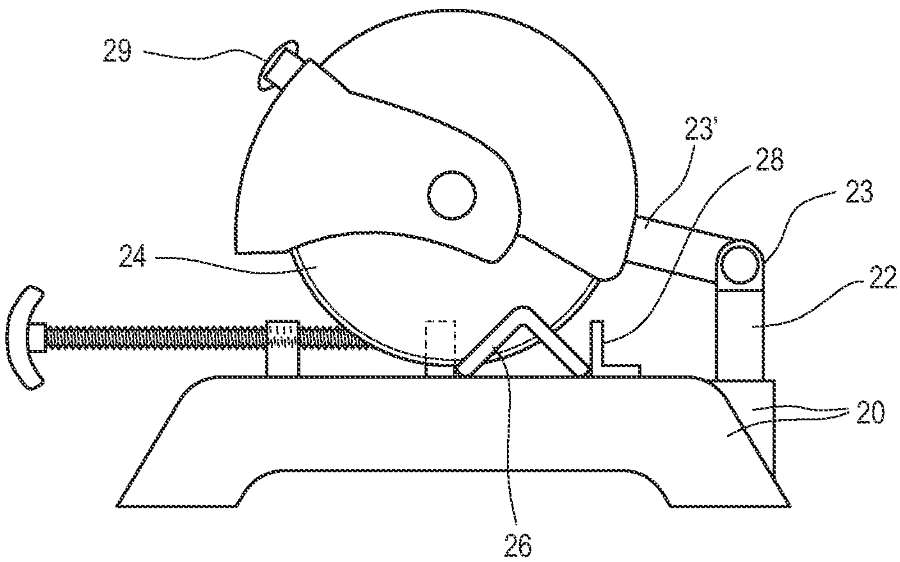

FIG. 2
(Prior Art)

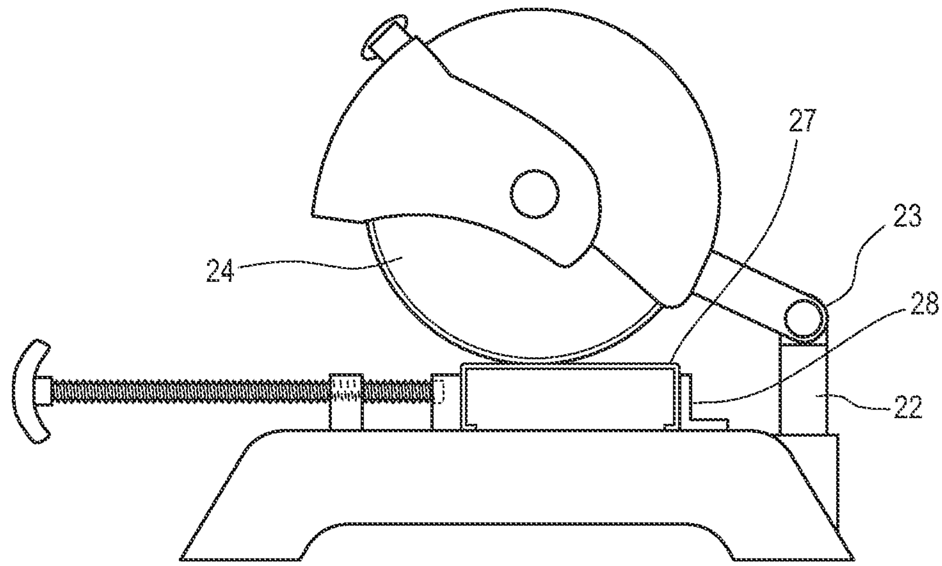

FIG. 3
(Prior Art)

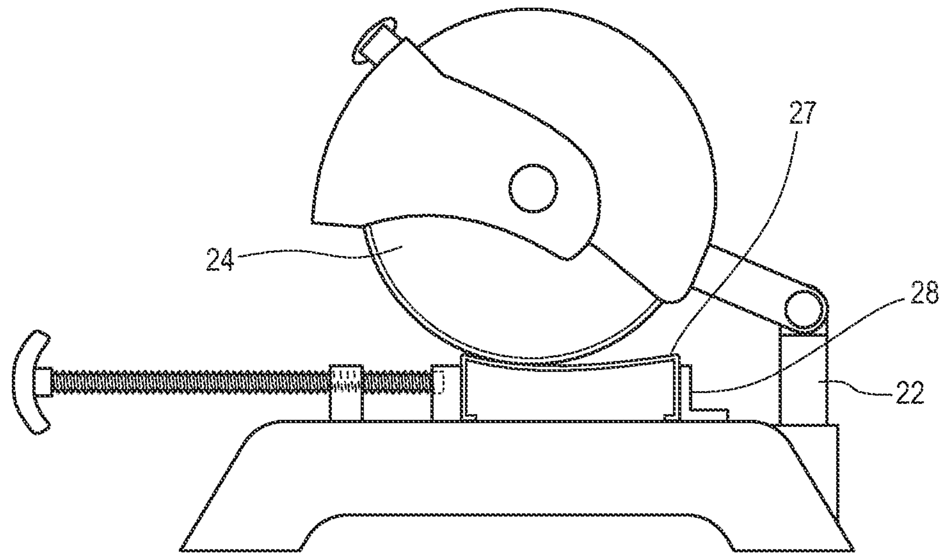

FIG. 4
(Prior Art)

