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Fastening assembly

Abstract

A fastening assembly for a plurality of tubular structures. The fastening assembly includes a positioning fitting member and a clamping element. The positioning fitting member is coupled to a first tubular structure of the plurality of tubular structures such that the positioning fitting member forms a part of the first tubular structure. The positioning fitting member includes a plurality of ribs. The clamping element extends around the plurality of tubular structures and around at least a portion of the positioning fitting member to bundle and to secure the plurality of tubular structures together. The clamping element is positioned between the plurality of ribs.

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Background/Summary

TECHNICAL FIELD

(1) The present disclosure relates generally to fastening assemblies for turbine engines and other engineering assemblies.

BACKGROUND

(2) Turbine engines and other engineering assemblies include arrays or banks of tubes, pipes, conduits, rods, bars, or the like, deployed in several locations for transport of liquids and gaseous products or to house cables or similar components of the turbine engine or engineering assembly.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

(1) The foregoing and other features and advantages will be apparent from the following, more particular, description of various exemplary embodiments, as illustrated in the accompanying drawings, wherein like reference numbers generally indicate identical, functionally similar, and/or structurally similar elements.

(2) FIG. **1** is a schematic cross-sectional diagram of a turbine engine, taken along a longitudinal centerline of the turbine engine, according to an embodiment of the present disclosure.

(3) FIG. **2**A is a schematic view of a positioning fitting member of a fastening assembly for the turbine engine of FIG. **1**, according to an embodiment of the present disclosure.

(4) FIG. **2**B is a schematic side view of the positioning fitting member of FIG. **2**A, according to an embodiment of the present disclosure.

(5) FIG. **2**C is a schematic cross-sectional view, taken along detail **2**C-**2**C in FIG. **2**B, of the positioning fitting member, according to an embodiment of the present disclosure.

(6) FIG. **3**A is an exploded view of a fastening assembly for tubular structures, according to an embodiment of the present disclosure.

(7) FIG. **3**B is an enlarged schematic view of the fastening assembly of FIG. **3**A in an assembled state, according to an embodiment of the present disclosure.

(8) FIG. **3**C is a schematic bottom view of the fastening assembly of FIG. **3**B, according to an embodiment of the present disclosure.

(9) FIG. **3**D is a schematic rear view of the fastening assembly of FIG. **3**B, according to an embodiment of the present disclosure.

(10) FIG. **3**E is a cross-sectional view of the fastening assembly, taken at detail **3**E-**3**E in FIG. **3**C, according to an embodiment of the present disclosure.
(11) FIG. **3**F is a cross-sectional view of the fastening assembly, taken at detail **3**F-**3**F in FIG. **3**D, according to an embodiment of the present disclosure.
(12) FIG. **4**A is an enlarged schematic view of another fastening assembly in an assembled state, according to another embodiment of the present disclosure.
(13) FIG. **4**B is an enlarged schematic view of another fastening assembly in an assembled state, according to another embodiment of the present disclosure.
(14) FIG. **5**A is an exploded view of another fastening assembly for tubular structures, according to another embodiment of the present disclosure.
(15) FIG. **5**B is an enlarged schematic view of the fastening assembly of FIG. **5**A in an assembled state, according to an embodiment of the present disclosure.
(16) FIG. **5**C is a schematic side view of the fastening assembly of FIG. **5**B, according to an embodiment of the present disclosure.
(17) FIG. **5**D is a schematic front view of the fastening assembly of FIG. **5**B, according to an embodiment of the present disclosure.
(18) FIG. **5**E is a cross-sectional view of the fastening assembly, taken at detail **5**E-**5**E in FIG. **5**C, according to an embodiment of the present disclosure.
(19) FIG. **5**F is a cross-sectional view of the fastening assembly, taken at detail **5**F-**5**F in FIG. **5**D, according to an embodiment of the present disclosure.
(20) FIG. **6**A is an exploded view of another fastening assembly for tubular structures, according to another embodiment of the present disclosure.
(21) FIG. **6**B is an enlarged schematic view of the fastening assembly of FIG. **6**A in an assembled state, according to an embodiment of the present disclosure.
(22) FIG. **6**C is a schematic side view of the fastening assembly of FIG. **6**B, according to an embodiment of the present disclosure.
(23) FIG. **6**D is a schematic front view of the fastening assembly of FIG. **6**B, according to an embodiment of the present disclosure.
(24) FIG. **6**E is a cross-sectional view of the fastening assembly, taken at detail **6**E-**6**E in FIG. **6**C, according to an embodiment of the present disclosure.
(25) FIG. **6**F is a cross-sectional view of the fastening assembly, taken at detail **6**F-**6**F in FIG. **6**D, according to an embodiment of the present disclosure.
(26) FIG. **7**A is an exploded view of another fastening assembly for tubular structures, according to another embodiment of the present disclosure.
(27) FIG. **7**B is an enlarged schematic view of the fastening assembly of FIG. **7**A in an assembled state, according to an embodiment of the present disclosure.
(28) FIG. **7**C is a schematic side view of the fastening assembly of FIG. **7**B, according to an embodiment of the present disclosure.
(29) FIG. **7**D is a schematic front view of the fastening assembly of FIG. **7**B, according to an embodiment of the present disclosure.
(30) FIG. **7**E is a cross-sectional view of the fastening assembly, taken at detail **7**E-**7**E in FIG. **7**C, according to an embodiment of the present disclosure.
(31) FIG. **7**F is a cross-sectional view of the fastening assembly, taken at detail **7**F-**7**F in FIG. **7**D, according to an embodiment of the present disclosure.
(32) FIG. **7**G is a cross-sectional view of the fastening assembly, taken at detail **7**G-**7**G in FIG. **7**D, according to an embodiment of the present disclosure.
(33) FIG. **8**A is an exploded view of another fastening assembly for tubular structures, according to another embodiment of the present disclosure.
(34) FIG. **8**B is an enlarged schematic view of the fastening assembly of FIG. **8**A in an assembled state, according to an embodiment of the present disclosure.

(35) FIG. **8**C is a schematic side view of the fastening assembly of FIG. **8**B, according to an embodiment of the present disclosure.
(36) FIG. **8**D is a schematic front view of the fastening assembly of FIG. **8**B, according to an embodiment of the present disclosure.
(37) FIG. **8**E is a cross-sectional view of the fastening assembly, taken at detail **8**E-**8**E in FIG. **8**C, according to an embodiment of the present disclosure.
(38) FIG. **8**F is a cross-sectional view of the fastening assembly, taken at detail **8**F-**8**F in FIG. **8**D, according to an embodiment of the present disclosure.
(39) FIG. **9** is an enlarged schematic view of another fastening assembly in an assembled state, according to another embodiment of the present disclosure.
(40) FIG. **10**A is an exploded view of another fastening assembly for tubular structures, according to another embodiment of the present disclosure.
(41) FIG. **10**B is an enlarged schematic view of the fastening assembly of FIG. **10**A in an assembled state, according to an embodiment of the present disclosure.
(42) FIG. **10**C is a schematic side view of the fastening assembly of FIG. **10**B, according to an embodiment of the present disclosure.
(43) FIG. **10**D is a schematic front view of the fastening assembly of FIG. **10**B, according to an embodiment of the present disclosure.
(44) FIG. **10**E is a cross-sectional view of the fastening assembly, taken at detail **10**E-**10**E in FIG. **10**C, according to an embodiment of the present disclosure.
(45) FIG. **10**F is a cross-sectional view of the fastening assembly, taken at detail **10**E-**10**F in FIG. **10**D, according to an embodiment of the present disclosure.
(46) FIG. **11**A is an exploded view of another fastening assembly for tubular structures, according to another embodiment of the present disclosure.
(47) FIG. **11**B is an enlarged schematic view of the fastening assembly of FIG. **11**A in an assembled state, according to an embodiment of the present disclosure.
(48) FIG. **11**C is a schematic side view of the fastening assembly of FIG. **11**B, according to an embodiment of the present disclosure.
(49) FIG. **11**D is a schematic front view of the fastening assembly of FIG. **11**B, according to an embodiment of the present disclosure.
(50) FIG. **11**E is a cross-sectional view of the fastening assembly, taken at detail **11**E-**11**E in FIG. **11**C, according to an embodiment of the present disclosure.
(51) FIG. **11**F is a cross-sectional view of the fastening assembly, taken at detail **11**F-**11**F in FIG. **11**D, according to an embodiment of the present disclosure.
(52) FIG. **12** is an enlarged schematic view of another fastening assembly in an assembled state, according to another embodiment of the present disclosure.
(53) FIG. **13**A is an exploded view of another fastening assembly for tubular structures, according to another embodiment of the present disclosure.
(54) FIG. **13**B is an enlarged schematic view of the fastening assembly of FIG. **13**A in an assembled state, according to an embodiment of the present disclosure.
(55) FIG. **13**C is a schematic side view of the fastening assembly of FIG. **13**B, according to an embodiment of the present disclosure.
(56) FIG. **13**D is a schematic front view of the fastening assembly of FIG. **13**B, according to an embodiment of the present disclosure.
(57) FIG. **13**E is a cross-sectional view of the fastening assembly, taken at detail **13**E-**13**E in FIG. **13**C, according to an embodiment of the present disclosure.
(58) FIG. **13**F is a cross-sectional view of the fastening assembly, taken at detail **13**F-**13**F in FIG. **13**D, according to an embodiment of the present disclosure.
(59) FIG. **14** is a cross-sectional view of another positioning fitting member coupled to a tubular structure, taken along a longitudinal centerline of the tubular structure, according to another

