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Inventor(s)	Gereg; Dustin J. et al.

KNIFE ASSEMBLIES OF SLICING MACHINES, METHODS OF CLAMPING AND RELEASING KNIVES THEREFROM, AND SLICING MACHINES EQUIPPED THEREWITH

Abstract

Knife assemblies for securing knives to slicing machines, slicing machines equipped therewith, and methods of operating knife assemblies for securing knives to and releasing knives from slicing machines. Such a knife assembly includes a knife holder having a knife support surface, a knife supported on the knife support surface, and a clamp having a base portion adjacent a trailing edge of the clamp and a knife-engaging portion adjacent a leading edge of the clamp. The knife assembly applies a clamping load to the clamp to secure the knife to the knife holder. The clamp is prevented from translating relative to the shaped knife in a leading direction of the knife assembly as the clamping load is applied and/or permits removal of the clamp by being translated in the leading direction.

Inventors: **Gereg; Dustin J. (Valparaiso, IN), Klockow; Scott Alan (Kouts, IN), Baxter; Corey Everette (Valparaiso, IN)**

Applicant: **Urschel Laboratories, Inc.** (Chesterton, IN)

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Background/Summary

CROSS REFERENCE TO RELATED APPLICATIONS [0001] This is a division patent application of co-pending U.S. patent application Ser. No. 17/705,498 filed Mar. 28, 2022, which application claims the benefit of U.S. Provisional Application No. 63/176,977 filed Apr. 20, 2021. The contents of these prior patent documents are incorporated herein by reference.

BACKGROUND OF THE INVENTION
[0002] The present invention generally relates to methods and machines for cutting products, including but not limited to slicing food products. The invention particularly relates to knife assemblies for securing knives to slicing machines, slicing machines equipped therewith, and methods of operating knife assemblies for securing knives to and releasing knives from slicing machines.
[0003] Various types of equipment are known for slicing, shredding and granulating food products, as nonlimiting examples, vegetables, fruits, dairy products, and meat products. Widely used machines for this purpose are commercially available from Urschel Laboratories, Inc., and include machines under the name Model CC®. The Model CC® machines are centrifugal-type slicers capable of slicing a wide variety of products at high production capacities. The Model CC® line of machines is particularly adapted to produce uniform slices, strip cuts, shreds, and granulations. Certain configurations and aspects of Model CC® machines are represented in U.S. Pat. Nos. 3,139,128, 3,139,129, 5,694,824, 6,968,765, 7,658,133, 8,161,856, 9,193,086, 10,456,943, and 10,632,639, the entire contents of which are incorporated herein by reference.
[0004] FIG. **1** schematically represents a cross-sectional view of a machine **10** that is representative of a Model CC® machine. The machine **10** includes a generally annular-shaped cutting head **12** and an impeller **14** coaxially mounted within the cutting head **12**. The impeller **14** has an axis **17** of rotation that coincides with the center axis of the cutting head **12**, and is rotationally driven about its axis **17** through a shaft (not shown) that is enclosed within a housing **18** and coupled to a gear box **16**. The cutting head **12** is mounted on a support ring **15** above the gear box **16** and remains stationary as the impeller **14** rotates. Products are delivered to the cutting head **12** and impeller **14** through a feed hopper **11** located above the impeller **14**. In operation, as the hopper **11** delivers products to the impeller **14**, centrifugal forces cause the products to move outward into engagement with cutting knives (not shown) that are mounted along the circumference of the cutting head **12**. The impeller **14** comprises generally radially oriented paddles **13**, each having a face that engages and directs the products radially outward toward and against the knives of the cutting head **12** as the impeller **14** rotates. Other aspects pertaining to the construction and operation of Model CC® machines, including various embodiments thereof, can be appreciated from the aforementioned prior patent documents incorporated herein by reference.
[0005] FIGS. **2**A and **2**B are, respectively, isolated and fragmentary bottom views of a particular but nonlimiting example of a cutting head **12** that has been used with Model CC® slicing machines, including the machine **10** schematically represented in FIG. **1**. The cutting head **12** represented in FIGS. **2**A and **2**B will be described hereinafter in reference to the machine **10** of

FIG. **1** equipped with an impeller **14** as described in reference to FIG. **1**. On the basis of the coaxial arrangement of the cutting head **12** and the impeller **14**, relative terms including but not limited to Aaxial, @ Acircumferential, @ Aradial, @ etc., and related forms thereof may be used below to describe the cutting head **12** represented in FIGS. **2**A and **2**B as well as other representations of cutting heads herein. Furthermore, as used herein, “leading” (and related forms thereof) refers to a position on a cutting head (or a component thereof) that is ahead of or precedes another in the direction of rotation of an impeller assembled with and rotating within the cutting head, whereas “trailing” (and related forms thereof) refers to a position on the cutting head (or a component thereof) that follows or succeeds another relative to the direction of the impeller's rotation.

[0006] In FIG. **2**A, the cutting head **12** can be seen as generally annular-shaped with cutting knives **20** mounted and circumferentially spaced apart along its perimeter. FIGS. **2**A and **2**B represent the knives **20** as each having a straight cutting edge and being substantially flat between its oppositely-disposed cutting and trailing edges, and as such are referred to herein as Aflat@ knives that are commonly used to produce flat slices, though the cutting head **12** can use knives of other shapes. As an example, a Ashaped@ knife is referred to herein as a knife that does not have a straight cutting edge and is not substantially flat between its cutting and trailing edges. Shaped knives include but are not limited to what may be referred to herein as “corrugated” knives characterized by a periodic pattern of alternating peaks and valleys when viewed edgewise and commonly used to produce corrugated, strip-cut, shredded, or granulated products. Each knife **20** projects radially inward in a direction generally opposite the direction of rotation of the impeller **14** within the cutting head **12**, and defines a cutting edge at its innermost radial extremity. The cutting head **12** further comprises lower and upper support members, represented in FIG. **2**A as rings **22** and ring **24**, to and between which circumferentially-spaced support segments, referred to herein as shoes **26**, are secured with fasteners **34**.

[0007] A knife **20** can be associated with each shoe **26**, in which case the shoes **26** may be referred to as cutting stations of the cutting head **12**. The knives **20** of the cutting head **12** are represented in FIGS. **2**A and **2**B as individually secured with knife assemblies **28** to their respective shoes **26**. Each knife assembly **28** is represented as including a knife holder **30** mounted to a shoe **26** and between the support rings **22** and **24**, and a clamp **32** positioned on the radially outward-facing side of the holder **30** to secure a knife **20** thereto. Each knife **20** is supported by a radially outer surface of one of the knife holders **30** at a leading edge of the knife holder **30**. The radially outer surfaces of the knife holders **30** that contact and support the knives **20** are referred to herein as knife support surfaces **30**A, and each is represented as having a shape (e.g., flat or shaped) that is complementary to the shape (e.g., flat or shaped) of the knife **20** it supports. The corresponding clamp **32** overlies the holder **30** so that the knife **20** is between the knife support surface **30**A of the holder **30** and a radially inner surface of the clamp **32** that faces the holder **30** and is located adjacent a leading edge of the clamp **32**. The radially inner surfaces of the clamps **32** that contact and overlie the knives **20** are referred to herein as knife clamping surfaces **32**A, and may have shapes (e.g., flat or shaped) that are complementary to the shapes (e.g., flat or shaped) of the knives **20** they contact. By forcing the clamp **32** toward the knife support surface **30**A of the holder **30**, for example, with bolts **36**, the clamp **32** applies a clamping force to the knife **20** adjacent its cutting edge. FIGS. **2**A and **2**B further show a gate **38** secured to each shoe **26**. A food product crosses the gate **38** prior to encountering the knife **20** mounted to the succeeding shoe **26**, and together the cutting edge of a knife **20** and a trailing edge of the preceding gate **38** define a gate opening **40** (FIG. **2**B) that determines the thickness of a slice produced by the knife **20**.

[0008] FIG. **2**B evidences that the bolts **36** advantageously prevent the clamp **32** from moving relative to the knife **20** and knife holder **30** in a leading direction of the cutting head **12** (indicated by the horizontal arrow in FIG. **2**B) as and after the bolts **36** are tightened to secure the clamp **32** and knife **20** to the knife holder **30**, which ensures that the leading edge of the clamp **32** is properly located in relation to the leading edge of the knife holder **30** to ensure a desirable clamping effect

on the knife **20**. Only after the bolts **36** are entirely removed are the clamp **32** and knife **20** able to be removed from the knife holder **30** by lifting them individually or together in the radial direction of the cutting head **12** (indicated by the vertical arrow in FIG. **2**B). The knife **20** and clamp **32** are also able to freely translate individually or together in the leading direction of the cutting head **12** (indicated by the horizontal arrow in FIG. **2**B) and the axial direction of the cutting head **12** (in a direction perpendicular to the vertical and horizontal arrows in FIG. **2**B). These movements are possible even while the knife **20** and clamp **32** remain engaged with the knife holder **30**.