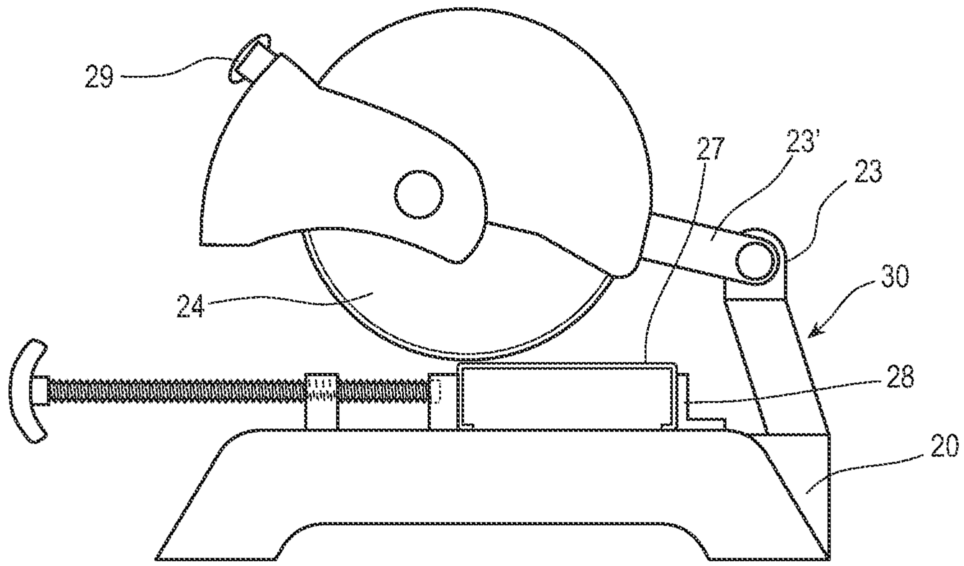

FIG. 5A

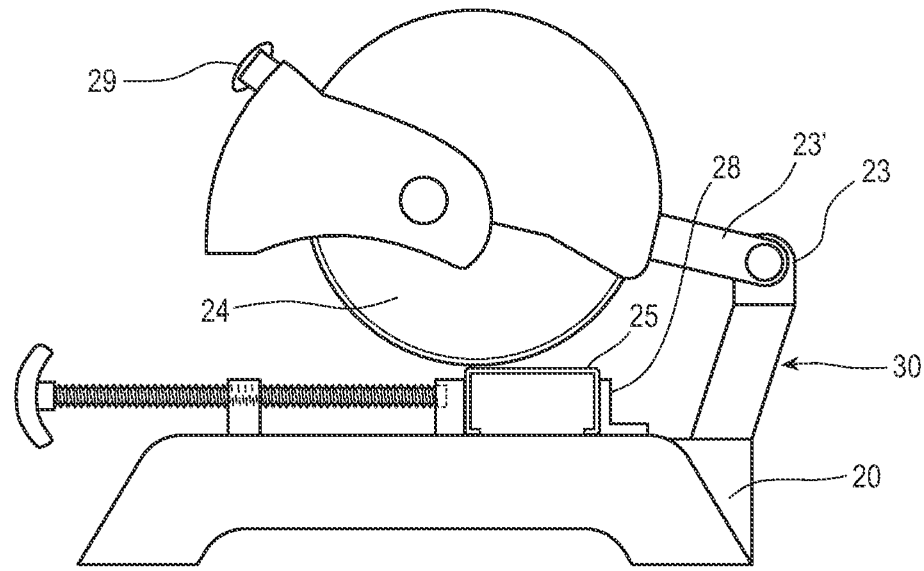

FIG. 5B

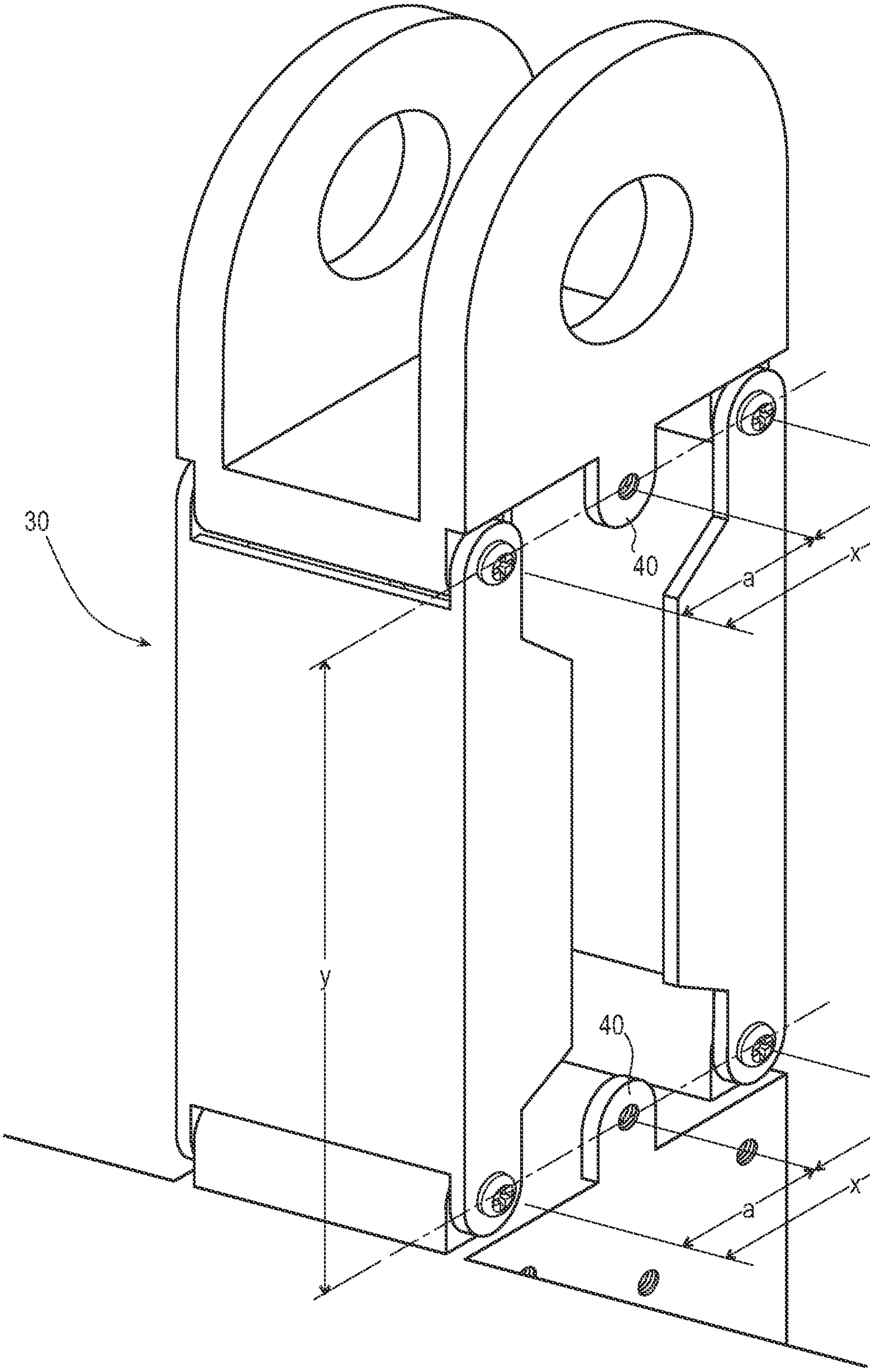

FIG. 6

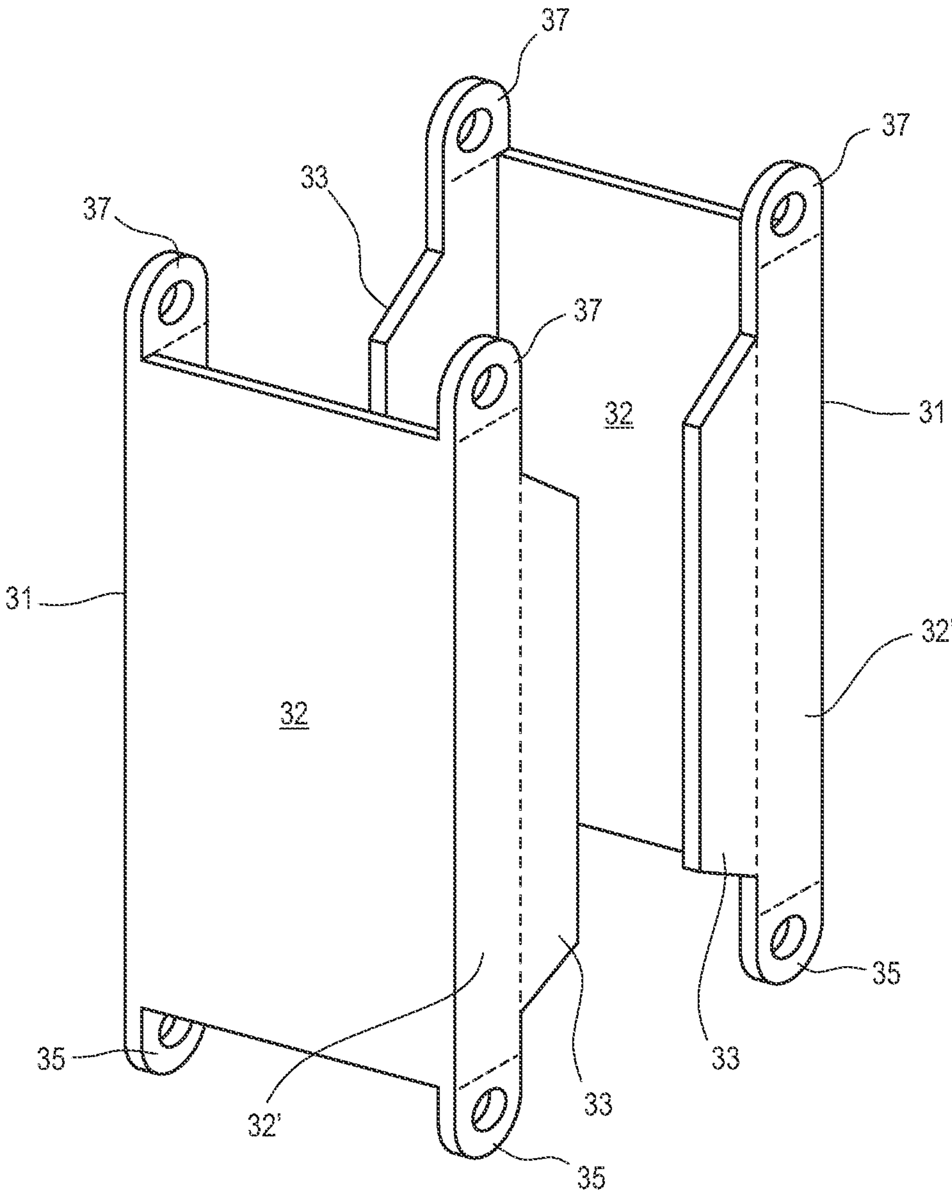