embodiment of the present disclosure.
(60) FIG. **15** is a cross-sectional view of another positioning fitting member coupled to a tubular structure, taken along a longitudinal centerline of the tubular structure, according to another embodiment of the present disclosure.
(61) FIG. **16** is a cross-sectional view of the positioning fitting member of FIG. **2**A coupled to a tubular structure, taken along a longitudinal centerline of the tubular structure, according to another embodiment of the present disclosure.
(62) FIG. **17** is a cross-sectional view of another positioning fitting member coupled to a tubular structure, taken along a longitudinal centerline of the tubular structure, according to another embodiment of the present disclosure.
(63) FIG. **18** is a cross-sectional view of another positioning fitting member coupled to a tubular structure, taken along a longitudinal centerline of the tubular structure, according to another embodiment of the present disclosure.
(64) FIG. **19** is a cross-sectional view of another positioning fitting member coupled to a tubular structure, taken along a longitudinal centerline of the tubular structure, according to another embodiment of the present disclosure.
(65) FIG. **20** is a cross-sectional view of another positioning fitting member coupled to a tubular structure, taken along a longitudinal centerline of the tubular structure, according to another embodiment of the present disclosure.
(66) FIG. **21** is a schematic, partial cut away, cross-sectional view of another positioning fitting member, taken along a longitudinal centerline of the positioning fitting member, according to another embodiment of the present disclosure.
(67) FIG. **22** is a flow diagram of a method of bundling and fastening tubular structures, according to an embodiment of the present disclosure.

DETAILED DESCRIPTION

(68) Additional features, advantages, and embodiments of the present disclosure are set forth or apparent from a consideration of the following detailed description, drawings, and claims. Moreover, both the foregoing summary of the present disclosure and the following detailed description are exemplary and intended to provide further explanation without limiting the scope of the disclosure as claimed.
(69) Various embodiments of the present disclosure are discussed in detail below. While specific embodiments are discussed, this is done for illustration purposes only. A person skilled in the relevant art will recognize that other components and configurations may be used without departing from the spirit and the scope of the present disclosure.
(70) As used herein, the terms “first,” “second,” and “third” may be used interchangeably to distinguish one component from another and are not intended to signify location or importance of the individual components.
(71) The terms “upstream” and “downstream” refer to the relative direction with respect to fluid flow in a fluid pathway. For example, “upstream” refers to the direction from which the fluid flows, and “downstream” refers to the direction to which the fluid flows.
(72) The terms “coupled,” “fixed,” “attached,” “connected,” and the like, refer to both direct coupling, fixing, attaching, or connecting, as well as indirect coupling, fixing, attaching, or connecting through one or more intermediate components or features, unless otherwise specified herein.
(73) The singular forms “a,” “an,” and “the” include plural references unless the context clearly dictates otherwise.
(74) As used herein, the terms “axial” and “axially” refer to directions and orientations that extend substantially parallel to a centerline of the turbine engine. Moreover, the terms “radial” and “radially” refer to directions and orientations that extend substantially perpendicular to the centerline of the turbine engine. In addition, as used herein, the terms “circumferential” and

“circumferentially” refer to directions and orientations that extend arcuately about the centerline of the turbine engine.

(75) As used herein, “tubular structure” includes any type of long, hollow or solid, generally cylindrical structure for holding or transporting liquids, gases, or other solids. For example, tubular structures include tubes or conduits for carrying fuel, oil, hydraulic fluids, pressurized air, cables, hoses, wires or the like. Tubular structures can also include the cables, wires, hoses, or the like. The terms “tube” or “tubes” are used interchangeably with “tubular structure” or “tubular structures” herein.

(76) As used herein, “fastening assembly” refers to a group of interacting or interrelated elements that act according to a set of rules to form a unified whole deployed to spatially separate tubes or its equivalents, such as pipes, rods, bars or any tubular structure and at the same time, to fasten them together.

(77) As used herein, “spacer element” refers to a device or piece used to create or maintain a desired amount of space between two or more objects.

(78) As used herein, “clamping element” refers to a device or component that structurally joins or affixes two or more objects together. In general, clamping elements are used to create non-permanent joints, that is, joints that can be removed or dismantled without damaging the joining components.

(79) As used herein, “top end” refers to the highest or uppermost point, portion, or surface of a spacer element.

(80) As used herein, “bottom end” refers to the lowest or lowermost point, portion, or surface of a spacer element.

(81) Here and throughout the specification and claims, range limitations are combined, and interchanged. Such ranges are identified and include all the sub-ranges contained therein unless context or language indicates otherwise. For example, all ranges disclosed herein are inclusive of the endpoints, and the endpoints are independently combinable with each other.

(82) Turbine engine installations include tubular structures, such as, for example, tubes or conduits, for carrying fuel, oil, hydraulic fluids, pressurized air, cables, hoses, etc. The tubes or conduits can be bundled together to carry the fluid within or across several compartments and components (such as a fan, a compressor, a turbine) of the engine under a nacelle or to discharge the fluid overboard. Tube or pipe assemblies deployed in engineering assemblies found in aircraft engines, heat exchangers, and nuclear power structures typically bundle the tubes where space and support availability is insufficient to fit multiple individual tubes. Typically, blocks, clamps, tabs and straps, or spacers are permanently joined to the tubes to bundle the tubes, for example, with brazed or welded joints. The brazed or welded joints include low reliability and may fail due to stress concentrations on the joints under operational loads on the bundle of tubes. For example, brazed or welded joints may fail due to the following reasons: (i) high stress concentrations at the joint, (ii) difficult to control the braze or weld quality (e.g., due to manufacturing defects), (iii) low high cycle fatigue capabilities of the braze or weld, (iv) geometric stress concentrations at the joint, and (v) rapid transition from flexible tube to stiff constraint. The manufacturing defects may result in reduced life and low reliability of the brazed joints or the welded joints. Variations in the surface preparation, the part setup, the cleaning process, the heat input, etc., can affect the manufacturing process outcomes during brazing operations or during welding operations, resulting in voids and lack of braze coverage at the brazed joints or resulting in lack of penetration and lack of fusion at the welded joints. Voids are material discontinuities and generate geometrical stress concentrators. Lack of coverage occurs when there is an unbonded area (e.g., an area within a brazed joint in which the braze filler flows but does not bond to one or more of the fraying surfaces). Further, braze witness may be difficult to include in tube cluster or in tube bundle applications due to a lack of space between tubes to access the brazed joint. The braze witness is a feature used to verify braze coverage and braze flow.

(83) Alternatively, loop clamps or similar clamping devices can be used to bundle the tubes together. The clamps, however, slide or move along the tubes, which results in wear on the tubes and maintainability issues due to a lack of position control. Additionally, brazed or welded tube bundles are difficult to manufacture, inspect, install, and repair as it is difficult to separate a brazed or welded joint without damaging the tubes. Thus, the present disclosure provides for a fastening assembly for bundling and fastening tubes together to enable a non-permanent tube bundling.
(84) Embodiments of the present disclosure provide a positioning fitting and a separate removable clamping device. The fastening assembly provides for a non-brazed and a non-welded tube bundle design using a removable bundling device. The fastening assembly allows for a reduced footprint of a tube bundle with added ease of manufacturing, inspection, and installation due to the removable clamping device and the positioning fitting. Thus, the present disclosure improves reliability, assembly, and maintainability of a tube bundle assembly as compared to assemblies that are bundled with brazed or welded joints. The fastening assembly does not include a brazed or a welded joint between individual tubes, thus reducing stress concentration compared to brazed or welded joints. The fastening assembly provides for a low stress tube bundling through the positioning fitting and the clamping device provides for added friction damping. The fastening assembly also eliminates inspection access and quality control needed for brazed or welded joints. The positioning fitting can be adapted to fit standard cushioned or un-cushioned loop clamps, saddle clamps, rubber blocks, or specialty clamping devices in order to adapt to operational and space requirements for a particular use. The fastening assembly improves vibration damping by using different materials for added damping and wear capability while providing retaining capabilities to locate and to maintain the tube assembly in the correct or intended position. The fastening assembly allows for on-site or off-site assembly, thus allowing for improved maintainability compared to assemblies without the benefit of the present disclosure.
(85) The fastening assembly provides vibration damping, thus increasing system stiffness as needed and reducing the number of supports required for a particular application. Accordingly, the fastening assembly reduces associated failure risks (e.g., high cycle fatigue, wear, low cycle fatigue, etc.) while providing retaining capabilities to locate and to maintain the assembly in the correct position and the positioning fitting prevents the displacement of the clamping device along the tube. The embodiments of the present disclosure allow for better packaging of tubes in clusters or bundles compared to assemblies without the benefit of the present disclosure. The present disclosure provides for a compact tube bundle for improved tube packaging to save space in applications in which space is limited, thus, saving space, cost, and weight. In turbine engine applications, the present disclosure improves time on wing compared to assemblies without the benefit of the present disclosure, thus, eliminating field issues related to brazed or welded joints in tube bundles and reduces fatigue or durability issues.
(86) Embodiments of the present disclosure provide for a non-permanent or a removable tube bundling and fastening assembly using a low stress concentration positioning fitting and a removable clamping device. Two or more tubes can be bundled using a removable clamping device. The clamping device may include, for example, loop clamps, custom clamps, metal straps, rubber blocks, metal blocks, composite blocks, or combinations thereof. The clamping device generates a high radial compressive force to maintain the tube bundling under operational loads, while the positioning fitting keeps the clamping device in the intended position or location for error-proofing of the assembly. For example, the positioning fitting includes ribs that prevent the clamping device or a respective tube from sliding or moving axially beyond the ribs. The positioning fitting can be coupled to a respective tube. Additionally, the clamping device provides friction damping while allowing slippage between bundled tubes, which allows for tubes in a bundle having different temperatures in the same bundle while minimizing thermal mismatch between the tubes.
(87) The positioning fitting is a machined or a formed part that provides a gradual transition to the