[0009] FIG. **3** illustrates a knife assembly **28** that utilizes a corrugated knife **20** of a type capable of producing corrugated, strip-cut, shredded, or granulated products. FIG. **3** is a circumferential view of the knife assembly **28** in the trailing direction, such that the leading edges of the knife **20**, knife holder **30**, and clamp **32** are visible. As evident from FIG. **3**, due to the complementary shapes of the knife **20**, knife clamping surface **32**A of the clamp **32**, and knife support surface **30**A of the holder **30**, the knife **20** and clamp **32** are prevented from translating relative to each other and to the knife holder **30** in the axial direction (indicated by the vertical arrow in FIG. **3**) of the cutting head **12** while the knife **20** and clamp **32** still engage the knife support surface **30**A of the knife holder **30**. As a result, to remove the clamp **32** and knife **20** from the knife holder **30**, the knife **20** and clamp **32** must first be translated in the radial direction (indicated by the horizontal arrow in FIG. **3**) or the leading direction of the cutting head **12** (in a direction perpendicular to the vertical and horizontal arrows in FIG. **3**) to disengage the knife **20** and clamp **32** from the knife support surface **30**A of the knife holder **30**.

[0010] While the Model CC® has performed extremely well for its intended purpose, further improvements are continuously desired and sought for slicing machines of the type represented by the Model CC®. As an example, in some situations it may be desirable to enable a shaped knife (for example, the corrugated knife **20** of FIG. **3**) to be secured with bolts **36** to prevent the clamp **32** from moving circumferentially relative to the knife **20** and knife holder **30** as and after the bolts **36** are tightened to ensure that the leading edge of the clamp **32** is properly located in relation to the leading edge of the knife holder **30**, and yet not require complete removal of the bolts **36** to remove the clamp **32** and knife **20** from the cutting head **12**.

BRIEF SUMMARY OF THE INVENTION

[0011] The present invention provides knife assemblies for securing knives to slicing machines, slicing machines equipped therewith, and methods of operating knife assemblies for securing knives to and releasing knives from slicing machines.

[0012] According to a nonlimiting aspect of the invention, a knife assembly includes a knife holder having a knife support surface, a knife supported on the knife support surface of the knife holder so as to protrude from a leading edge of the knife holder, and a clamp having a base portion adjacent a trailing edge of the clamp and a knife-engaging portion adjacent a leading edge of the clamp. The base portion has at least one slot formed therein and at least part of the knife-engaging portion has a shape complementary to the knife. The knife assembly further has means for applying a clamping load to the clamp to secure the knife to the knife holder, wherein the applying means comprises a fastener received in the slot in the base portion of the clamp. The knife assembly also has means for preventing the clamp from translating relative to the knife in a leading direction of the knife assembly as the clamping load is applied to the clamp by the applying means.

[0013] According to another nonlimiting aspect of the invention, a method is provided for removing a clamp of a knife assembly that secures a knife to a cutting head of a slicing machine. The cutting head has a leading direction, a trailing direction opposite the leading direction, an axial direction perpendicular to the leading and trailing directions, and a radial direction perpendicular to the leading, trailing, and radial directions. The clamp has a knife-engaging portion that forms a leading edge of the clamp, has a shape that is complementary to the knife, and physically contacts the knife when in a clamping position. The method includes removing a clamping load from the clamp that secures the clamp in the clamping position, translating the clamp in the leading direction

of the cutting head so that the clamp arrives at a release position and the knife-engaging portion no longer contacts the knife in the release position, and then removing the clamp from the knife assembly.
[0014] According to other aspects of the invention, slicing machines are provided that are equipped with one or more knife assemblies having elements as described above.
[0015] Technical effects of the invention include the ability to enable a clamp to be removed from a knife assembly equipped with a knife by translating the clamp in the leading direction of the knife assembly, and in some cases prevent the clamp from translating relative to the knife, particularly in the leading direction of the knife assembly, as the clamping load is applied to the clamp.
[0016] Other aspects and advantages of this invention will be appreciated from the following detailed description.

Description

BRIEF DESCRIPTION OF THE DRAWINGS
[0017] FIG. **1** schematically represents a side view in partial cross-section of a centrifugal-type slicing machine known in the art.
[0018] FIGS. **2**A and **2**B are, respectively, isolated and fragmentary bottom views representing details of a cutting head that has found use in slicing machines of the type represented in FIG. **1**.
[0019] FIG. **3** is a circumferential view of a knife assembly capable of use with the cutting head of FIGS. **2**A and **2**B.
[0020] FIGS. **4**A through **9**D schematically represent knife assemblies adapted to mount to cutting heads of slicing machines, such as but not limited to the cutting head of FIG. **2**A and the slicing machine of FIG. **1**, and represent alternative methods of removing clamps from the knife assemblies.
[0021] FIG. **10** is a fragmentary side view of a knife assembly of a slicing machine, such as but not limited to the slicing machine of FIG. **1**, and represents the knife assembly as comprising a knife holder and a clamp retaining a shaped knife on the knife holder.
[0022] FIG. **11** schematically represents an end view of the clamp of FIG. **10**, and diagrammatically represents forces acting on the clamp when secured to the knife holder as shown in FIG. **10**.
[0023] FIG. **12** is a fragmentary side view of a knife assembly for a slicing machine, and represents the knife assembly as comprising a knife holder, a clamp retaining a shaped knife on the knife holder, and a support bar securing the clamp to the knife holder according to a nonlimiting embodiment of the present invention.
[0024] FIG. **13** is an isolated view of the support bar of FIG. **12**.
[0025] FIG. **14** is a fragmentary side view of the knife assembly of FIG. **12**, and represents the support bar rotated out of contact with the clamp according to a nonlimiting aspect of the present invention.
[0026] FIG. **15** schematically represents an end view of the clamp and support bar of FIG. **12**, and diagrammatically represents forces acting on the clamp when secured to the knife holder with the support bar as shown in FIG. **12**.
[0027] FIG. **16** is a fragmentary side view of a knife assembly that differs from the knife assembly of FIGS. **12** and **14** by the clamp being attached to the support bar according to another nonlimiting embodiment of the present invention.
[0028] FIG. **17** schematically represents an end view of the clamp and support bar of FIG. **16**, and diagrammatically represents forces acting on the clamp when secured to the knife holder with the support bar as shown in FIG. **16**.
[0029] FIG. **18** is a fragmentary side view of a knife assembly for a slicing machine, and represents

the knife assembly as comprising a knife holder and a clamp retaining a shaped knife on the knife holder according to another nonlimiting embodiment of the present invention.
[0030] FIG. **19** is a detailed side view of the knife assembly of FIG. **18**, and FIG. **20** is a fragmentary cross-sectional view of the knife assembly of FIG. **18**.
[0031] FIG. **21** is a perspective view of a knife assembly for a slicing machine, and represents the knife assembly as comprising a knife holder, a clamp retaining a shaped knife on the knife holder, and a wedge assembly securing the clamp to the knife holder according to another nonlimiting embodiment of the present invention.
[0032] FIG. **22** is a perspective view of the knife assembly of FIG. **21** with an upper member of the wedge assembly removed.
[0033] FIGS. **23**, **24**, and **25** are three different perspective views of the upper member of the wedge assembly of FIG. **21** showing the upper member in isolation.
[0034] FIGS. **26** and **27** are cross-sectional views of the knife assembly of FIGS. **21** and **22**, representing the knife assembly in unlocked (FIG. **26**) and locked (FIG. **27**) configurations.
[0035] FIG. **28** schematically represents an end view of the knife assembly of FIGS. **21**, **26**, and **27**, and diagrammatically represents forces acting on the clamp when secured to the knife holder with the wedge assembly as shown in FIGS. **21** and **27**.
[0036] FIG. **29** is a side view of a knife assembly for a slicing machine, and represents the knife assembly as comprising a knife holder, a clamp retaining a shaped knife on the knife holder, and a cam rod generating a clamping load applied by the clamp to the knife according to another nonlimiting embodiment of the present invention.
[0037] FIG. **30** shows the knife assembly of FIG. **29**, and represents the cam rod as having been rotated to release the clamping load applied by the clamp to the knife.
[0038] FIG. **31** schematically represents an end view of the knife assembly of FIGS. **29** and **30**, and diagrammatically represents forces acting on the clamp when secured to the knife holder with the cam rod as shown in FIG. **29**.