FIG. 7A

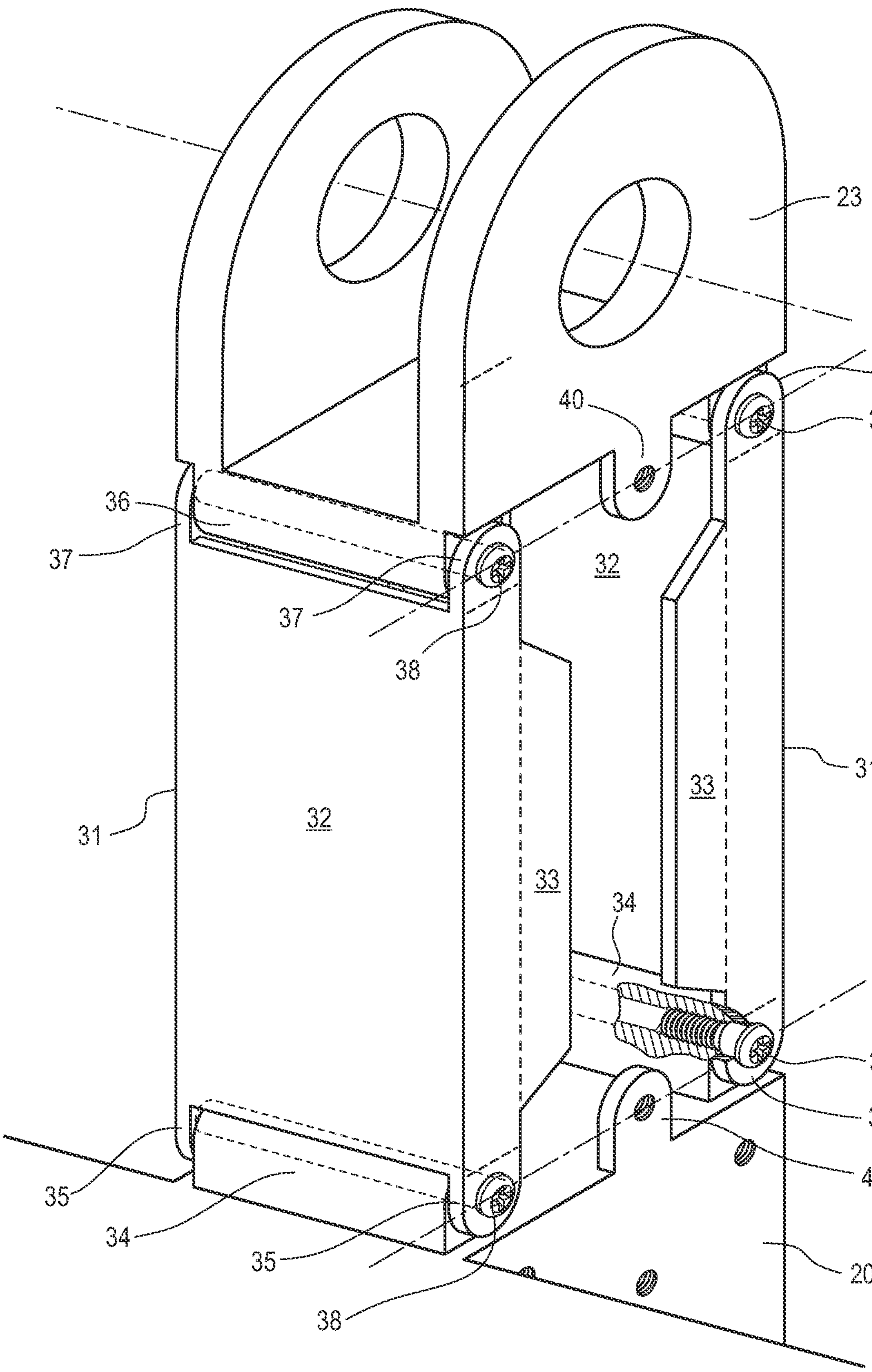

FIG. 7B

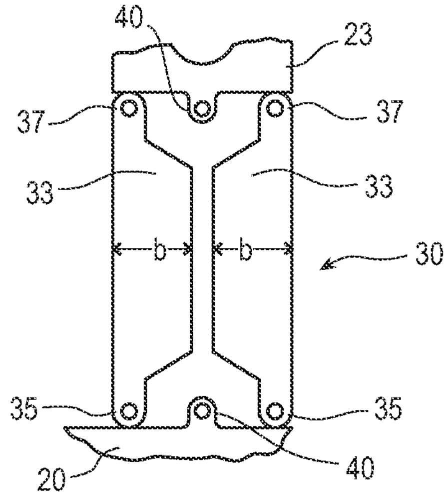

FIG. 8A

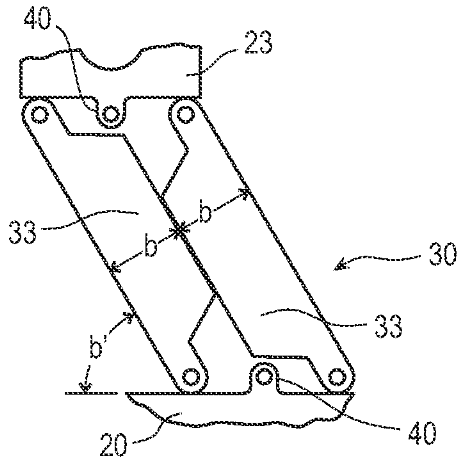

FIG. 8B