tube to reduce the stress concentration. The positioning fitting is permanently coupled to the tube through thermal, mechanical, or chemical bonding methods. For example, the positioning fitting member may be chemically bonded (e.g., epoxy or composite), coupled by a thermal joint (e.g., brazing or welding), or threaded to a respective tube. In some embodiments, the positioning fitting may be integral with other fittings or connectors and may be used for manifold attachment to brackets or support systems. In some embodiments, the fastening assembly of the present disclosure includes spacer blocks to provide separation between the tubes in the bundle while providing a compact arrangement of the tubes in the bundle. The spacer blocks may be made of metal, rubber, composite, or combinations thereof. The materials of the spacer blocks and the clamping device may be selected based on requirements of vibration damping, stiffness, temperature conditions, etc., for a particular application. For example, metals may provide greater stiffness and may be used in higher temperature applications, but metals provide less friction damping compared to non-metals. Thus, rubbers, composites, ceramics, or the like, may be used in lower temperature conditions to provide greater vibration damping. In some embodiments, the blocks or straps may be coupled to a support bracket or structure and the blocks or straps may be stacked as desired.

(88) Referring now to the drawings, FIG. **1** is a schematic cross-sectional diagram of a turbine engine **10**, taken along a centerline axis of the turbine engine **10**, according to an embodiment of the present disclosure. FIG. **1** shows the turbine engine **10** defines an axial direction A (extending parallel to a longitudinal centerline **12** provided for reference) and a radial direction R that is normal to the axial direction A. In general, the turbine engine **10** includes a fan section **14** and a core turbine engine **16** disposed downstream from the fan section **14**.

(89) The core turbine engine **16** depicted generally includes an outer casing **18** that is substantially tubular and defines an annular inlet **20**. As schematically shown in FIG. **1**, the outer casing **18** encases, in serial flow relationship, a compressor section **21** including a booster or a low pressure (LP) compressor **22** followed downstream by a high pressure (HP) compressor **24**, a combustion section **26**, a turbine section **27** including a high pressure (HP) turbine **28** followed downstream by a low pressure (LP) turbine **30**, and a jet exhaust nozzle section **32**. A high pressure (HP) shaft **34** or spool drivingly connects the HP turbine **28** to the HP compressor **24** to rotate the HP turbine **28** and the HP compressor in unison. A low pressure (LP) shaft **36** drivingly connects the LP turbine **30** to the LP compressor **22** to rotate the LP turbine **30** and the LP compressor **22** in unison. The compressor section **21**, the combustion section **26**, the turbine section **27**, and the jet exhaust nozzle section **32** together define a core air flowpath.

(90) For the embodiment depicted in FIG. **1**, the fan section **14** includes a fan **38** (e.g., a variable pitch fan) having a plurality of fan blades **40** coupled to a disk **42** in a spaced apart manner. As depicted in FIG. **1**, the fan blades **40** extend outwardly from the disk **42** generally along the radial direction R. Each fan blade **40** is rotatable relative to the disk **42** about a pitch axis P by virtue of the fan blades **40** being operatively coupled to an actuation member **44** configured to collectively vary the pitch of the fan blades **40** in unison. The fan blades **40**, the disk **42**, and the actuation member **44** are together rotatable about the longitudinal centerline **12** via a fan shaft **45** that is powered by the LP shaft **36** across a power gearbox **46**, also referred to as a gearbox assembly **46**. The gearbox assembly **46** includes a plurality of gears for adjusting the rotational speed of the fan shaft **45** and, thus, the fan **38** relative to the LP shaft **36** to a more efficient rotational fan speed.

(91) Referring still to the exemplary embodiment of FIG. **1**, the disk **42** is covered by a rotatable fan hub **48** aerodynamically contoured to promote an airflow through the plurality of fan blades **40**. In addition, the fan section **14** includes an annular fan casing or a nacelle **50** that circumferentially surrounds the fan **38** and/or at least a portion of the core turbine engine **16**. The nacelle **50** is supported relative to the core turbine engine **16** by a plurality of circumferentially spaced outlet guide vanes **52**. Moreover, a downstream section **54** of the nacelle **50** extends over an outer portion of the core turbine engine **16** to define a bypass airflow passage **56** therebetween.

(92) During operation of the turbine engine **10**, a volume of air **58** enters the turbine engine **10** through an inlet **60** of the nacelle **50** and/or the fan section **14**. As the volume of air **58** passes across the fan blades **40**, a first portion of air **62** is directed or routed into the bypass airflow passage **56**, and a second portion of air **64** is directed or is routed into the upstream section of the core air flowpath, or, more specifically, into the annular inlet **20** of the LP compressor **22**. The ratio between the first portion of air **62** and the second portion of air **64** is commonly known as a bypass ratio. The pressure of the second portion of air **64** is then increased as the second portion of air **64** is routed through the HP compressor **24** and into the combustion section **26**, where the highly pressurized air is mixed with fuel and burned to provide combustion gases **66**.
(93) The combustion gases **66** are routed into the HP turbine **28** and expanded through the HP turbine **28** where a portion of thermal and/or of kinetic energy from the combustion gases **66** is extracted via sequential stages of HP turbine stator vanes **68** that are coupled to the outer casing **18** and HP turbine rotor blades **70** that are coupled to the HP shaft **34**, thus, causing the HP shaft **34** to rotate, thereby supporting operation of the HP compressor **24**. The combustion gases **66** are then routed into the LP turbine **30** and expanded through the LP turbine Here, a second portion of thermal and kinetic energy is extracted from the combustion gases **66** via sequential stages of LP turbine stator vanes **72** that are coupled to the outer casing **18** and LP turbine rotor blades **74** that are coupled to the LP shaft **36**, thus, causing the LP shaft **36** to rotate. This thereby supports operation of the LP compressor **22** and rotation of the fan **38** via the gearbox assembly **46**.
(94) The combustion gases **66** are subsequently routed through the jet exhaust nozzle section **32** of the core turbine engine **16** to provide propulsive thrust. Simultaneously, the pressure of the first portion of air **62** is substantially increased as the first portion of air **62** is routed through the bypass airflow passage **56** before being exhausted from a fan nozzle exhaust section **76** of the turbine engine **10**, also providing propulsive thrust. The HP turbine **28**, the LP turbine **30**, and the jet exhaust nozzle section **32** at least partially define a hot gas path **78** for routing the combustion gases **66** through the core turbine engine **16**.
(95) The turbine engine **10** depicted in FIG. **1** is by way of example only. In other exemplary embodiments, the turbine engine **10** may have any other suitable configuration. For example, in other exemplary embodiments, the fan **38** may be configured in any other suitable manner (e.g., as a fixed pitch fan) and further may be supported using any other suitable fan frame configuration. Moreover, in other exemplary embodiments, any other suitable number or configuration of compressors, turbines, shafts, or a combination thereof may be provided. In still other exemplary embodiments, aspects of the present disclosure may be incorporated into any other suitable gas turbine engine, such as, for example, turbofan engines, propfan engines, turbojet engines, and/or turboshaft engines.
(96) FIG. **2**A is a schematic view of a positioning fitting member **202** for a fastening assembly, according to an embodiment of the present disclosure. FIG. **2**B is a schematic side view of the positioning fitting member **202**, according to an embodiment of the present disclosure. FIG. **2**C is a schematic cross-sectional view, taken along detail **2**C-**2**C in FIG. **2**B, of the positioning fitting member **202**, according to an embodiment of the present disclosure. The positioning fitting member **202** may be used in any of the fastening assemblies detailed herein. The positioning fitting member **202** defines an axial direction (A), a radial direction (R), and a circumferential direction (C). The axial direction, the radial direction, and the circumferential direction of the positioning fitting member **202** may be the same or may be different as the axial direction and the radial direction of the turbine engine **10**, depending on an orientation of the positioning fitting member **202** when the positioning fitting member **202** is mounted in the turbine engine **10**.
(97) With reference to FIGS. **2**A to **2**C, the positioning fitting member **202** includes a positioning fitting body **204** extending between a proximal end **206** and a distal end **208**. The positioning fitting body **204** includes a diameter and a shape that generally corresponds to a diameter and to a shape of a respective tube. The positioning fitting body **204** includes a generally cylindrical shape.