DETAILED DESCRIPTION OF THE INVENTION

[0039] The intended purpose of the following detailed description of the invention and the phraseology and terminology employed therein is to describe what is shown in the drawings, which relate to one or more nonlimiting embodiments of the invention, and to describe certain but not all aspects of what is depicted in the drawings. The following detailed description also identifies certain but not all alternatives of the embodiment(s) depicted in the drawings. Therefore, the appended claims, and not the detailed description, are intended to particularly point out subject matter regarded as the invention, including certain but not necessarily all of the aspects and alternatives described in the detailed description.
[0040] FIGS. **4**A through **31** schematically represent nonlimiting embodiments of knife assemblies and components thereof that are capable of use with a variety of cutting machines, including the centrifugal-type slicing machine **10** depicted in FIG. **1** and the cutting head of FIG. **2**A, and in some instances may be a replacement or modification of knife assemblies and components for such machines. As a matter of convenience, the knife assemblies will be illustrated and described hereinafter in reference to the slicing machine **10** of FIG. **1** equipped with an annular-shaped cutting head **12** as described in reference to FIGS. **1** and **2**A, and as such the following discussion will focus primarily on certain aspects of knife assemblies that will be described in reference to the slicing machine **10** and cutting head **12**, whereas other aspects not discussed in any detail below may be, in terms of structure, function, materials, etc., essentially as was described in reference to FIGS. **1** and **2**A. However, it will be appreciated that the teachings of the invention are also generally applicable to other types of cutting machines. Moreover, though such machines are particularly well suited for slicing food products, it is within the scope of the invention that impellers described herein could be utilized in cutting machines that cut a wide variety of other types of materials.

[0041] To facilitate the description provided below of the knife assemblies represented in the drawings, relative terms may be used in reference to the orientation of the knife assemblies within an annular-shaped cutting head, as represented and described in reference to FIGS. **1** and **2**A. On the basis of the coaxial arrangement of the cutting head **12** and impeller **14** in FIG. **1**, relative terms including but not limited to “axial,” “circumferential,” “radial,” etc., and related forms thereof may also be used below to describe the nonlimiting embodiments represented in the drawings. All such relative terms are useful to describe the knife assemblies depicted in FIGS. **4**A through **31**, but should not be otherwise interpreted as limiting the scope of the invention. Furthermore, as used herein, “leading” (and related forms thereof) refers to a position on the cutting head **12** (or a component thereof) that is circumferentially ahead of or precedes another in the direction of rotation of the impeller **14** when assembled with and rotating within a cutting head **12**, whereas “trailing” (and related forms thereof) refers to a position on the cutting head **12** (or a component thereof) that circumferentially follows or succeeds another relative to the direction of rotation of the impeller **14**. As such, the cutting head **12** can be characterized as having a leading direction, a trailing direction opposite the leading direction, an axial direction perpendicular to the leading and trailing directions, and a radial direction perpendicular to the leading, trailing, and radial directions.
[0042] For convenience, consistent reference numbers are used throughout FIGS. **4**A through **31** to identify the same or functionally related/equivalent elements of the various embodiments of knife assemblies represented in the drawings.
[0043] FIGS. **4**A through **9**D schematically represent different methods by which a clamp can be removed from a knife assembly mounted to a cutting head of a slicing machine, such as but not limited to the slicing machine of FIG. **1**. Though shown as secured with threaded fasteners (bolts), the clamps depicted in FIGS. **4**A through **9**D may be secured by other means, as nonlimiting examples, various types of fasteners, levers, and/or cams.
[0044] FIGS. **4**A, **4**B, and **4**C are a series of fragmentary side views of a nonlimiting embodiment of a knife assembly **50** that is represented as comprising a knife holder **52** and a clamp **54** securing a flat knife **56** on a knife support surface **52**A of the knife holder **52**. As previously noted, a Aflat@ knife refers to a knife **56** that has a straight cutting edge and is substantially flat between its oppositely-disposed cutting and trailing edges, while a “shaped” knife refers to a knife **56** that does not have a straight cutting edge and is not substantially flat between its cutting and trailing edges. At least the portion of the knife support surface **52**A beneath the knife **56** in FIGS. **4**A through **4**C preferably has a shape complementary to the knife **56**. Though other mounting arrangements are foreseeable and within the scope of the invention, it should be understood that the knife holder **52** depicted in FIGS. **4**A, **4**B, and **4**C is configured to be mounted to a shoe **26** and between support rings **22** and **24** of the cutting head **12**, generally as represented in FIG. **2**A. The clamp **54** is indicated as comprising a knife-engaging portion **54**A that forms a leading edge of the clamp **54**, physically contacts the knife **56**, and therefore has a shape that is complementary to the knife **56**. The clamp **54** further comprises a base portion **54**B that forms a trailing edge **76** of the clamp **54** and is configured to be engaged by means adapted to secure the clamp **54** to the knife holder **52** and apply a clamping load to the clamp **54** when the clamp **54** is in a clamping position depicted in FIG. **4**A. In FIGS. **4**A, **4**B, and **4**C, such means is represented as threaded fasteners **60** (in this particular example, bolts) that pass through the clamp **54** and are threaded into the knife holder **52**. The knife-engaging and base portions **54**A and **54**B of the clamp **54** are not coplanar, enabling the knife-engaging portion **54**A to more closely coincide with the orientation of the knife **56** on the knife support surface **52**A of the knife holder **52**.
[0045] Loosening the fasteners **60** removes the clamping load that secures the clamp **54** in the clamping position of FIG. **4**A. The shafts (not visible) of the fasteners **60** are received in keyway slots **74**, which are narrower than the heads of the fasteners **60** so that the clamping load can be applied by tightening the fasteners **60** so that their heads engage the base portion **54**B along the edges of the slots **74**. The slots **74** are configured so that the clamp **54** can be removed from the

knife holder **52** by loosening the fasteners **60** without requiring complete removal of the fasteners **60** from the knife holder **52**. The keyway slots **74** are formed in the base portion **54**B of the clamp **54** to be contiguous with the trailing edge **76** of the clamp **54** and extend toward (but shown as terminating short of) the knife-engaging portion **54**A of the clamp **54** to form an interior distal edge **74**A (FIGS. **4**B and **4**C) within each slot **74**. Each slot **74** is represented as having a constant width along its entire length, though it is foreseeable that any of the slots **74** could be defined to have wider and narrower portions. As evident from FIGS. **4**A, **4**B, and **4**C, the distal edges **74**A of the slots **74** serve as stops that prevent the clamp **54** from being removed from the knife assembly **50** by being translated in the circumferential trailing direction (leftward in FIGS. **4**A, **4**B, and **4**C) of the cutting head **12**. However, the slots **74** are configured to enable the clamp **54** to be removed from the knife assembly **50** by translating the clamp **54** in the leading direction (rightward as indicated by the arrows in FIGS. **4**B and **4**C) of the cutting head **12** so that the fasteners **60** are no longer within the slots **74** and the clamp **54** is freed from the knife holder **52** (FIG. **4**B). In particular, translating the clamp **54** in the leading direction causes the knife-engaging portion **54**A, which forms the leading edge of the clamp **54**, has a shape that is complementary to the knife **56**, and physically contacts the knife **56** when in the clamping position (FIG. **4**A), to no longer contact the knife **56** in the release position (FIG. **4**B). From the release position, translation of the clamp **54** in the leading direction can continue as represented in FIG. **4**C, or the clamp **54** can be lifted from the knife assembly **50** in a radial direction of the cutting head **12**. Once released by the complete removal of the clamp **54** (FIG. **4**C), the underlying knife **56** is exposed and may also be removed. To reinstall the clamp **54** on the knife holder **52**, the clamp **54** can be translated in the circumferential trailing direction (leftward in FIGS. **4**A, **4**B, and **4**C) to insert the fasteners **60** into their respective slots **74** until the fasteners **60** abut the distal edges **74**A of the slots **74** prior to tightening the fasteners **60** to secure the clamp **54** to the knife holder **52** (and in so doing expose the cutting edge of the knife **56**). Such a configuration facilitates removal of the knife and cleaning of the knife assembly **50** and its components.