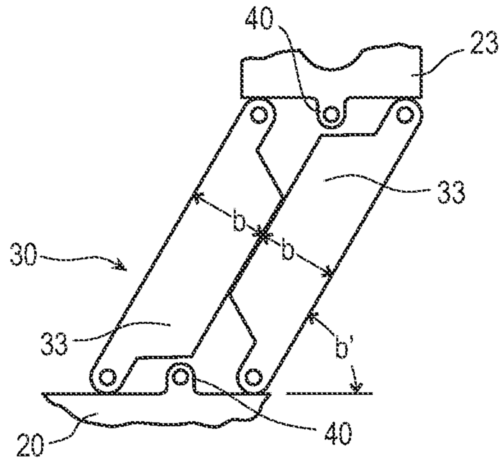

FIG. 8C

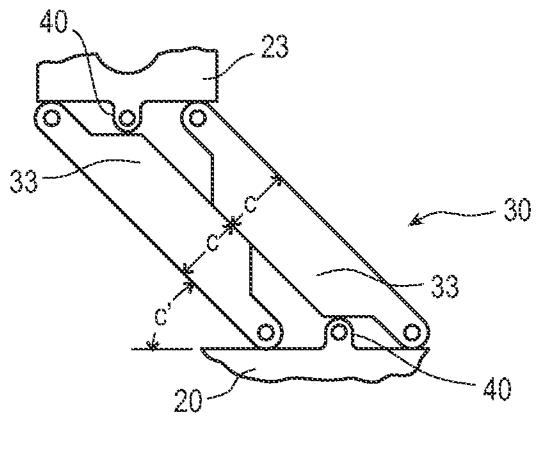

FIG. 8D

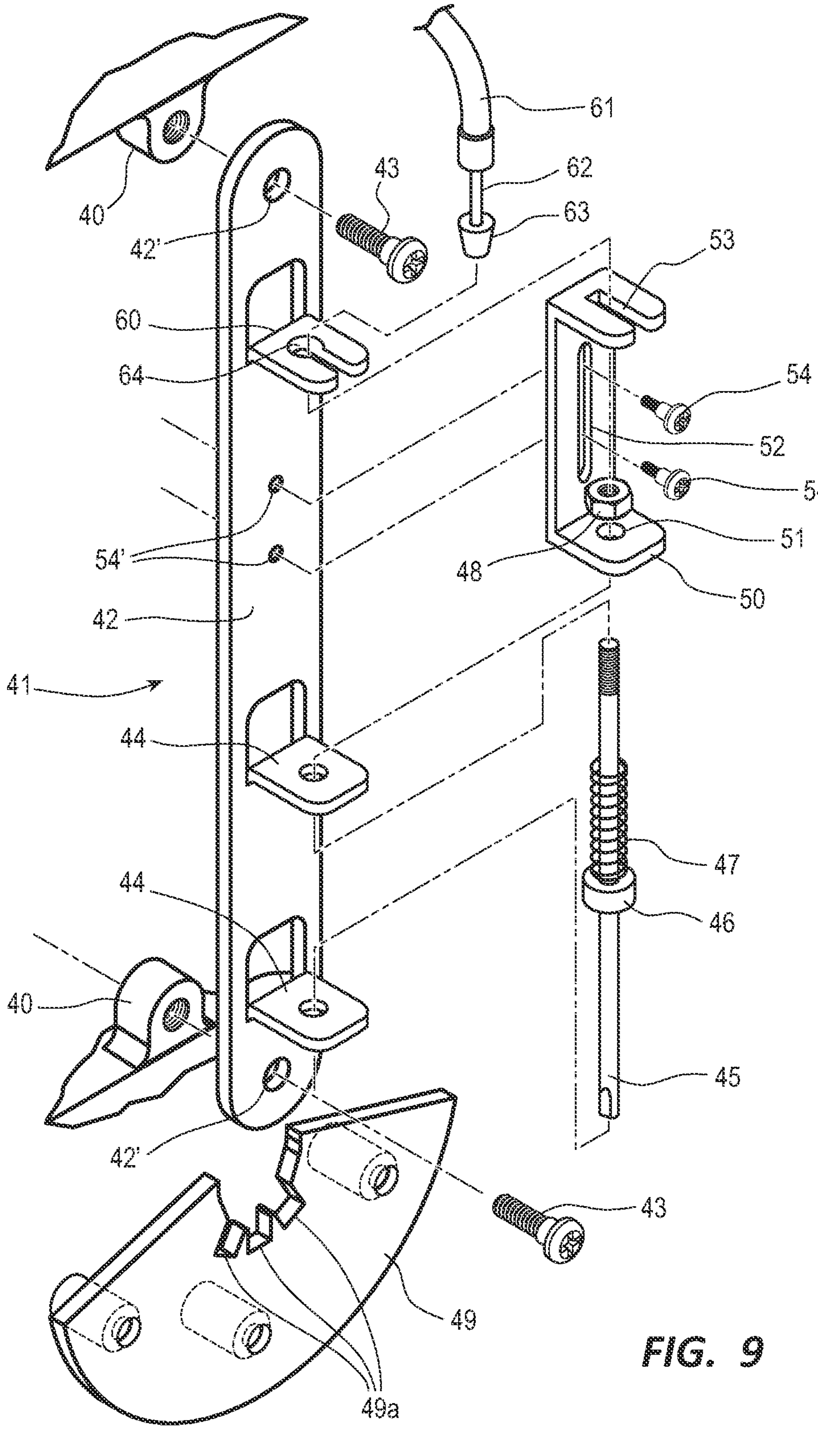
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