The positioning fitting body **204** is hollow such that the positioning fitting member **202** includes a bore **210** extending therethrough. The bore **210** is sized and is shaped to receive a corresponding tube such that the positioning fitting member **202** is placed on the corresponding tube and the tube is disposed within the bore **210**, as detailed further below. In this way, the positioning fitting member **202** includes an inner surface **211** defining an inner diameter of the positioning fitting member **202** and an outer surface **213** defining an outer diameter of the positioning fitting member **202**. The inner surface **211** extends substantially axially such that the internal diameter of the positioning fitting member **202** is substantially the same along an axial direction of the positioning fitting member **202**. The outer surface **213** extends in the axial direction and includes a varying outer diameter that varies along the axial direction, as detailed further below. The positioning fitting member **202** is the same material as a material of the tubes, as detailed below. For example, the positioning fitting member **202** may be made of metals (e.g., steel, titanium, etc.), alloys, composites, ceramics, or the like. In some examples, the positioning fitting member **202** may be a different material than the material of the tubes. In some examples, the positioning fitting member **202** is a combination of materials.

(98) The positioning fitting body **204** includes a clamping surface **212** extending between a plurality of ribs **214** and forms a portion of the outer surface **213**. The clamping surface **212** is sized such that a corresponding clamp may be coupled thereto, as detailed further below. In the embodiment of FIGS. **2**A to **2**C, the plurality of ribs **214** includes a pair of ribs including a first rib **214***a* and a second rib **214***b* that form a portion of the outer surface **213**. The first rib **214***a* is located at a proximal end of the clamping surface **212** and the second rib **214***b* is located at a distal end of the clamping surface **212**. The plurality of ribs **214** extend radially outward from the positioning fitting body **204** such that an outer diameter of the plurality of ribs **214** is greater than an outer diameter of the clamping surface **212**. The plurality of ribs **214** are sized such that the pair of ribs **214** prevent a corresponding clamp from moving or from sliding axially beyond the pair of ribs **214**, as detailed further below. In some examples, the plurality of ribs **214** each includes a different size. In some examples, the plurality of ribs **214** may include any number of ribs, as desired, for preventing axial movement of a corresponding clamping element.

(99) The positioning fitting member **202** includes a pair of weld notches **216** located at respective ends of the positioning fitting body **204**. For example, the pair of weld notches **216** includes a first weld notch **216***a* located at the proximal end **206** of the positioning fitting body **204** and includes a second weld notch **216***b* located at the distal end **208** of the positioning fitting body **204**. The pair of weld notches **216** provides additional material for welding the positioning fitting member **202** to a corresponding tube, as detailed further below. For example, the pair of weld notches **216** provides for a stronger welded joint between the positioning fitting member **202** and the corresponding tube as compared to welded joints without the benefit of the present disclosure. The weld notch **216** includes an inner radial surface **217** that is disposed within the bore **210** and forms a portion of the inner surface **211**. The inner radial surface **217** extends radially inwardly and includes a greater inner diameter than the inner diameter of the inner surface **211**. The inner radial surface **217** provides a surface such that a corresponding tube contacts and abuts the inner radial surface **217**. Thus, the inner radial surface **217** helps to position the corresponding tube when the positioning fitting member **202** is being coupled to the corresponding tube. In some examples, the positioning fitting member **202** is coupled to a corresponding tube by means other than welding such that the positioning fitting member **202** does not include weld notches, as detailed further below.

(100) The positioning fitting member **202** includes a plurality of tapered surfaces **218** defining a portion of the outer surface of the positioning fitting body **204**. The plurality of tapered surfaces **218** reduce stress on a coupling between the positioning fitting member **202** and a corresponding tube, as detailed further below. For example, the plurality of tapered surfaces **218** provide a smooth transition step from the positioning fitting member **202** to the corresponding tube such that stresses between the positioning fitting member **202** and the corresponding tube are reduced.

(101) In FIGS. **2**A to **2**C, the plurality of tapered surfaces **218** include a pair of tapered surfaces including a first tapered surface **218***a* and a second tapered surface **218***b*. The first tapered surface **218***a* extends axially from the first rib **214***a* to the proximal end **206** of the positioning fitting body **204**. For example, the first tapered surface **218***a* extends to the first weld notch **216***a*. The first tapered surface **218***a* is tapered from the first rib **214***a* to the proximal end **206** such that a diameter of the first tapered surface **218***a* at the first rib **214***a* is greater than a diameter of the first tapered surface **218***a* at the proximal end **206**. The second tapered surface **218***b* extends axially from the second rib **214***b* to the distal end **208** of the positioning fitting body **204**. For example, the second tapered surface **218***b* extends to the second weld notch **216***b*. The second tapered surface **218***b* is tapered from the second rib **214***b* to the distal end **208** such that a diameter of the second tapered surface **218***b* at the second rib **214***b* is greater than a diameter of the second tapered surface **218***b* at the distal end **208**. A diameter of the plurality of tapered surfaces **218** at the plurality of ribs **214** is greater than a diameter of the clamping surface **212**. In some examples, the diameter of the plurality of tapered surfaces **218** at the plurality of ribs **214** is equal to or less than the diameter of the clamping surface **212**, as detailed further below.

(102) FIG. **3**A is an exploded view of a fastening assembly for tubular structures, such as tubes, pipes, conduits, rods, and bars, according to an embodiment of the present disclosure, typically found in engineering assemblies associated with turbine engines, such as the turbine engine **10** (FIG. **1**). FIG. **3**A shows a plurality of tubes **340** and a fastening assembly **350**. The fastening assembly **350** includes a positioning fitting member **202**, one or more clamping elements **352**, and a removable fastening mechanism **354**. The plurality of tubes **340** is a bank of tubes and includes a first tube **340***a* and a second tube **340***b*. The plurality of tubes **340** may include any number of tubes as desired. The plurality of tubes **340** may be made of any material, as desired. For example, the plurality of tubes **340** may be made of metal (e.g., steel, titanium, etc.), alloys, composites, ceramics, or the like. Each tube **340** defines a tube outer surface **342** defining an outer diameter of the tube **340**. The tube outer surface **342** is an outermost or an uppermost or an exterior boundary or a layer or an area of a tube. For example, the first tube **340***a* includes a first tube outer surface **342***a* and the second tube **340***b* includes a second tube outer surface **342***b*. The outer diameter of each tube **340** is between point two five inches and two inches. The outer diameter of each tube **340** may, however, include any size, as desired. The positioning fitting member **202** is coupled to the first tube **340***a* such that the positioning fitting member **202** forms a part of the first tube **340***a*. In some examples, the positioning fitting member **202** is formed integral with the first tube **340***a*, as detailed further below. In some examples, both the first tube **340***a* and the second tube **340***b* include a respective positioning fitting member. While FIG. **3**A shows a single fastening assembly **350**, the plurality of tubes **340** may include any number of fastening assemblies positioned at various axial locations along the plurality of tubes **340**, as desired.

(103) In FIG. **3**A, the one or more clamping elements **352** includes a pair of clamping elements that includes a first clamping element **352***a* and a second clamping element **352***b*. The one or more clamping elements **352** may include any number of clamping elements **352**, as desired. The one or more clamping elements **352** each includes loop clamps that form a looped section **351**. The looped section **351** includes a hinge **353** such that looped section **351** can be opened (FIG. **3**A) and closed (FIG. **3**B). In some examples, the one or more clamping elements **352** do not include a hinge and may be opened and closed by means other than a hinge. The looped section includes a size and a shape that generally corresponds to a size and a shape of the tubes **340**. In this way, the clamping elements **352** can be closed to clamp around a respective tube **340**, as detailed further below. Each clamping element **352** includes a plurality of clamp arms **355** disposed at, and extending from, opposing ends of the looped section **351**. FIG. **3**A shows each clamping element **352** includes two clamp arms **355**, but the clamping element **352** may include any number of clamp arms **355** as desired. Each of the plurality of clamp arms **355** includes an aperture **357** disposed therein for receiving the removable fastening mechanism **354**. When the clamping element **352** is closed, the

first clamp arm **355***a* and the second clamp arm **355***b* contact each other, and the aperture **357** of the first clamp arm **355***a* aligns with a corresponding aperture **357** of the second clamp arm **355***b* such that the removable fastening mechanism **354** can be inserted therethrough.

(104) The removable fastening mechanism **354** includes a nut **358** and a bolt **360**. Thus, the removable fastening mechanism **354** is removable such that the fastening assembly **350** may be disassembled and re-assembled as needed, as detailed further below. The removable fastening mechanism **354** may include any type of removable fastening mechanism such as, for example, studs, bolts, screws, nuts, or the like.

(105) FIG. **3**B shows an enlarged schematic side view of the fastening assembly **350** of FIG. **3**A in an assembled state, according to an embodiment of the present disclosure. FIG. **3**B shows the first clamping element **352***a* is clamped to the positioning fitting member **202** of the first tube **340***a* such that the first clamping element **352***a* extends around at least a portion of the positioning fitting member **202**, as detailed further below. The second clamping element **352***b* is clamped to the second tube **340***b* such that the second clamping element **352***b* extends around at least a portion of the second tube outer surface **342***b* of the second tube **340***b*. The first clamping element **352***a* includes first clamp arms **355***a* and the second clamping element **352***b* includes second clamp arms **355***b*. When the fastening assembly **350** is assembled, the first clamp arms **355***a* contact the second clamp arms **355***b*. The removable fastening mechanism **354** is inserted into the respective apertures of each clamping element **352** to fasten and to secure the clamping elements **352** together. Thus, the fastening assembly **350** extends around at least a portion of the positioning fitting member **202** and around at least a portion of the tube outer surface **342** of the tubes **340** to bundle and to fasten the tubes **340** together. The positioning fitting member **202** prevents the clamping elements **352** from sliding or from moving axially beyond the ribs **214** of the positioning fitting member **202**. The clamping elements **352** provide friction damping while allowing slippage between the tubes **340**, thus allowing tubes **340** with different temperatures in the same bundle while minimizing thermal mismatch, as detailed further below. For example, the second tube **340***b* does not include a positioning fitting member. Thus, the second tube **340***b* can slide or move axially with respect to the first tube **340***a*. In this way, the fastening assembly **350** provides friction damping to the bundle of tubes **340** such that the tubes **340** can vibrate and move independently with respect to each other while the clamping elements **352** remain in place without sliding.