[0046] FIGS. **5**A and **5**B illustrate that the method of removing the clamp **54** as represented in FIGS. **4**A, **4**B, and **4**C is equally applicable to a knife assembly **50** that differs from the assembly **50** of FIGS. **4**A, **4**B, and **4**C by utilizing a shaped knife **56** and being equipped with a clamp **54** (or at least a knife clamping surface **54**C on the knife-engaging portion **54**A of the clamp **54**) and knife holder **52** (or at least the knife support surface **52**A of the knife holder **52**) that have shapes complementary to the shaped knife **56**. In this example, the knife **56** is a corrugated knife **56** of a type capable of producing corrugated, strip-cut, shredded, or granulated products. FIG. **5**A shows a clamping position in which the knife **56** is clamped to the knife support surface **52**A of the knife holder **52** as a result of the clamp **54** being secured with a fastener **60** to the knife holder **52**, and FIG. **5**B shows a release position in which the fastener **60** has been sufficiently loosened to enable the clamp **54** to be translated in the leading direction (rightward as indicated by the horizontal arrow in FIG. **5**B). As evident from FIG. **5**B, the knife-engaging portion **54**A of the clamp **54**, which forms the leading edge of the clamp **54** and has the knife clamping surface **54**C whose shape is complementary to the knife **56** and physically contacts the knife **56** when in the clamping position (FIG. **5**A), no longer contacts the knife **56** in the release position (FIG. **5**B). From the release position, further translation of the clamp **54** in the circumferential leading direction of the cutting head **12** can continue in the same manner as represented in FIG. **4**C, or the clamp **54** can be lifted from the knife assembly **50** in a radial direction of the cutting head **12** (indicated by the vertical arrow in FIG. **5**B), or translated in the axial direction of the cutting head **12** (in a direction perpendicular to the vertical and horizontal arrows in FIG. **5**B).

[0047] FIG. **6** is a circumferential view of the knife assembly **50** of FIGS. **5**A and **5**B looking in the trailing direction, such that the leading edges of the knife **56**, knife holder **52**, and clamp **54** are visible. FIG. **6** corresponds to the condition of the knife assembly **50** shown in FIG. **5**B, and as such depicts the release position in which the fastener **60** (not shown) has been sufficiently

loosened to enable the clamp **54** to be translated in the leading direction. As evident from FIG. **6**, translating the clamp **54** in the leading direction causes its knife clamping surface **54**C to disengage the complementary-shaped knife **56**, and as such the clamp **54** can be freely translated relative to the knife **56** and knife holder **52** in the axial direction (indicated by the vertical arrow in FIG. **6**) of the cutting head **12**. As a result, the clamp **54** can be fully removed from the knife assembly **50** after being translated in the leading direction as shown in FIGS. **5**B and **6**.

[0048] In view of similarities between the embodiments of FIGS. **4**A through **6** and FIGS. **7**A through **9**D, the following discussion of FIGS. **7**A through **9**D will focus primarily on aspects of their respective embodiments that differ from the embodiments of FIGS. **4**A through **6** in some notable or significant manner. Other aspects of the embodiments of FIGS. **7**A through **9**D not discussed in any detail can be, in terms of structure, function, materials, etc., essentially as was described for the embodiments of FIGS. **4**A through **6**.

[0049] FIGS. **7**A and **7**B are a series of fragmentary side views of another nonlimiting embodiment of a knife assembly **50**, and FIG. **7**C is a top view of the same knife assembly **50**. FIG. **7**A depicts the clamping position in which the clamp **54** is secured with fasteners **60** whose shafts (not visible) are received in slots **74** that have wider and narrower portions. The wider portions of the slots **74** extend toward but are not contiguous with the trailing edge **76** of the clamp **54**, and the narrower portions of the slots **74** extend toward (but terminate short of) the knife-engaging portion **54**A of the clamp **54**, forming an interior distal edge **74**A (FIG. **7**B) within each slot **74** that serves as a stop to prevent the clamp **54** from being removed from the knife assembly **50** by being translated in the circumferential trailing direction (leftward in FIGS. **7**A, **7**B, and **7**C) of the cutting head **12**. The narrower portions of the slots **74** are narrower than the heads of the fasteners **60**, enabling the fasteners **60** to secure the clamp **54** to the knife holder **52** in the clamping position. The wider portions of the slots **74** are larger than the heads of the fasteners **60** (FIG. **7**B), permitting the clamp **54** to be removed from the knife holder **52** by loosening the fasteners **60** and translating the clamp **54** in the leading direction (rightward in FIGS. **7**A and **7**B as indicated by the arrow in FIG. **7**B) without requiring removal of the fasteners **60** from the knife holder **52**. In FIG. **7**B, which depicts the release position, the heads of the fasteners **60** are aligned with the wider portions of the slots **74** and able to pass through the slots **74** as the clamp **54** is lifted from the knife assembly **50** in a radial direction (indicated by the arrow in FIG. **7**C) of the cutting head **12**.

[0050] On the basis of FIGS. **5**A and **5**B, it can be appreciated that the method of removing the clamp **54** as represented in FIGS. **7**A, **7**B, and **7**C is equally applicable to a knife assembly **50** that utilizes a shaped knife **56** and a clamp **54** and knife holder **52** that have complementary-shaped support and clamping surfaces **52**A and **54**C, since translating the clamp **54** in the leading direction disengages the knife clamping surface **54**C of the clamp **54** from the complementary-shaped knife **56**.

[0051] FIGS. **8**A through **8**C are similar to FIGS. **7**A through **7**C, representing another nonlimiting embodiment of a knife assembly **50** that differs from the embodiment of FIGS. **7**A through **7**C as a result of the wider portions of its slots **74** extending toward and being open to and contiguous with the trailing edge **76** of the clamp **54**. As with the embodiment of FIGS. **7**A through **7**C, narrower portions of the slots **74** are narrower than the heads of the fasteners **60**, enabling the fasteners **60** to secure the clamp **54** to the knife holder **52** in a clamping position, and the clamp **54** can be removed from the knife holder **52** by loosening the fasteners **60** and translating the clamp **54** in the leading direction (rightward in FIGS. **8**A through **8**C as indicated by the arrow in FIG. **8**B) without requiring removal of the fasteners **60** from the knife holder **52**. Thereafter, FIG. **8**B evidences that in the release position, the heads of the fasteners **60** are aligned with the wider portions of the slots **74** and able to pass through the slots **74** so that the clamp **54** can be lifted from the knife assembly **50** in a radial direction (indicated by the arrow in FIG. **8**C) of the cutting head **12**. Alternatively, because the wider portions of the slots **74** are open to and contiguous with the trailing edge **76** of the clamp **54**, from the release position of FIG. **8**B the clamp **54** may be further translated in the

leading direction in the same manner as represented in FIG. **4**C and discussed in reference to FIG. **5**B.

[0052] It can be appreciated that the method of removing the clamp **54** as represented in FIGS. **8**A through **8**C is equally applicable to a knife assembly **50** that utilizes a shaped knife **56** and equipped with a clamp **54** and knife holder **52** that have complementary-shaped support and clamping surfaces **52**A and **54**C, since translating the clamp **54** in the leading direction disengages the knife clamping surface **54**C of the clamp **54** from the complementary-shaped knife **56**.

[0053] FIGS. **9**A through **9**D are similar to FIGS. **7**A through **7**C, representing another nonlimiting embodiment of a knife assembly **50** that differs from the embodiment of FIGS. **7**A through **7**C as a result of the slots **74** being L-shaped. As a result, from the clamping position of FIG. **9**A, the clamp **54** can be removed from the knife holder **52** by loosening the fasteners **60**, translating the clamp **54** in the leading direction (rightward in FIG. **9**B as indicated by the arrow) of the cutting head **12**, and then translating the clamp **54** in the axial direction (downward in FIG. **9**C as indicated by the arrow) of the cutting head **12** to arrive at the release position (FIG. **9**C). Thereafter, the clamp **54** can be lifted from the knife assembly **50** in a radial direction (indicated by the arrow in FIG. **9**D) of the cutting head **12**.

[0054] Again, it should be appreciated that the method of removing the clamp **54** as represented in FIGS. **9**A through **9**D is equally applicable to a knife assembly **50** that utilizes a shaped knife **56** and equipped with a clamp **54** and knife holder **52** that have complementary-shaped support and clamping surfaces **52**A and **54**C. In particular, translating the clamp **54** in the leading direction to the release position of FIG. **9**B causes the knife clamping surface **54**C of the clamp **54** to disengage from the complementary-shaped knife **56**, such that the clamp **54** is able to be translated in the axial direction (downward in FIG. **9**C as indicated by the arrow) of the cutting head **12**.