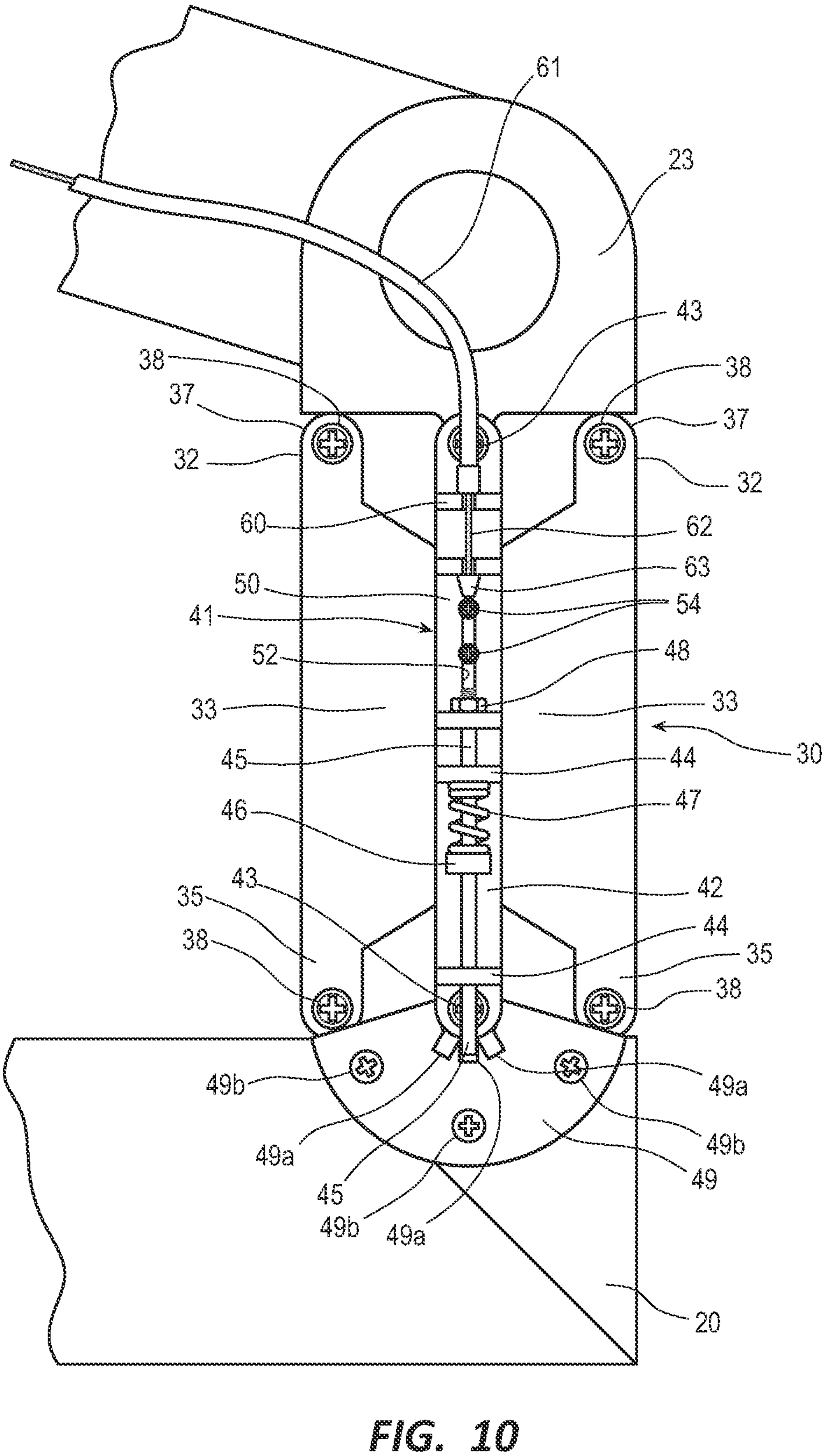
FIG. 9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49b
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FIG. 10