(106) FIG. **3**C shows a schematic bottom view of the fastening assembly **350**, according to an embodiment of the present disclosure. FIG. **3**C shows that each of the clamping elements **352** includes a plurality of radial faces **362** including a first radial face **362***a* and a second radial face **362***b*. The radial faces **362** extend radially and define a portion of an outer surface of the clamping elements **352**. When the first clamping element **352***a* is clamped to the positioning fitting member **202** of the first tube **340***a*, the radial faces **362** are spaced from the ribs **214** of the positioning fitting member **202**. During operation of the turbine engine or of the engineering assembly, the tubes **340** may move axially, circumferentially, or radially due to vibrations and relative motion of the various tubes and other assemblies. The positioning fitting member **202** prevents the clamping elements **352** from sliding or moving axially with respect to the tubes **340**. When the clamping elements **352** begin to slide or to move axially, the radial faces **362** contact the ribs **214** of the positioning fitting member **202** such that the clamping elements **352** are prevented from sliding or moving axially beyond the ribs **214**. For example, the first radial face **362***a* may contact the first rib **214***a* if the clamping elements **352** or the first tube **340***a* slide or move in a first axial direction, and the second radial face **362***b* may contact the second rib **214***b* if the clamping elements **352** or the first tube **340***a* slide or move in a second axial direction opposite the first axial direction.

(107) FIG. **3**D shows a schematic rear view of the fastening assembly **350**, according to an embodiment of the present disclosure. In FIG. **3**D, the fastening assembly **350** is rotated ninety degrees about the axial direction from the view in FIG. **3**B. The clamping elements **352** include a cushion **370** disposed about the clamping element **352** that includes an outer cushion portion **370***a*

and an inner cushion portion **370***b* (shown in FIG. **3**E). FIG. **3**D shows the outer cushion portion **370***a* is disposed about an outer surface of the clamping element **352**. The inner cushion portion **370***b* (FIG. **3**E) of the cushion **370** is disposed within a respective clamping element **352** such that the cushion **370** extends around and contacts a respective tube **340**, as detailed further below. The cushion **370** provides friction damping between the clamping element **352** and a respective tube **340**. The cushion **370** is made from a polymer composite material such as, for example, a polybenzimidazole (PBI) fiber, polytetrafluoroethylene, rubber, or the like, for providing friction damping. The cushion **370** provides improved friction damping compared to a metal-to-metal contact between the clamping element **352** and the tube **340** or the positioning fitting member **202**.

(108) FIG. **3**E shows a cross-sectional view of the fastening assembly **350**, taken at detail **3**E-**3**E in FIG. **3**C, according to an embodiment of the present disclosure. FIG. **3**E shows each of the clamping elements **352** includes a clamp body **372**. The clamp body **372** defines a size and a shape of the clamping element **352**. For example, the clamp body **372** defines the looped section **351** and the clamp arms **355** of each clamping element **352**. The looped section **351** and the clamp arms **355** are integrally formed such that the looped section **351** and the clamp arms **355** together form a single unitary structure. In some examples, the looped section **351** and the clamp arms **355** are formed of separate structures and coupled together to form the clamp body **372**. The clamp body **372** is made of any material such as, for example, metal, alloys, composites, polymers, ceramics, or combinations thereof. The clamp body **372** also defines the hinge **353**. The cushion **370** is coupled to, and disposed within, the clamp body **372** and forms a shape corresponding to the shape of the clamp body **372**. For example, the cushion includes the outer cushion portion **370***a* and the inner cushion portion **370***b*. The clamp body **372** can be inserted between the outer cushion portion **370***a* and the inner cushion portion **370***b* such that the cushion **370** is coupled to the clamp body **372**. Thus, the inner cushion portion **370***b* of the cushion **370** defines an interior surface of the clamping element **352** and engages with a respective tube **340** or with a positioning fitting member **202** to bundle and to secure the tubes **340** together.

(109) FIG. **3**F shows a cross-sectional view of the fastening assembly **350**, taken at detail **3**F-**3**F in FIG. **3**D, according to an embodiment of the present disclosure. FIG. **3**F shows the clamping elements **352** engage with respective tubes **340**. For example, the first clamping element **352***a* engages with the positioning fitting member **202** of the first tube **340***a* and the second clamping element **352***b* engages with the second tube **340***b*. When the clamping elements **352** are engaged with the tubes **340**, the clamping elements **352** generate high radial compressive force on the tubes **340** to maintain the bundle of tubes **340** under operational loads while the positioning fitting member **202** maintains the clamping elements **352** in the intended location and position. For example, the ribs **214** of the positioning fitting member **202** prevent the clamping elements **352** from sliding or moving axially about the tubes **340**.

(110) FIG. **3**F shows the weld notch **216** of the positioning fitting member **202**. The inner radial surface **217** of the weld notch **216** contacts a corresponding surface of the first tube **340***a*. For example, the first tube **340***a* includes a first tube portion **341** and a second tube portion **343**. The first tube portion **341** contacts and abuts a first inner radial surface **217***a* and the second tube portion **343** contacts and abuts a second inner radial surface **217***b*. The positioning fitting member **202** is then welded to each of the first tube portion **341** and the second tube portion **343** such that the first tube portion **341**, the positioning fitting member **202**, and the second tube portion **343** form a single integral structure. In some examples, the first tube **340***a* includes a single tube portion and the first tube **340***a* may extend through the positioning fitting member **202**. When the positioning fitting member **202** is coupled to the first tube **340***a*, the tapered surfaces **218** provide a smooth transition between the positioning fitting member **202** and the first tube **340***a* to reduce the stress concentration on the coupling between the positioning fitting member **202** and the first tube **340***a* under operational loads on the tubes **340** during operation of the turbine engine **10** or the engineering assembly.

(111) FIG. **4**A shows an enlarged schematic side view of another fastening assembly **450***a* in an assembled state, according to another embodiment of the present disclosure. The fastening assembly **450***a* includes many of the same components as the fastening assembly **350** (FIG. **3**B). The second clamping element **352***b*, however, is oriented in a different direction in the fastening assembly **450***a* than in the fastening assembly **350**. The clamping elements **352** may be oriented in any orientation for bundling and securing the tubes **340** together.
(112) FIG. **4**B shows an enlarged schematic side view of another fastening assembly **450***b* in an assembled state, according to another embodiment of the present disclosure. The fastening assembly **450***b* includes many of the same components as the fastening assembly **350** (FIG. **3**B). The second clamping element **352***b*, however, is oriented in a different direction in the fastening assembly **450***b* than in the fastening assembly **350**. The clamping elements **352** may be oriented in any orientation for bundling and securing the tubes **340** together.
(113) FIG. **5**A is an exploded view of another fastening assembly **550** for tubular structures, according to another embodiment of the present disclosure. FIG. **5**A shows a plurality of tubes **540** and a fastening assembly **550**. The fastening assembly **550** includes a positioning fitting member **502**, one or more clamping elements **552**, a spacer element **590**, and a removable fastening mechanism **554**. The plurality of tubes **540** is a bank of tubes and includes a first tube **540***a* and a second tube **540***b*. Each tube **540** defines a tube outer surface **542**. For example, the first tube **540***a* includes a first tube outer surface **542***a* and the second tube **540***b* includes a second tube outer surface **542***b*. The positioning fitting member **502** is coupled to the first tube **540***a* such that the positioning fitting member **502** forms a part of the first tube outer surface **542***a* of the first tube **540***a*. The second tube **540***b* includes a wear sleeve **520** coupled thereto. The wear sleeve **520** is a metal sleeve that provides additional material for a metal-to-metal contact between the clamping element **552** and the second tube **540***b*. In this way, the wear sleeve **520** may wear as the second tube **540***b* slides or moves axially within the clamping element **552** such that the wear sleeve **520** protects the second tube **540***b* from wear.
(114) In FIG. **5**A, the one or more clamping elements **552** includes a single clamping element. The clamping element **552** includes a metallic band that forms a plurality of looped sections **551**. For example, the clamping element **552** includes a first looped section **551***a* and a second looped section **551***b*. The looped sections **551** are coupled together at a first end by a hinge **553** such that looped sections **551** can be opened (FIG. **5**A) and closed (FIG. **5**B). The looped sections **551** include a size and a shape that generally corresponds to a size and a shape of the tubes **540**. In this way, the clamping element **552** can be closed to clamp around the tubes **540**, as detailed further below. The clamping element **552** includes a plurality of clamp arms **555**. Each clamp arm **555** is disposed at, and extends from, a second end of a respective looped section **551**. FIG. **5**A shows the clamping element **552** includes two clamp arms **555**, but the clamping element **552** may include any number of clamp arms **555** as desired. Each of the plurality of clamp arms **555** includes an aperture **557** disposed therein for receiving the removable fastening mechanism **554**. When the clamping element **552** is closed, the clamp arms **555** contact each other and the respective apertures **557** align with each other such that the removable fastening mechanism **554** can be inserted therethrough. The removable fastening mechanism **554** includes a nut **558** and a bolt **560**, as detailed above.
(115) The spacer element **590** includes a body having one or more cradle brackets **591** that define contact faces of the spacer element **590**. The cradle brackets **591** are concave to correspond to a shape of the tubes **540**. The cradle brackets **591** may include any shape that corresponds to respective tubes, conduits, pipes, etc. The spacer element **590** includes two opposing cradle brackets **591** including a first cradle bracket **591***a* and a second cradle bracket **591***b*. The spacer element **590** includes a first end **592** and a second end **593** opposite the first end **592**. The first end **592** may be a top end and the second end **593** may be a bottom end in the orientation of FIG. **5**A. While “top end” and “bottom end” are used herein, the spacer element **590** may be oriented in any

direction, as desired. The spacer element **590** includes raised edges **594** extending radially outwardly from the first end **592** and from the second end **593** to provide a secure or a snug seating arrangement for the clamping element **552**. In this way, the raised edges **594** prevent the clamping element **552** from sliding axially beyond the raised edges **594**.