[0055] FIG. **10** is a fragmentary side view of an embodiment of a knife assembly **50** similar to that of FIGS. **8**A through **8**C. The knife assembly **50** is represented as mounted to a cutting head **12** of a slicing machine, such as but not limited to the slicing machine of FIG. **1**, and mounted by and between a pair of bases **72** mounted to support rings (not shown) of the cutting head **12**. The knife assembly **50** is further represented as configured to utilize a shaped knife (concealed by the clamp **54**), which is clamped by a clamp **54** to a knife support surface (also concealed by the clamp **54**) of a knife holder **52**, such that at least portions of the knife support surface of the knife holder **52** and a knife clamping surface of the clamp **54** have shapes complementary to the shaped knife. Other aspects of the knife assembly **50** are generally as was described for the embodiment of FIGS. **8**A through **8**C. As such, and consistent with the embodiments of FIGS. **4**A through **9**D, distal edges **74**A of slots **74** in the clamp **54** serve as stops that prevent the clamp **54** from being removed from the knife assembly **50** by being translated in the circumferential trailing direction (leftward in FIG. **10**) of the cutting head **12**, but the clamp **54** can be removed from the knife assembly **50** by being translated in the leading direction (rightward in FIG. **10**) of the cutting head **12**. In the nonlimiting embodiment portrayed in FIG. **10** (and consistent with the embodiment of FIGS. **8**A through **8**C), the clamp **54** is translated in the leading direction so that the fasteners **60** are no longer aligned with the narrower portions of the slots **74** and instead are aligned with the wider portions of the slots **74** to permit the fasteners **60** to pass through the slots **74** as the clamp **54** is lifted from the knife assembly **50** in the radial direction of the cutting head **12**. Once released by the removal of the clamp **54**, the underlying knife **56** may also be removed. Alternatively, to secure the clamp **54** to the knife holder **52**, the clamp **54** would be translated to the left (as viewed in FIG. **10**) to insert the fasteners **60** into a narrowed section of each slot **74** until they abut the distal edges **74**A of the slots **74** prior to tightening the fasteners **60** to secure the clamp **54** to the knife holder **52** (and in so doing expose the cutting edge of the knife).

[0056] FIG. **11** schematically represents an end view of the clamp **54** of FIG. **10** and diagrammatically represents forces acting on the clamp **54** when secured to the knife holder **52** as shown in FIG. **10** (the knife is omitted for clarity). The forces acting on the clamp **54** in FIG. **11** are

also illustrative of the forces acting on the clamps **54** represented in each of the embodiments of FIGS. **4**A through **9**D. As evident from FIG. **11**, the fasteners **60** apply a force F.sub.B to the base portion **54**B of the clamp **54** coincident with the axis of the fastener **60**, inducing resultant forces F.sub.R1 and F.sub.R2 along a contact surface **78** representative of the surfaces of the knife holder **52** and knife contacted by the clamp **54**. Because the knife-engaging and base portions **54**A and **54**B of the clamp **54** are not coplanar, the bolt force F.sub.B is not perpendicular to the base portion **54**B, such that the bolt force F.sub.B has x and y components (respectively, parallel and normal to the outer surface of the clamp **54**) identified as F.sub.x and F.sub.y, respectively. As evident from FIGS. **10** and **11**, whereas F.sub.y is primarily responsible for the clamping load applied by the clamp **54** to a knife, F.sub.x pushes the clamp **54** in the leading direction of the cutting head **12** (rightward as viewed in FIGS. **10** and **11**). If F.sub.x is greater than the force of friction between the clamp **54** and the knife holder **52**, F.sub.x is capable of causing the clamp **54** to translate rightward as and after the fasteners **60** are tightened to secure the clamp **54**. Torque reaction forces can also rotate the clamp **54** out of position if such forces are greater than the frictional forces between the clamp **54** and knife holder **52**. Any resulting translation or shift could result in undesirable movement of the knife relative to the knife holder **52**.

[0057] FIG. **12** is a fragmentary side view of the knife assembly **50** of FIG. **10** to which a support bar **58** has been added. As such, the knife assembly **50** is represented as comprising the knife holder **52** and clamp **54** securing a shaped knife **56** on a knife support surface **52**A of the knife holder **52**. In FIG. **12**, the entire knife support surface **52**A preferably has a shape complementary to the shaped knife **56**. (In FIG. **12**, the knife support surface **52**A is nearly entirely concealed beneath the knife **56**.) The support bar **58** secures the clamp **54** to the knife holder **52** in cooperation with the fasteners **60**. The heads of the fasteners **60** are received in recesses **62** in an outer surface **58**A of the support bar **58**. As more readily evident from the isolated view of the support bar **58** in FIG. **13**, each recess **62** defines a recessed surface **64** in which a keyhole slot **66** is defined having wider and narrower portions, with the narrower portion in proximity to a leading edge **68** of the support bar **58**. In the nonlimiting embodiment shown, the slots **66** are not contiguous with the leading edge **68** of the support bar **58**, nor contiguous with any other peripheral edge of the support bar **58**. The heads of the fasteners **60** are sized to pass through the wider portions of the slots **66**, but cannot pass through the narrower portions of the slots **66** as a result of being larger in diameter than the widths of the narrower portions of the slots **66**. As such, by sufficiently threading the fasteners **60** into the knife holder **52** while aligned with the narrower portions of the slots **66**, heads of the fasteners **60** apply a clamping force directly to the recessed surfaces **64** of the support bar **58**, which is transmitted through the clamp **54** to the knife **56**, by which the knife **56** is clamped to the knife holder **52**. As also shown in FIG. **10**, the knife-engaging portion **54**A of the clamp **54** is at least adjacent a leading edge of the clamp **54**, in the embodiment shown is at and defines the leading edge of the clamp **54**, and at least part of the knife-engaging portion **54**A has a shape complementary to the shaped knife **56** and transmits the clamping force to the knife **56** in proximity to a leading edge of the knife holder **52**, from which the knife **56** protrudes as seen in FIG. **12**. With this arrangement, the clamp **54** is not physically attached to the support bar **58** (FIG. **14**), but instead is clamped by the support bar **58** to the knife holder **52**, which in turn causes the clamp **54** to clamp the knife **56** to the knife holder **52**.

[0058] The support bar **58** has a pair of pivot recesses **70** (one of which is visible in FIG. **13**) by which the support bar **58** is pivotally coupled to the pair of bases **72** mounted to the support rings **22** and **24** of the cutting head **12**. For example, each base **72** may be equipped with a pin (not shown) that is received in a corresponding one of the pivot recesses **70** of the support bar **58**. As evident from FIG. **13**, the pivot recesses **70** are oblong, allowing for translation movement of the support bar **58** relative to the bases **72** (generally in a circumferential direction of the cutting head **12**) as well as a pivot motion about a pivot axis (generally parallel to the center axis of the cutting head **12**). As such, the support bar **58** is also configured to translate and pivot relative to other