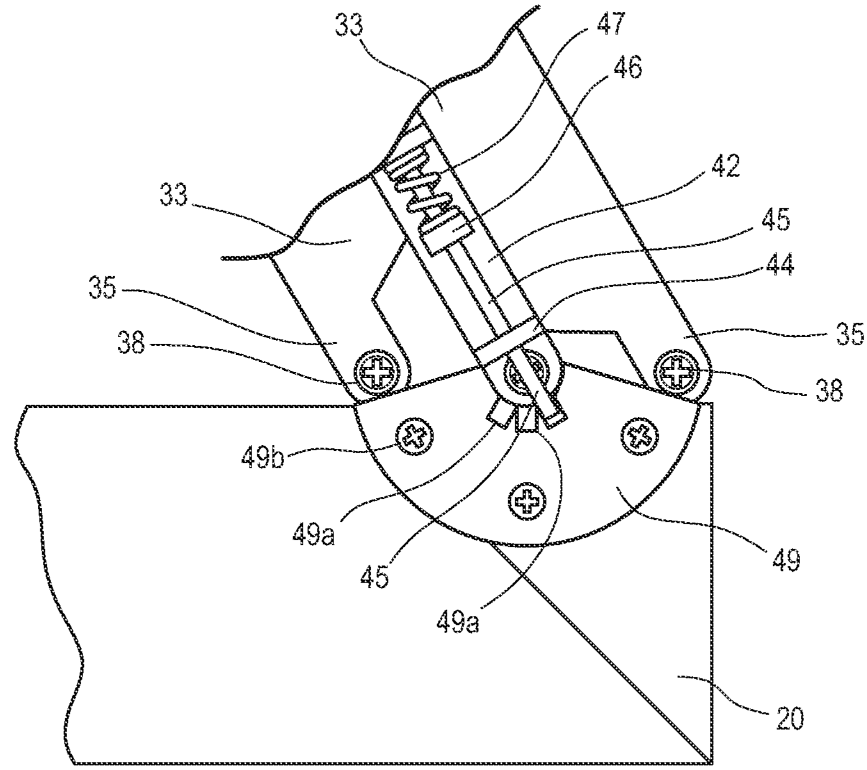

FIG. 11A

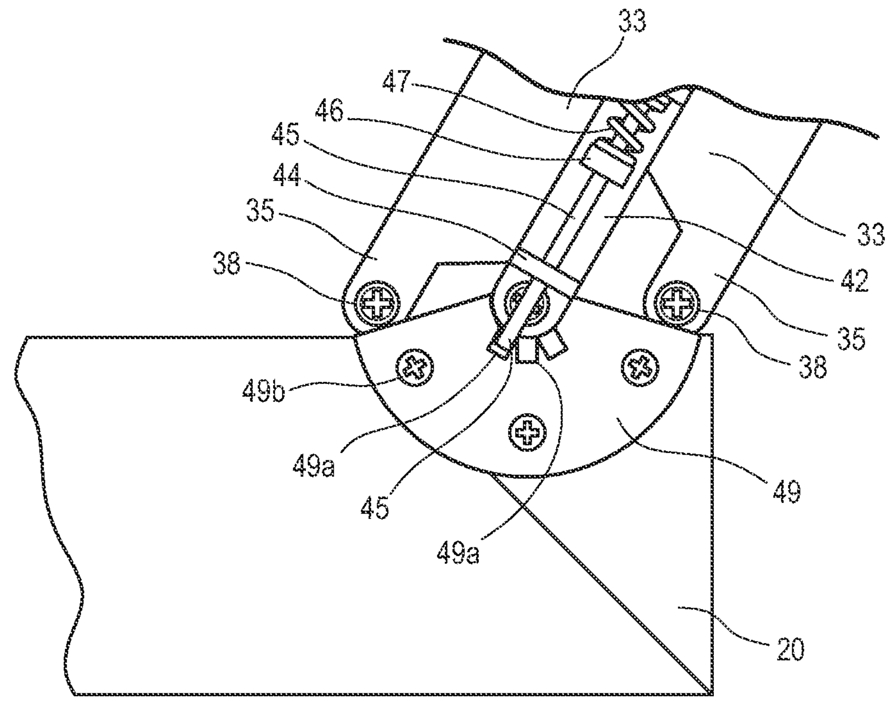

FIG. 11B

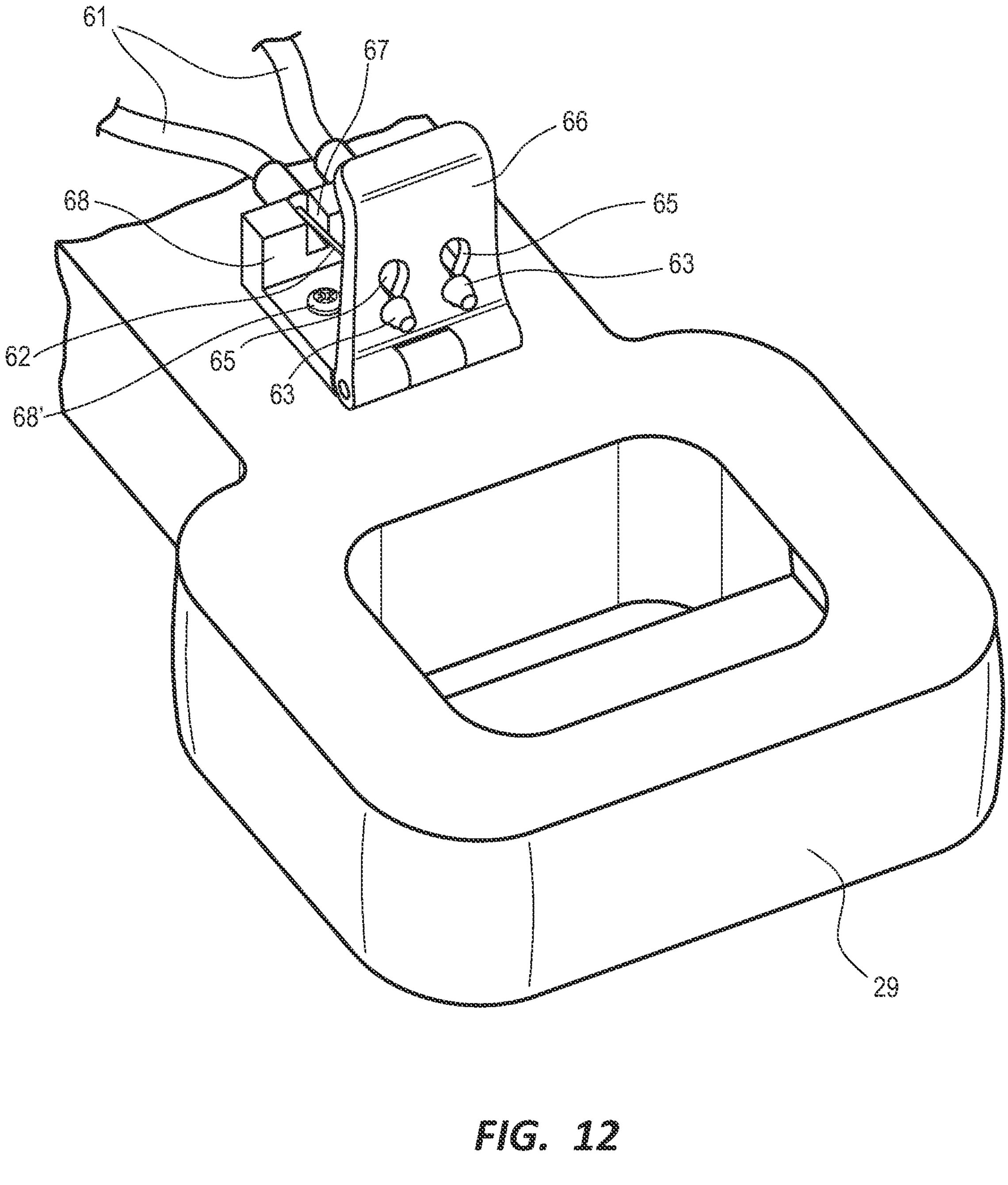

FIG. 12

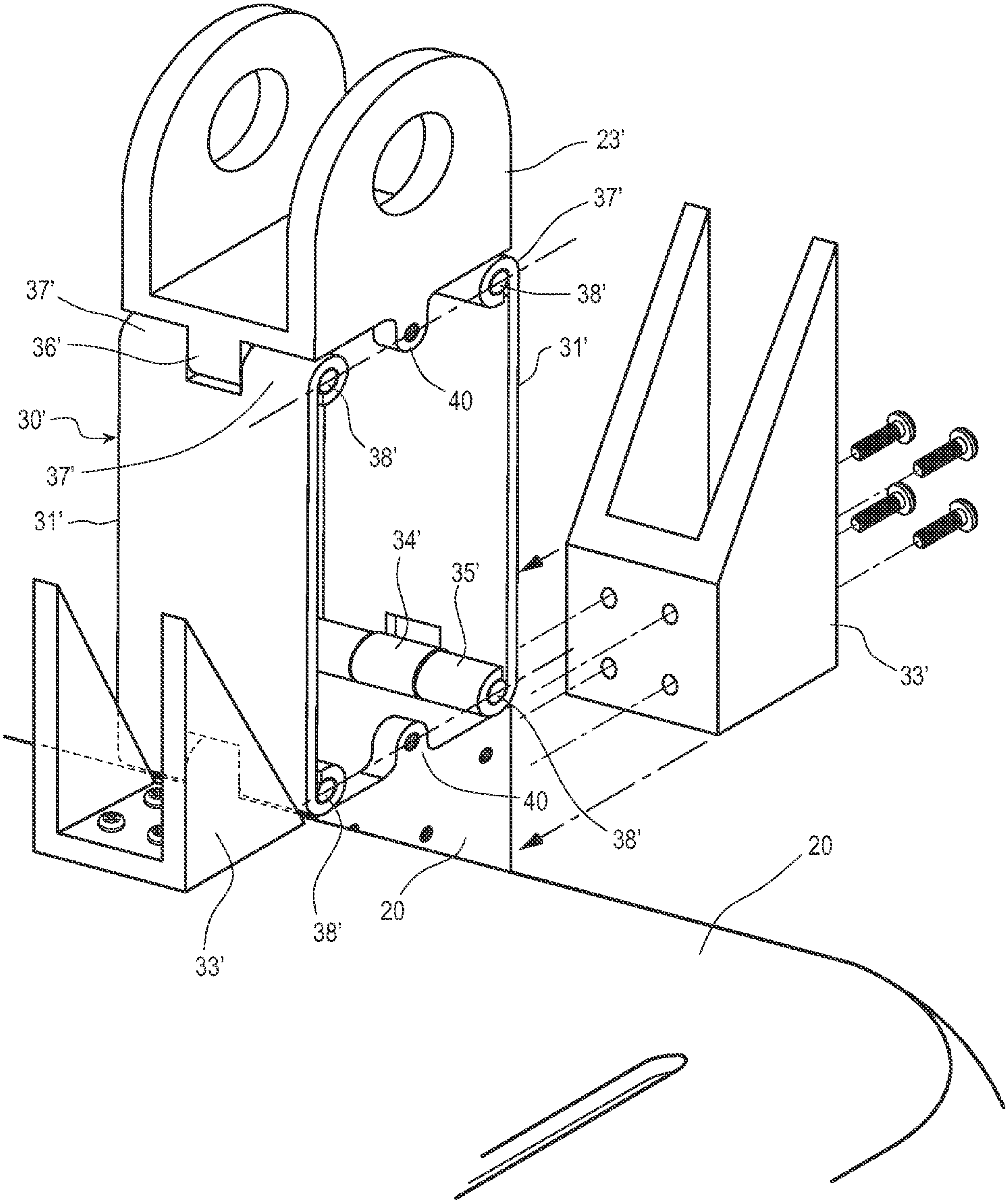

FIG. 13

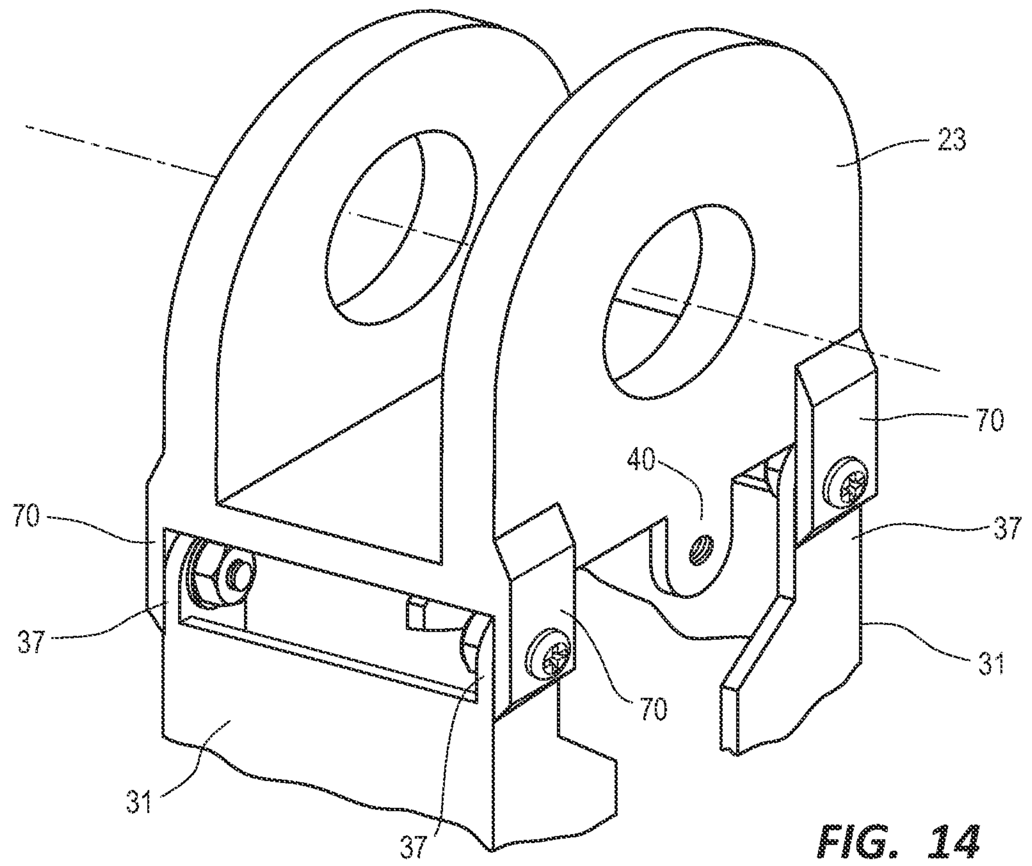

FIG. 14

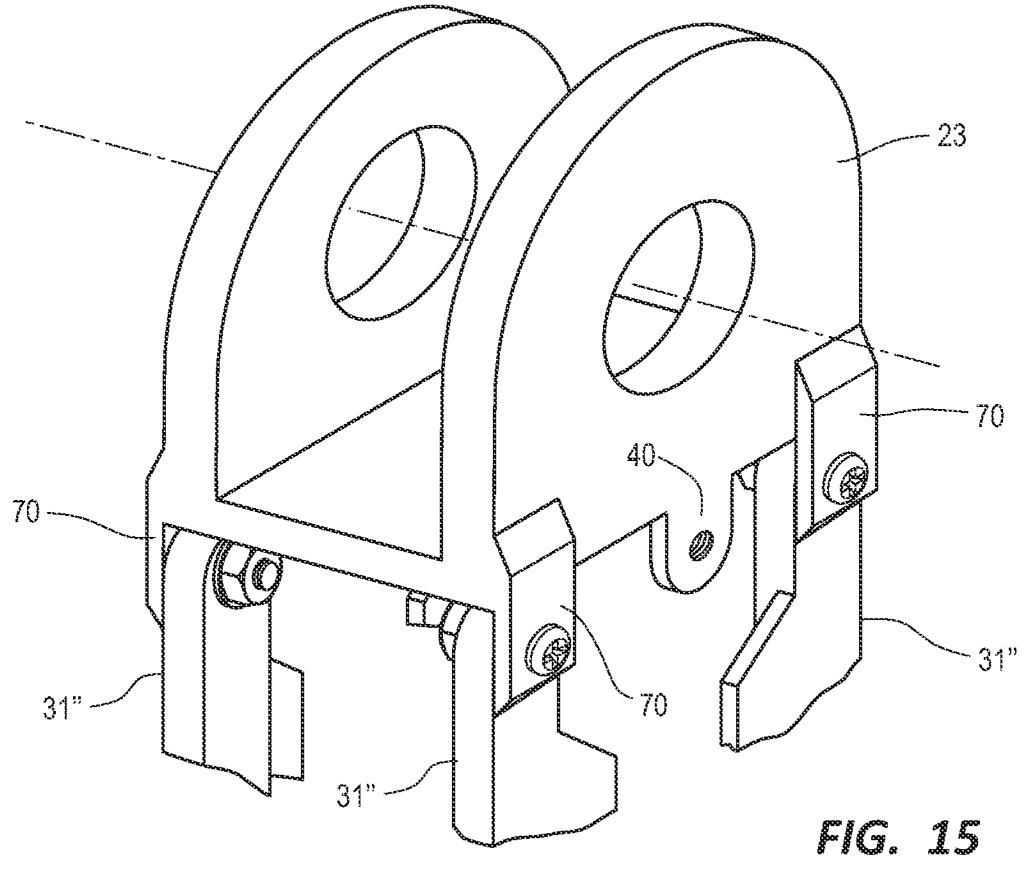

FIG. 15

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 21/19486

A. CLASSIFICATION OF SUBJECT MATTER
IPC - B23D 45/04, B26D 1/01 (2021.01)

CPC - B23D 45/04, B23D 45/046, B23D 45/061, Y10T 83/7693, Y10T 83/7697

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
See Search History document

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
See Search History document

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
See Search History document

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X — A	US 2010/0212467 A1 (Oohama) 26 August 2010 (26.08.2010), entire document, especially Fig. 1-3, para [0018], [0032], [0037], [0041], [0064]	1-2 — 3-7
A	US 2011/0303065 A1 (Liu et al.) 15 December 2011 (15.12.2011), entire document	1-7
A	US 2007/0113718 A1 (Oberheim) 24 May 2007 (24.05.2007), entire document	1-7
A	US 2016/0303666 A1 (Robert Bosch Tool Corportation) 20 October 2016 (20.10.2016), entire document	1-7
A	US 2011/0308368 A1 (Brown et al.) 22 December 2011 (22.12.2011), entire document	1-7
A	US 5,791,224 A (Suzuki et al.) 11 August 1998 (11.08.1998), entire document	1-7

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
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"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
26 April 2021	JUN 03 2021

Name and mailing address of the ISA/US	Authorized officer
Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-8300	Lee Young Telephone No. PCT Helpdesk: 571-272-4300