(116) FIG. **5**B shows an enlarged schematic side view of the fastening assembly **550** of FIG. **5**A in an assembled state, according to an embodiment of the present disclosure. In FIG. the spacer element **590** spatially separates the tubes **540** and distributes stress in the fastening assembly **550**. For example, the tubes **540** are inserted into and contact the respective cradle brackets **591** (FIG. **5**A). The clamping element **552** extends around at least a portion of the tube outer surfaces **542** of the tubes **540**. The clamping element **552** extends about and contacts the first end **592** (FIG. **5**A) and the second end **593** (FIG. **5**A) of the spacer element **590** between the raised edges **594** of the first end **592** and the second end **593**.

(117) The positioning fitting member **502** is similar to the positioning fitting member **202**. The positioning fitting member **502** includes a clamping surface **512**, a plurality of ribs **514** including a first rib **514***a* and a second rib **514***b*, a plurality of weld notches **516** including a first weld notch **516***a* and a second weld notch **516***b*, and a plurality of tapered surfaces **518** including a first tapered surface **518***a* and a second tapered surface **518***b*. A thickness of the clamping surface **512** is greater than a thickness of the clamping surface **212** (FIG. **2**C), as detailed further below.

(118) The first looped section **551***a* of the clamping element **552** is clamped to the positioning fitting member **502** of the first tube **540***a* such that the clamping element **552** extends around at least a portion of the positioning fitting member **502**. In this way, the clamping element **552** is positioned between the first rib **514***a* and the second rib **514***b* of the positioning fitting member **502** when the fastening assembly **550** is assembled. The second looped section **551***b* is clamped to the wear sleeve **520** of the second tube **540***b* such that the clamping element **552** extends around at least a portion of the wear sleeve **520** of the second tube **540***b*. When the fastening assembly **550** is assembled, the clamp arms **555** contact each other and the removable fastening mechanism **554** is inserted into the respective apertures **557** (FIG. **5**A) to fasten and to secure the clamping element **552** about the tubes **540**. Thus, the clamping element **552** extends around at least a portion of the positioning fitting member **502** and around at least a portion of the tube outer surfaces **542** of the tubes **540** to bundle and to fasten the tubes **540** together. The positioning fitting member **502** prevents the first tube **540***a* from sliding or from moving axially beyond the ribs **514** of the positioning fitting member **502**, as detailed above.

(119) FIG. **5**C shows a schematic side view of the fastening assembly **550**, according to an embodiment of the present disclosure. FIG. **5**C shows that the clamping element **552** includes a plurality of radial faces **562** including a first radial face **562***a* and a second radial face **562***b*. The radial faces **562** extend radially and define a portion of an outer surface of the clamping element **552**. When the clamping element **552** is clamped to the positioning fitting member **502** of the first tube **540***a*, the radial faces **562** are spaced from the ribs **514** of the positioning fitting member **502**. During operation of the turbine engine or of the engineering assembly, the tubes **540** may move axially, circumferentially, or radially due to vibrations and relative motion of the various tubes and other assemblies. The positioning fitting member **502** prevents the clamping element **552** from sliding or moving axially with respect to the tubes **540**. When the clamping element **552** begins to slide or to move axially, the radial faces **562** contact the ribs **514** of the positioning fitting member **502** such that the clamping element **552** is prevented from sliding or moving axially beyond the ribs **514**. For example, the first radial face **562***a* may contact the first rib **514***a* if the clamping elements **552** or the first tube **540***a* slide or move in a first axial direction, and the second radial face **562***b* may contact the second rib **514***b* if the clamping elements **552** or the first tube **540***a* slide or move in a second axial direction opposite the first axial direction.

(120) FIG. **5**D shows a schematic front view of the fastening assembly **550**, according to an embodiment of the present disclosure. FIG. **5**D shows the spacer element **590** spatially separates

the tubes **540** and the tubes **540** engage with the cradle brackets **591**. For example, the first tube **540***a* engages with the first cradle bracket **591***a* and the second tube **540***b* engages with the second cradle bracket **591***b*. The clamping element **552** is disposed on the first end **592** (FIG. and the second end **593** (FIG. **5**A) of the spacer element **590** such that the clamping element **552** is disposed within the raised edges **594**.

(121) FIG. **5**E shows a cross-sectional view of the fastening assembly **550**, taken at detail **5**E-**5**E in FIG. **5**C, according to an embodiment of the present disclosure. FIG. **5**C shows the clamping element **552** includes a clamp body **572**. The clamp body **572** defines a size and a shape of the clamping element **552**. For example, the clamp body **572** defines the looped sections **551** and the clamp arms **555** of the clamping element **552**. Each clamp arm **555** is integrally formed with a respective looped section **551** such that the respective looped sections **551** and the respective clamp arms **555** together form a single unitary structure. The clamp body **572** is made of any material such as, for example, metal, alloys, composites, or the like. The clamping element **552** does not include a cushion. In this way, the clamping element **552** can be used in high temperature environments and includes a greater stiffness as compared with the clamping elements **352** that include cushions. The clamping element **552** provides less friction damping as compared to the clamping elements **352** because of the metal-to-metal contact of the clamping element **552** on the tubes **540**. FIG. **5**E also shows that the wear sleeve **520** engages with the second cradle bracket **591***b* and the positioning fitting member **502** engages with the first cradle bracket **591***a* when the fastening assembly **550** is assembled.

(122) FIG. **5**F shows a cross-sectional view of the fastening assembly **550**, taken at detail **5**F-**5**F in FIG. **5**D, according to an embodiment of the present disclosure. FIG. **5**F shows the clamping element **552** engages with respective tubes **540**. For example, the first looped section **551***a* engages with the positioning fitting member **502** of the first tube **540***a* and the second looped section **551***b* engages with the wear sleeve **520** of the second tube **540***b*. When the clamping element **552** is engaged with the tubes **540**, the clamping element **552** generates high radial compressive force on the tubes **540** to maintain the bundle of tubes **540** under operational loads while the positioning fitting member **502** maintains the clamping element **552** in the intended location and position. For example, ribs **514** of the positioning fitting member **502** prevent the clamping elements **552** from sliding or moving axially about the tubes **540**, as detailed above.

(123) In applications that include an all-metal fastening assembly (e.g., the fastening assembly does not include composite or other materials), the thickness of the clamping surface **512** is greater as compared to applications in which the fastening assembly includes non-metal materials. The greater thickness provides additional wear resistance for the positioning fitting member **502**. The greater thickness of the clamping surface **512** provides for a greater diameter as compared to the clamping surface **212** (FIG. **2**C). FIG. **5**F shows a diameter of the plurality of tapered surfaces **518** at the plurality of ribs **514** is equal to or less than a diameter of the clamping surface **512**. Accordingly, the positioning fitting member **502** may be used in applications that include an all-metal fastening assembly.

(124) FIG. **5**F shows the weld notch **516** of the positioning fitting member **502**. The first tube **540***a* contacts an inner radial surface **517** of the weld notches **516** and the positioning fitting member **502** is welded to the first tube **540***a* such that a first tube portion **541** of the first tube **540***a*, the positioning fitting member **502**, and a second tube portion **543** of the first tube **540***a* form a single integral structure, as detailed above. When the positioning fitting member **502** is coupled to the first tube **540***a*, the tapered surfaces **518** provide a smooth transition between the positioning fitting member **502** and the first tube **540***a* to reduce the stress concentration on the coupling between the positioning fitting member **502** and the first tube **540***a* under operational loads on the tubes **540** during operation of the turbine engine **10** or the engineering assembly. During operation, the radial faces **562** may contact the ribs **514** to prevent the clamping element **552** from sliding or from moving axially about the tubes **540**.