components of the knife assembly **50**, including the knife holder **52**, clamp **54**, and knife **56**.
[0059] FIG. **14** represents the result of loosening the fasteners **60** to allow the support bar **58** to translate and pivot relative to the bases **72**. In particular, FIG. **14** depicts the result of the support bar **58** having been translated relative to the bases **72** so that the fasteners **60** are no longer aligned with the narrower portions of the slots **66** in the support bar **58** and instead are aligned with the wider portions of the slots **66** to permit the fasteners **60** to pass through the slots **66**, and then the support bar **58** having been pivoted about its pivot axis to expose the underlying base portion **54**B of the clamp **54**, which is at least adjacent the trailing edge **76** of the clamp **54** and in the embodiment shown is at and defines the trailing edge **76** of the clamp **54**. In FIG. **14**, the support bar **58** has been sufficiently pivoted to completely disengage the clamp **54**, exposing a lower surface **58**B of the support bar **58** that had contacted the clamp **54** in the clamping position depicted in FIG. **12**. As also shown and/or discussed in reference to FIG. **10**, the clamp **54** can be seen to have keyway slots **74** that are formed in the base portion **54**B of the clamp **54** to be contiguous with the trailing edge **76** of the clamp **54** formed by the base portion **54**B, and extend toward but terminate short of the knife-engaging portion **54**A of the clamp **54**, forming an interior distal edge **74**A within each slot **74**. As with the slots **66** of the support bar **58**, each slot **74** is defined to have wider and narrower portions, and in this respect the slots **66** of the support bar **58** may be complementary in size and shape to the slots **74** of the clamp **54**. The wider portions of the slots **74** are contiguous with the trailing edge **76** of the clamp **54**, and the narrower portions of the slots **74** form the distal edges **74**A of the slots **74**. As such, and as shown in FIG. **14**, the distal edges **74**A of the slots **74** serve as stops that prevent the clamp **54** from being removed from the knife assembly **50** by being translated in the trailing direction (leftward in FIG. **14**) of the cutting head **12**, but the clamp **54** can be removed from the knife assembly **50** by being translated in the leading direction (rightward in FIG. **14**) of the cutting head **12** so that the fasteners **60** are no longer aligned with the narrower portions of the slots **74** and instead are aligned with the wider portions of the slots **74** to permit the fasteners **60** to pass through the slots **74** as the clamp **54** is lifted from the knife assembly **50** in the radial direction of the cutting head **12**. Once released by the removal of the clamp **54**, the underlying knife **56** may also be removed.
[0060] As evident from FIG. **14** (and similar to the discussion of the clamp **54** in reference to FIG. **10**), the knife-engaging portion **54**A and base portion **54**B of the clamp **54** are not coplanar, enabling the knife-engaging portion **54**A to more closely coincide with the orientation of the knife **56**. This relationship is exaggerated in FIG. **15** for purposes of illustration, which schematically represents an end view of the clamp **54** and diagrammatically represents forces acting on the clamp **54** when secured to the knife holder **52** as shown in FIG. **12**. FIG. **15** also schematically represents the support bar **58** and one of its recessed surfaces **64**, which is directly engaged by one of the fasteners **60** (schematically represented in FIG. **15**) that secure the clamp **54**, knife **56** (not shown in FIG. **15**), and support bar **58** to the knife holder **52**. As evident from FIG. **15**, each fastener **60** applies a force F.sub.B to the base portion **54**B of the clamp **54** coincident with the axis of the fastener **60**, inducing resultant forces F.sub.R1 and F.sub.R2 along a contact surface **78** representative of the surfaces of the knife holder **52** and knife **56** contacted by the clamp **54**. Because the knife-engaging and base portions **54**A and **54**B of the clamp **54** are not coplanar, the bolt force FB is not perpendicular to the base portion **54**B.
[0061] As schematically represented in FIG. **15**, the recessed surface **64** is intentionally tapered relative to the lower surface **58**B of the support bar **58** so that its thickness increases toward the trailing edge of the clamp **54**. An effect of the tapered recessed surface **64** is that the bolt force F.sub.B induces a surface friction force F.sub.Bs as a result of the bolt force FB urging the support bar **58** downward and to the left in FIG. **15** over the surface of the base portion **54**B of the clamp **54**, but is prevented from doing so by the pivot pins engaging the pivot recesses **70** of the support bar **58**. This surface friction force F.sub.Bs is applied by the support bar **58** to the clamp **54**, and counters a force F.sub.Bc transmitted by the fastener **60** to the clamp **54** that would otherwise cause

the clamp **54** to slide rightward in FIG. **15** (toward the cutting edge of the knife **56**), which would be possible because the slots **74** formed in a base portion **54**B of the clamp **54** are contiguous with the trailing edge of the clamp **54**. Because the clamp **54** is effectively immobilized by the support bar **58**, the position of the clamp **54** relative to the knife **56** is not altered as the fasteners **60** are tightened.

[0062] In view of similarities between embodiments represented in the drawings, the following discussion will focus primarily on aspects of the embodiments of FIGS. **16** through **31** that differ from the embodiment of FIGS. **10** through **15** in some notable or significant manner. Other aspects of the embodiments of FIGS. **16** through **31** that are not discussed in any detail may be, in terms of structure, function, materials, etc., essentially as was described for the embodiment of FIGS. **10** through **15**.

[0063] FIG. **16** is a fragmentary side view of a second embodiment of a knife assembly **80** that differs from the knife assembly **50** of FIGS. **12** and **14** by the clamp **54** being physically attached to the support bar **58** so that the clamp **54** translates and pivots with the support bar **58** relative to the knife holder **52**, clamp **54**, and shaped knife **56**. The means of attaching the clamp **54** to the lower surface **58**B of the support bar **58** is represented as screws **82**, but it is within the scope of the invention to use any suitable attachment means capable of mounting the clamp **54** to the support bar **58**. FIG. **17** schematically represents an end view of the clamp **54** and support bar **58** of FIG. **16**, and diagrammatically represents forces acting on the clamp **54** when secured to the knife holder **52** with the support bar **58** as shown in FIG. **16**. Because the clamp **54** is attached to the support bar **58** so that the clamp **54** is prevented from moving relative to the support bar **58**, the forces F.sub.Bs and F.sub.Bc are no longer a factor because the support bar **58** ensures that the position of the clamp **54** relative to the knife **56** is not altered as the fasteners **60** are tightened.

[0064] FIG. **18** is a fragmentary side view of the cutting head **12** in which a third embodiment of a knife assembly **90** is depicted. As with the embodiments of FIGS. **10** through **17**, the knife assembly **90** is shown in FIG. **18** as comprising a knife holder **52** and a clamp **54** securing a shaped knife **56** (concealed by the clamp **54**) on the knife support surface (also concealed by the clamp **54**) of the knife holder **52**. Preferably the entire knife support surface **52**A has a shape complementary to the shaped knife **56**. Contrary to the prior embodiments, the knife assembly **90** does not comprise a support bar for securing the clamp **54** to the knife holder **52**. Instead, the clamp **54** is shown as secured to the knife holder **52** only with fasteners **60** that pass through the clamp **54** and are threaded into the knife holder **52**. The heads of the fasteners **60** are received in keyway slots **74** that (similar to the slots **74** of the clamps **50** and **80** of FIGS. **12**, **14**, and **16**) that are formed in a base portion **54**B of the clamp **54** to be contiguous with a trailing edge **76** of the clamp **54** and extend toward but terminate short of a knife-engaging portion **54**A of the clamp **54**, forming an interior distal edge **74**A within each slot **74**. As such, the distal edges **74**A of the slots **74** serve as stops that prevent the clamp **54** from being removed from the knife assembly **90** by being translated in the trailing direction (leftward in FIGS. **18** and **19**) of the cutting head **12**, but the clamp **54** can be removed from the knife assembly **90** by being translated in the leading direction (rightward in FIGS. **18** and **19**) of the cutting head **12**. Thereafter, the knife **56** may also be removed.

[0065] As more readily seen in the isolated view of one slot **74** in FIG. **19**, similar to the slots **74** formed in the knife assemblies **50** and **80** of FIGS. **10** through **17**, each slot **74** of the clamp **54** is defined to have wider and narrower portions, with the wider portions contiguous with the trailing edge **76** of the clamp **54** and the narrower portions forming the distal edges **74**A of the slots **74**. From FIG. **19**, which depicts the result of loosening the fastener **60** and translating the clamp **54** to the right to align the head of the fastener **60** with the wider portion of the slot **74**, it can be seen that the heads of the fasteners **60** are sized to pass through the wider portions of the slots **74**, but cannot pass through the narrower portions of the slots **74** as a result of being larger in diameter than the widths of the narrower portions of the slots **74**. As such, by sufficiently threading the fasteners **60**

into the knife holder **52** while aligned with the narrower portions of the slots **74**, the fasteners **60** apply a clamping force directly to the base portion **54**B of the clamp **54**, which is transmitted through the knife-engaging portion **54**A of the clamp **54** to the knife **56** to clamp the knife **56** to the knife holder **52**, from whose leading edge the knife **56** protrudes (not shown) when the knife **56** is clamped to the knife holder **52** by the clamp **54**. The shaped knife **56** is overlaid and engaged by a part of the knife-engaging portion **54**A that has a shape complementary to the shaped knife **56**.

[0066] FIG. **19** further shows the slot **74** as having a neck **92** defined where the narrower portion of the slot **74** adjoins the wider portion of the slot **74**. The neck **92** defines the narrowest width of the slot **74**. FIGS. **19** and **20** further illustrate that the narrower portion of the slot **74** has a tapered wall **94** contiguous with an outer surface of the clamp **54** and extends inward into the clamp **54** to a second wall **96** formed within the slot **74** below the tapered wall **94**. As seen in FIG. **20**, which shows the fastener **60** within the narrower portion of the slot **74**, the widths defined by the neck **92** and second wall **96** are larger than the shank **98** of the fastener **60**, enabling the shank **98** to pass through all portions (the neck **92** and the wider and narrower portions) of the slots **74**. However, the fastener **60** further has a shoulder **99** between the shank **99** and the fastener head that is wider/larger than the neck **92** of the slot **74**, such that if the fastener **60** is sufficiently threaded into the knife holder **52** to position the shoulder **99** within the narrower portion of the slot **74**, the fastener **60** cannot pass through the neck **92** and, likewise, the clamp **54** cannot be removed from the knife holder **52**. As such, the neck **92** physically prevents the clamp **54** from sliding forward past the fasteners **60** as the fasteners **60** are tightened. Though shown as tapered to be complementary to the taper of the tapered wall **94** of the slot **74**, the shoulder **99** could alternatively be untapered, i.e., parallel to the axis of the fastener **60**. However, a benefit of the shoulder **99** being tapered is that it reduces the required number of turns needed to loosen the fasteners **60** sufficiently to release the clamp **54** from the fasteners **60**.