(125) FIG. **6**A is an exploded view of another fastening assembly for tubular structures, according to another embodiment of the present disclosure. FIG. **6**A shows a plurality of tubes **640** and a fastening assembly **650**. The fastening assembly **650** includes a positioning fitting member **202**, one or more clamping elements **652**, a spacer element **690**, and a removable fastening mechanism **654**. The plurality of tubes **640** is a bank of tubes and includes a first tube **640***a* and a second tube **640***b*. Each tube **640** defines a tube outer surface **642**. For example, the first tube **640***a* includes a first tube outer surface **642***a* and the second tube **640***b* includes a second tube outer surface **642***b*. The positioning fitting member **202** is coupled to the first tube **640***a* such that the positioning fitting member **202** forms a part of the first tube outer surface **642***a* of the first tube **640***a*.
(126) The one or more clamping elements **652** includes a single clamping element. The clamping element **652** is substantially similar to the clamping element **552** (FIG. **5**A) but includes a cushion, as detailed further below. The clamping element **652** includes a metallic band that forms a plurality of looped sections **651**. For example, the clamping element **652** includes a first looped section **651***a* and a second looped section **651***b*. The looped sections **651** are coupled together at a first end by a hinge **653** such that looped sections **651** can be opened (FIG. **6**A) and closed (FIG. **6**B). The looped sections **651** include a size and a shape that generally corresponds to a size and a shape of the tubes **640**. In this way, the clamping element **652** can be closed to clamp around the tubes **640**, as detailed further below. The clamping element **652** includes a plurality of clamp arms **655**. Each clamp arm **655** is disposed at, and extends from, a second end of a respective looped section **651**. FIG. **6**A shows the clamping element **652** includes two clamp arms **655**, but the clamping element **652** may include any number of clamp arms **655** as desired. Each of the plurality of clamp arms **655** includes an aperture **657** disposed therein for receiving the removable fastening mechanism **654**. When the clamping element **652** is closed, the clamp arms **655** contact each other and the respective apertures **657** align with each other such that the removable fastening mechanism **654** can be inserted therethrough. The removable fastening mechanism **654** includes a nut **658** and a bolt **660**, as detailed above.
(127) The spacer element **690** includes a body having one or more cradle brackets **691** that define contact faces of the spacer element **690**. The cradle brackets **691** are concave to correspond to a shape of the tubes **640**. The cradle brackets **691** may include any shape that corresponds to respective tubes, conduits, pipes, etc. The spacer element **690** includes two opposing cradle brackets **691** including a first cradle bracket **691***a* and a second cradle bracket **691***b*. The spacer element **690** includes a first end **692** and a second end **693** opposite the first end **692**. The spacer element **690** does not include raised edges like the spacer element **590**.
(128) FIG. **6**B shows an enlarged schematic side view of the fastening assembly **650** of FIG. **6**A in an assembled state, according to an embodiment of the present disclosure. In FIG. **6**B, the spacer element **690** spatially separates the tubes **640** and distributes stress in the fastening assembly **650**. For example, the tubes **640** are inserted into and contact the respective cradle brackets **691** (FIG. **6**A). The clamping element **652** extends around at least a portion of the tube outer surfaces **642** of the tubes **640**. The clamping element **652** extends about and contacts the first end **692** (FIG. **6**A) and the second end **693** (FIG. **6**A) of the spacer element **690**.
(129) The first looped section **651***a* of the clamping element **652** is clamped to the positioning fitting member **202** of the first tube **640***a* such that the clamping element **652** extends around at least a portion of the positioning fitting member **202**. In this way, the clamping element **652** is positioned between the first rib **214***a* and the second rib **214***b* of the positioning fitting member **202** when the fastening assembly **650** is assembled. The second looped section **651***b* is clamped to the second tube **640***b* such that the clamping element **652** extends around at least a portion of the second tube outer surface **642***b* of the second tube **640***b*. When the fastening assembly **650** is assembled, the clamp arms **655** contact each other and the removable fastening mechanism **654** is inserted into the respective apertures **657** (FIG. **6**A) to fasten and to secure the clamping element **652** about the tubes **640**. Thus, the clamping element **652** extends around at least a portion of the

positioning fitting member **202** and around at least a portion of the tube outer surfaces **642** of the tubes **640** to bundle and to fasten the tubes **640** together. The positioning fitting member **202** prevents the first tube **640***a* from sliding or from moving axially beyond the ribs **214** of the positioning fitting member **202**, as detailed above.

(130) FIG. **6**C shows a schematic side view of the fastening assembly **650**, according to an embodiment of the present disclosure. FIG. **6**C shows that the clamping element **652** includes a plurality of radial faces **662** including a first radial face **662***a* and a second radial face **662***b*. The radial faces **662** extend radially and define a portion of an outer surface of the clamping element **652**. When the clamping element **652** is clamped to the positioning fitting member **202** of the first tube **640***a*, the radial faces **662** are spaced from the ribs **214** of the positioning fitting member **202**. During operation of the turbine engine or of the engineering assembly, the tubes **640** may move axially, circumferentially, or radially due to vibrations and relative motion of the various tubes and other assemblies. The positioning fitting member **202** prevents the clamping element **652** from sliding or moving axially with respect to the tubes **640**. When the clamping element **652** begins to slide or to move axially, the radial faces **662** contact the ribs **214** of the positioning fitting member **202** such that the clamping element **652** is prevented from sliding or moving axially beyond the ribs **214**. For example, the first radial face **662***a* may contact the first rib **214***a* if the clamping elements **652** or the first tube **640***a* slide or move in a first axial direction, and the second radial face **662***b* may contact the second rib **214***b* if the clamping elements **652** or the first tube **640***a* slide or move in a second axial direction opposite the first axial direction.

(131) FIG. **6**D shows a schematic front view of the fastening assembly **650**, according to an embodiment of the present disclosure. FIG. **6**D shows the spacer element **690** spatially separates the tubes **640** and the tubes **640** engage with the cradle brackets **691**. For example, the first tube **640***a* engages with the first cradle bracket **691***a* and the second tube **640***b* engages with the second cradle bracket **691***b*. The clamping element **652** is disposed on the first end **692** (FIG. **6**A) and the second end **693** (FIG. **6**A) of the spacer element **690**. The clamping element **652** includes a cushion **670** disposed about the clamping element **652** that includes an outer cushion portion **670***a* and an inner cushion portion **670***b* (shown in FIG. **6**E). FIG. **6**D shows the outer cushion portion **670***a* disposed about an outer surface of the clamping element **652**. The inner cushion portion **670***a* (FIG. **6**E) of the cushion **670** is disposed within a respective clamping element **652** such that the cushion **670** extends around and contacts a respective tube **640**, as detailed further below. The cushion **670** provides friction damping between the clamping element **652** and a respective tube **640**. The cushion **670** is made from a polymer composite material or a similar material, as detailed above, for providing friction damping. The cushion **670** provides improved friction damping compared to a metal-to-metal contact between the clamping element **652** and the tube **640** or the positioning fitting member **202**. In this way, the clamping element **652** provides improved friction damping but less heat resistance and stiffness as compared to the clamping element **552** (FIG. **5**B). Thus, clamping elements with cushions can be used for improved friction damping for environments with low or moderate temperatures.

(132) FIG. **6**E shows a cross-sectional view of the fastening assembly **650**, taken at detail **6**E-**6**E in FIG. **6**C, according to an embodiment of the present disclosure. FIG. **6**E shows the clamping element **652** includes a clamp body **672**. The clamp body **672** defines a size and a shape of the clamping element **652**. For example, the clamp body **672** defines the looped sections **651** and the clamp arms **655** of the clamping element **652**. The clamp body **672** is made of any material such as, for example, metal, alloys, composites, or the like. The cushion **670** is coupled to, and disposed within, the clamp body **672** and forms a shape corresponding to the shape of the clamp body **672**. For example, the cushion **670** includes the outer cushion portion **670***a* and the inner cushion portion **670***b*. The clamp body **672** can be inserted between the outer cushion portion **670***a* and the inner cushion portion **670***b* to couple the cushion **670** to the clamp body **672**. Thus, the inner cushion portion **670***b* of the cushion **670** defines an interior surface of the clamping element **652**

and engages with a respective tube **640** or with a positioning fitting member **202** to bundle and to secure the tubes **640** together.

(133) FIG. **6**F shows a cross-sectional view of the fastening assembly **650**, taken at detail **6**F-**6**F in FIG. **6**D, according to an embodiment of the present disclosure. FIG. **6**F shows the clamping element **652** engages with respective tubes **640**. For example, the first looped section **651***a* engages with the positioning fitting member **202** of the first tube **640***a* and the second looped section **651***b* engages with the second tube **640***b*. When the clamping element **652** is engaged with the tubes **640**, the clamping element **652** generates a high radial compressive force on the tubes **640** to maintain the bundle of tubes **640** under operational loads while the positioning fitting member **202** maintains the clamping element **652** in the intended location and position. For example, the ribs **214** of the positioning fitting member **202** prevent the clamping elements **652** from sliding or moving axially about the tubes **640**, as detailed above.

(134) FIG. **6**F shows the weld notch **216** of the positioning fitting member **202**. The first tube **640***a* contacts the inner radial surface **217** of the weld notches **216** and the positioning fitting member **202** is welded to the first tube **640***a* such that a first tube portion **641** of the first tube **640***a*, the positioning fitting member **202**, and a second tube portion **643** of the first tube **640***a* form a single integral structure, as detailed above. When the positioning fitting member **202** is coupled to the first tube **640***a*, the tapered surfaces **218** provide a smooth transition between the positioning fitting member **202** and the first tube **640***a* to reduce the stress concentration on the coupling between the positioning fitting member **202** and the first tube **640***a* under operational loads on the tubes **640** during operation of the turbine engine **10** or the engineering assembly. During operation, the radial faces **662** may contact the ribs **214** to prevent the clamping element **652** from sliding or from moving axially about the tubes **640**.