[0067] FIG. **21** is a perspective view of a knife assembly **100** for a cutting head of a slicing machine (such as the cutting head **12** and machine **10** of FIG. **1**) according to a fourth embodiment. According to this nonlimiting embodiment of the invention, the knife assembly **100** is represented as comprising a knife holder **52**, and a clamp **54** securing a shaped knife **56** on a knife support surface **52**A of the knife holder **52**, from whose leading edge the knife **56** protrudes. At least a portion of the knife support surface **52**A of the knife holder **52** has a shape complementary to the shaped knife **56**, and the shaped knife **56** is engaged by a part of a knife-engaging portion **54**A of the clamp **54** that has a shape complementary to the shaped knife **56**. The knife assembly **100** further includes a wedge assembly **102** securing the clamp **54** to the knife holder **52** in cooperation with fasteners **60** that pass through the clamp **54** and are threaded into the knife holder **52**. As with previous embodiments, the clamp **54** has slots (not shown) for receiving the fasteners **60**, and the slots are formed in the base portion **54**B of the clamp **54** to be contiguous with the trailing edge **76** of the clamp **54** and extend toward but terminate short of the knife-engaging portion **54**A of the clamp **54**, so that the clamp **54** can be removed from the knife assembly **100** by being translated in the leading direction (rightward in FIGS. **26**, **27**, and **28**).

[0068] The wedge assembly **102** is represented in FIG. **21** as comprising a lower member **102**A, an upper member **102**B, and a handle **102**C to which a threaded shaft **102**D is attached. FIG. **22** is a perspective view of the knife assembly **100** of FIG. **21** with the upper member **102**B of the wedge assembly **102** removed to expose the lower member **102**A. The lower member **102**A can be generally described as a beam **104** from which two flanges **106** protrude on one side of the beam **104**. As evident from FIG. **22**, the heads of the fasteners **60** are received in recesses **108** formed in the flanges **106** of the lower member **102**A, with the result that the lower member **102**A is directly secured to the knife holder **52** with the fasteners **60**. The lower member **102**A is further represented as having a shoulder **110** formed by the beam **104** in proximity to the trailing edge **76** of the clamp **54**, and a tapered sliding surface **112** also formed by the beam **104** and positioned to interact with the upper member **102**B, as will be discussed below. The threaded shaft **102**D of the handle **102**C

extends through a slot **114** (FIGS. **26** and **27**) formed in the beam **104**.

[0069] FIGS. **23**, **24**, and **25** are perspective isolated views of the upper member **102**B of the wedge assembly **102**. Slots **116** are formed in a leading edge **118** of the upper member **102**B for receiving the heads of the fasteners **60**, with the result that the upper member **102**B is not directly secured to the knife holder **52** with the fasteners **60**. Instead, the threaded shaft **102**D couples the upper member **102**B to the lower member **102**A, which indirectly couples the upper member **102**B to the knife holder **52**. The upper member **102**B is seen in FIGS. **23** and **24** as having a U-shaped cavity **120** on its lower side that is sized and shaped to receive the beam **104** and flanges **106** of the lower member **102**A. The cavity **120** surrounds a central boss **122**A in which a threaded hole **124** is formed that threadably receives the end of the threaded shaft **102**D of the handle **102**C that protrudes from the slot **114** in the beam **104** of the lower member **102**A. The central boss **122**A defines a bearing surface **126** adapted to bear against the tapered sliding surface **112** of the beam **104** of the lower member **102**A. The upper member **102**A also defines end bosses **122**B at its longitudinal ends. The central and end bosses **122**A and **122**B define clamping surfaces **127**A and **127**B adapted to bear against the base portion **54**B of the clamp **54** and thereby force the clamp **54** toward the knife holder **52**.

[0070] FIGS. **26** and **27** are cross-sectional views of the knife assembly **100** of FIG. **21**, representing the knife assembly **100** in unlocked (FIG. **26**) and locked (FIG. **27**) configurations. In FIG. **26**, the fasteners **60** mount the lower member **102**A to the knife holder **52**, the lower member **102**A is received in the cavity **120** of the upper member **102**B, and the threaded shaft **102**D is threaded into the threaded hole **124** formed in the central boss **122**A of the upper member **102**B to indirectly couple the upper member **102**B to the knife holder **52**. The shoulder **110** of the lower member **102**A formed by the beam **104** is in proximity to the trailing edge **76** of the clamp **54**, and the tapered sliding surface **112** formed by the beam **104** bears against the bearing surface **126** formed by the central boss **122**A of the upper member **102**B. In this unlocked configuration, the clamp **54** can be removed from the knife assembly **100** by translating the clamp **54** in the leading direction (rightward in FIGS. **26** and **27**) so that the fasteners **60** exit the slots at the trailing edge **76** of the clamp **54**.

[0071] FIG. **27** represents the result of using the handle **102**C to thread the threaded shaft **102**D into the threaded hole **124** formed in the central boss **122**A of the upper member **102**B, causing the upper member **102**B to be pulled downward into further engagement with the lower member **102**A. In particular, as the handle **102**C is rotated to draw the upper member **102**B toward the lower member **102**A, the bearing surface **126** of the upper member **102**B contacting with the tapered sliding surface **112** causes the upper member **102**B to slide down the tapered sliding surface **112** because of the shorter slot depth d.sub.1 in the lower member **102**A at the bottom of the slot **114** as compared to the depth d.sub.2 of the slot **114** in the lower member **102**A at the top of the slot **114**. As a result, the clamping surfaces **127**A and **127**B of the central and end bosses **122**A and **122**B of the upper member **102**B force the clamp **54** toward the knife holder **52**, clamping the knife **56** therebetween.

[0072] FIG. **28** schematically represents an end view of the knife assembly **100** of FIGS. **21**, **26**, and **27**, and diagrammatically represents forces acting on the clamp **54** when secured to the knife holder **52** with the wedge assembly **102** as shown in FIGS. **21** and **27**. Because the wedge assembly **102** applies a clamping force F.sub.W in the direction shown (parallel to the tapered sliding surface **112** of the lower member **102**A), the clamp **54** is pushed in the trailing direction (leftward in FIG. **28**), forcing the clamp **54** (or the narrower portions of its slots) to bear against the fasteners **60**, ensuring that the position of the clamp **54** relative to the knife **56** is not altered as the fasteners **60** are tightened.

[0073] FIGS. **29**, **30**, and **31** depict a knife assembly **130** for a cutting head of a slicing machine (such as the cutting head **12** and machine **10** of FIG. **1**) according to a fifth embodiment. According to this nonlimiting embodiment of the invention, the knife assembly **130** is represented as

comprising a knife holder **52**, and a clamp **54** securing a shaped knife **56** on a knife support surface **52**A of the knife holder **52**, from whose leading edge the knife **56** protrudes. As with previous embodiments, at least a portion of the knife support surface **52**A of the knife holder **52** has a shape complementary to the shaped knife **56**, and the shaped knife **56** is engaged by a part of a knife-engaging portion **54**A of the clamp **54** that has a shape complementary to the shaped knife **56**. The knife assembly **130** further includes a cam rod **132** between the knife holder **52** and the base portion **54**B of the clamp **54** for securing the clamp **54** to the knife holder **52** in cooperation with fasteners **60** that pass through the clamp **54** and are threaded into the knife holder **52**. As with previous embodiments, the clamp **54** has slots **74** for receiving the fasteners **60** so that the clamp **54** can be removed from the knife assembly **100** by being translated in the leading direction (rightward in FIGS. **29**, **30**, and **31**). In particular, and similar to previous embodiments, wider portions of the slots **74** are contiguous with the trailing edge **76** of the clamp **54**, and narrower portions of the slots **74** form distal edges **74**A of the slots **74**. As such, and as evident from FIGS. **29** and **31**, the distal edges **74**A of the slots **74** serve as stops that prevent the clamp **54** from being removed from the knife assembly **50** by being translated in the trailing direction (leftward in FIGS. **29**, **30**, and **31**), but the clamp **54** can be removed from the knife assembly **50** by being translated in the leading direction (rightward in FIGS. **29**, **30**, and **31**) so that the fasteners **60** exit the slots **74** at the trailing edge **76** of the clamp **54** or are aligned with the wider portions of the slots **74** to permit the fasteners **60** to pass through the slots **74** as the clamp **54** is lifted from the knife assembly **50** in the radial direction of the cutting head **12**.

[0074] The clamp **54** and knife **56** are held in place on the knife holder **52** as a result of the clamp **54** being forcibly held in place on the knife holder **52** with the cam rod **132**. The cam rod **132** is shown received in a channel **136** formed in the surface of the knife holder **52** and located in the trailing direction (leftward in FIGS. **29**, **30**, and **31**) from the fasteners **60**. Additionally, the longitudinal axis of the cam rod **132** is represented as oriented parallel to the longitudinal directions of the knife holder **52**, clamp **54**, and knife **56**, and the cam rod **132** is capable of being rotated about its longitudinal axis within the channel **136**. A lever **134** is attached to or formed as an extension of the cam rod **132**, and rotating the cam rod **132** with the lever **134** creates a camming action that applies a force F.sub.C to the base portion **54**B of the clamp **54** outward against the heads of the fasteners **60**, which serve as a fulcrum for the clamp **54** so that the camming action also generates a reaction force FRI where the fasteners **60** contact the clamp **54** and a reaction force F.sub.R2 where the knife-engaging portion **54**A of the clamp **54** contacts the knife **56**, as shown in FIG. **31**. The cam rod **132** has a recessed surface **138** defined in an otherwise circular-shaped circumferential surface **140**. When the cam rod **132** is rotated so that the recessed surface **138** faces the clamp **54**, the clamp **54** is released from its engagement with the cam rod **132**, which in turn causes the knife-engaging portion **54**A of the clamp **54** to release the knife **56**. In this embodiment, FIG. **31** shows the result of having rotated the lever **134** counterclockwise (as viewed in FIG. **31**) to apply the clamping load to the base portion **54**B of the clamp **54** with a corner of the cam rod **132** defined by the intersection of its recessed and circumferential surfaces **138** and **140**, though it is foreseeable that the cam rod **132** could be further rotated in the counterclockwise direction so that the clamping load is entirely applied to the base portion **54**B with the circumferential surface **140**. Rotating the lever **134** clockwise (as viewed in FIG. **31**) turns the recessed surface **138** on the cam rod **132** to face the clamp **54**, releasing the clamp **54** from its engagement with the cam rod **132**. In this embodiment, the cam rod **132** is configured so that the corner formed by the recessed and circumferential surfaces **138** and **140** is able to engage the base portion **54**B of the clamp **54** and pull the clamp **54** in the trailing direction (leftward in FIG. **31**) as the clamping load is applied to pull the clamp **54** into the fasteners **60** until the fasteners **60** abut the distal edges **74**A of the slots **74**. Rotating the cam rod **132** in the clockwise direction pushes the clamp **54** in the leading direction (rightward in FIG. **31**), pushing the edges of the slots **74** away from the fasteners **60**. Consequently, the ability of this configuration to ensure that the position of the clamp **54** relative to

the knife **56** is not altered as the clamping load is applied is dependent on the rotation of the cam rod **132** and on the relative locations the recessed and circumferential surfaces **138** and **140** being properly coordinated.

[0075] From the embodiments described and represented in the drawings, it should be apparent that each embodiment shown utilized fasteners **60** (or other suitable fasteners) to apply a clamping load to shaped knives **56** through knife-engaging portions **54**A of clamps **54** that preferably have shapes complementary to the knives **56**. According to preferred but nonlimiting aspects, the fasteners **60** are received in slots **74** that are formed in the clamps **54** and are contiguous with (open to) the trailing edges **76** of the clamps **54**, which enables the clamps **54** to be removed from the knife assemblies by translating the clamps **54** in the leading direction. While desirable for enabling the removal of the clamps **54** and shaped knives **56** secured by the clamps **54**, the open configurations of the slots **74** do not prevent the clamps **54** from translating relative to the knives **54** during the clamping process. To address this, each embodiment described and represented in the drawings provides means by which its clamp **54** is prevented from translating relative to the knife **56**, particularly in the leading direction of the knife assembly, as the clamping load is applied to the clamp **54**. In the nonlimiting embodiments, such means included the support bar **58** of FIGS. **12** through **17**, the slot neck **92** and tapered wall **94** of FIGS. **12** through **20**, the wedge assembly **102** of FIGS. **21** through **28**, and the cam rod **132** of FIGS. **29** through **31**.

[0076] While the invention has been described in terms of specific embodiments, it is apparent that other forms could be adopted by one skilled in the art. For example, the knife assemblies and cutting heads and machines in which they may be installed could differ in appearance and construction from what is shown in the drawings. Also, the knife assemblies could be used with knives that differ from what is shown in the drawings, for example, in terms of shape (flat or shaped) and, in the case of shaped knives, amplitude (distance from valley to peak) and/or pitch (distance between peaks). Furthermore, various materials and processes could be used in the manufacture of the knife assemblies and their components. Therefore, the scope of the invention is to be limited only by the claims.

Claims

1. A method of securing and releasing a clamp of a knife assembly that clamps a knife to a knife holder on a cutting head of a slicing machine, the cutting head having a leading direction, a trailing direction opposite the leading direction, and an axial direction perpendicular to the leading and trailing directions, the clamp having a base portion adjacent a trailing edge of the clamp, the base portion having at least a first slot formed therein, the method comprising: securing the clamp to clamp the knife to the knife holder by: causing a fastener to enter the first slot of the clamp; pivoting a support bar so that a head of the fastener passes through a first portion of a slot in the support bar; translating the support bar in the trailing direction so that the fastener enters a second portion of the slot in the support bar through which the head of the fastener cannot pass as a result of the head of the fastener being larger than a width of the second portion of the slot in the support bar; and tightening the fastener so that the head of the fastener applies a force to a surface of the support bar surrounding the second portion of the slot in the support bar; and removing the clamp from the knife assembly to release the knife from the knife holder by: loosening the fastener so that the head of the fastener releases the force at the surface surrounding the second portion of the slot in the support bar; translating the support bar in the leading direction so that the fastener passes from the second portion of the slot in the support bar to the first portion of the slot in the support bar; pivoting the support bar so that the head of the fastener passes through the first portion of the slot in the support bar; and causing the fastener to exit the first slot of the clamp.

2. The method of claim 1, wherein the first slot of the clamp is contiguous with and open to the trailing edge of the clamp, and the step of causing the fastener to enter the first slot comprises

sliding the clamp in the trailing direction to cause the fastener to enter the first slot at the trailing edge of the clamp.

3. The method of claim 1, wherein the first slot of the clamp is contiguous with and open to the trailing edge of the clamp, and the step of causing the fastener to exit the first slot comprises sliding the clamp in the leading direction to cause the fastener to exit the first slot at the trailing edge of the clamp.

4. The method of claim 1, wherein the first slot has a wider portion adjacent the trailing edge of the clamp and a narrower portion extending toward a leading edge of the clamp.

5. The method of claim 1, wherein the support bar is pivoted about a pivot axis disposed in the axial direction.

6. The method of claim 1, wherein the surface surrounding the second portion of the slot in the support bar is a tapered surface that increases in thickness toward a trailing edge of the support bar.

7. The method of claim 6, wherein as a result of the tapered surface the force applied by the fastener urges the support bar in the trailing direction, causing the support bar to apply a surface friction force to the clamp that counters a force transmitted by the fastener to the clamp that urges the clamp in the leading direction, whereby the support bar immobilizes the clamp so that the position of the clamp relative to the knife is not altered as the fastener is tightened.

8. The method of claim 1, wherein the surface surrounding the second portion of the slot in the support bar is within a recess in an outer surface of the support bar, and tightening the fastener causes the head of the fastener to be received in the recess.

9. The method of claim 1, wherein tightening the fastener comprises threading the fastener into the knife holder.

10. The method of claim 1, wherein the clamp has a knife-engaging portion that is adjacent a leading edge of the clamp and transmits the force to the knife.

11. The method of claim 10, wherein the knife is a shaped knife and the knife-engaging portion of the clamp has a shape complementary to the shaped knife.

12. The method of claim 10, wherein the knife-engaging portion and the base portion of the clamp are not coplanar.

13. The method of claim 1, wherein the first slot extends toward but terminates short of the knife-engaging portion of the clamp and forms an interior distal edge within the slot, and the interior distal edge prevents the clamp from being removed from the knife assembly by being translated in the trailing direction.

14. The method of claim 1, further comprising removing the knife from the knife assembly after removing the clamp from the knife assembly.