(135) FIG. **7**A is an exploded view of another fastening assembly **750** for tubular structures, according to another embodiment of the present disclosure. FIG. **7**A shows a plurality of tubes **740** and a fastening assembly **750**. The fastening assembly **750** includes a positioning fitting member **202**, one or more clamping elements **752**, a spacer element **790**, and a removable fastening mechanism **754**. The plurality of tubes **740** is a bank of tubes and includes a first tube **740***a*, a second tube **740***b*, and a third tube **740***c*. Each tube **740** defines a tube outer surface **742**. For example, the first tube **740***a* includes a first tube outer surface **742***a*, the second tube **740***b* includes a second tube outer surface **742***b*, and the third tube **740***c* includes a third tube outer surface **742***c*. The positioning fitting member **202** is coupled to the first tube **740***a* such that the positioning fitting member **202** forms a part of the first tube outer surface **742***a* of the first tube **740***a*.

(136) The one or more clamping elements **752** includes a single clamping element. The clamping element **752** includes a generally triangular shape. The clamping element **752** includes a metallic band that forms a plurality of straight sections **749** and a plurality of looped sections **751**. For example, the clamping element **752** includes a first straight section **749***a* and a second straight section **749***b* coupled together at a hinge **753** such that the clamping element **752** can be opened (FIG. **7**A) and closed (FIG. **7**B). The straight sections **749** each includes a curved portion at a first end thereof such that the curved portions engage a respective tube **740** when the clamping element **752** is closed. The clamping element **752** includes a first looped section **751***a* and a second looped section **751***b*. The looped sections **751** extend from the respective straight sections **749**. For example, the first looped section **751***a* extends at a first end from the first straight section **749***a* and the second looped section **751***b* extends at a first end from the second straight section **749***b*. The looped sections **751** include a size and a shape that generally corresponds to a size and a shape of the tubes **740**. In this way, the clamping element **752** can be closed to clamp around the tubes **740**, as detailed further below. The clamping element **752** includes a plurality of clamp arms **755**. Each clamp arm **755** is disposed at, and extends from, a second end of a respective looped section **751**. FIG. **7**A shows the clamping element **752** includes two clamp arms **755**, but the clamping element **752** may include any number of clamp arms **755** as desired. Each of the plurality of clamp arms

755 includes an aperture **757** disposed therein for receiving the removable fastening mechanism **754**. When the clamping element **752** is closed, the clamp arms **755** contact each other and the respective apertures **757** align with each other such that the removable fastening mechanism **754** can be inserted therethrough. The removable fastening mechanism **754** includes a nut **758** and a bolt **760**, as detailed above.

(137) The spacer element **790** includes a body having one or more cradle brackets **791** that define contact faces of the spacer element **790**. The cradle brackets **791** are concave to correspond to a shape of the tubes **740**. The cradle brackets **791** may include any shape that corresponds to respective tubes, conduits, pipes, etc. The spacer element **790** includes three cradle brackets **791**. The spacer element **790** includes a core part **793** and a plurality of radial arms **795** extending radially outward from the core part **793**. The plurality of radial arms **795** include a first radial arm **795***a*, a second radial arm **795***b*, and a third radial arm **795***c*. The radial arms **795** define a portion of the cradle brackets **791**. The core part **793** and the radial arms **795** may be integral and unitary or may be separate components coupled together. The spacer element **790** may include any number of radial arms **795** and cradle brackets **791** as desired. Each cradle bracket **791** includes a cushion **796**. The cushion **796** includes a shape that generally corresponds to a shape of the cradle brackets **791**. In this way, the tubes **740** engage with the cushion **796** and the cushion provides friction damping similar to the cushions detailed above.

(138) FIG. **7**B shows an enlarged schematic side view of the fastening assembly **750** of FIG. **7**A in an assembled state, according to an embodiment of the present disclosure. In FIG. **7**B, the spacer element **790** spatially separates the tubes **740** and distributes stress in the fastening assembly **750**. For example, the tubes **740** are inserted into and contact the respective cradle brackets **791** (FIG. **7**A). The clamping element **752** extends around at least a portion of the tube outer surfaces **742** of the tubes **740**. The clamping element **752** extends about and contacts outer surfaces of the radial arms **795** (FIG. **7**A) of the spacer element **790**.

(139) When the clamping element **752** is closed, the curved portion of the straight sections **749** forms a shape that generally corresponds to a shape of the first tube **740***a* and thus clamps to the positioning fitting member **202** of the first tube **740***a*. In this way, the clamping element **752** is positioned between the first rib **214***a* and the second rib **214***b* of the positioning fitting member **202** when the fastening assembly **750** is assembled. The first looped section **751***a* of the clamping element **752** is clamped to the second tube **740***b* such that the clamping element **752** extends around at least a portion of the second tube outer surface **742***b* of the second tube **740***b*. The second looped section **751***b* is clamped to the third tube **740***c* such that the clamping element **752** extends around at least a portion of the third tube outer surface **742***c* of the third tube **740***c*. When the fastening assembly **750** is assembled, the clamp arms **755** contact each other and the removable fastening mechanism **754** is inserted into the respective apertures **757** (FIG. **7**A) to fasten and to secure the clamping element **752** about the tubes **740**. Thus, the clamping element **752** extends around at least a portion of the positioning fitting member **202** and around at least a portion of the tube outer surfaces **742** of the tubes **740** to bundle and to fasten the tubes **740** together. The positioning fitting member **202** prevents the first tube **740***a* from sliding or from moving axially beyond the ribs **214** of the positioning fitting member **202**, as detailed above.

(140) FIG. **7**C shows a schematic side view of the fastening assembly **750**, according to an embodiment of the present disclosure. FIG. **7**C shows that the clamping element **752** includes a plurality of radial faces **762** including a first radial face **762***a* and a second radial face **762***b*. The radial faces **762** extend radially and define a portion of an outer surface of the clamping element **752**. When the clamping element **752** is clamped to the positioning fitting member **202** of the first tube **740***a*, the radial faces **762** are spaced from the ribs **214** of the positioning fitting member **202**. During operation of the turbine engine or of the engineering assembly, the tubes **740** may move axially, circumferentially, or radially due to vibrations and relative motion of the various tubes and other assemblies. The positioning fitting member **202** prevents the clamping element **752** from

sliding or moving axially with respect to the tubes **740**. When the clamping element **752** begins to slide or to move axially, the radial faces **762** contact the ribs **214** of the positioning fitting member **202** such that the clamping element **752** is prevented from sliding or moving axially beyond the ribs **214**. For example, the first radial face **762***a* may contact the first rib **214***a* if the clamping elements **752** or the first tube **740***a* slide or move in a first axial direction, and the second radial face **762***b* may contact the second rib **214***b* if the clamping elements **752** or the first tube **740***a* slide or move in a second axial direction opposite the first axial direction.

(141) FIG. **7**D shows a schematic front view of the fastening assembly **750**, according to an embodiment of the present disclosure. FIG. **7**D shows the spacer element **790** spatially separates the tubes **740** and the tubes **740** engage with the cradle brackets **791**. For example, the first tube **740***a* engages with the first cradle bracket **791***a*, the second tube **740***b* engages with the second cradle bracket **791***b*, and the third tube **740***c* engages with the third cradle bracket **791***c*. The clamping element **752** is disposed about the outer surfaces of the radial arms **795** (FIG. **7**A). The clamping element **752** includes a cushion **770** disposed about the clamping element **752** that includes an outer cushion portion **770***a* and an inner cushion portion **770***b* (shown in FIG. **7**E). FIG. **7**D shows the outer cushion portion **770***a* is disposed about an outer surface of the clamping element **752**. The inner cushion portion **770***b* (FIG. **7**E) of the cushion **770** is disposed within the clamping element **752** such that the cushion **770** extends around and contacts a respective tube **740**, as detailed further below. The cushion **770** provides friction damping between the clamping element **752** and a respective tube **740**. The cushion **770** is made from a polymer composite material or similar material, as detailed above, for providing friction damping.

(142) FIG. **7**E shows a cross-sectional view of the fastening assembly **750**, taken at detail **7**E-**7**E in FIG. **7**C, according to an embodiment of the present disclosure. FIG. **7**C shows the clamping element **752** includes a clamp body **772**. The clamp body **772** defines a size and a shape of the clamping element **752**. For example, the clamp body **772** defines the looped sections **751** and the clamp arms **755** of the clamping element **752**. The clamp body **772** is generally triangular but may include any shape as desired. The clamp body **772** is made of any material such as, for example, metal, alloys, composites, or the like. The cushion **770** is coupled to, and disposed within, the clamp body **772** and forms a shape corresponding to the shape of the clamp body **772**. For example, the cushion **770** includes the outer cushion portion **770***a* and the inner cushion portion **770***b*. The clamp body **772** can be inserted between the outer cushion portion **770***a* and the inner cushion portion **770***b* to couple the cushion **770** to the clamp body **752**. The cushion **770** and the cushions **796** together form a shape that corresponds to the tubes **740** when the clamping element **752** is closed. Thus, the inner cushion portion **770***b* of the cushion **770** and the cushions **796** define an interior surface of the clamping element **752** and engage with a respective tube **740** or with a positioning fitting member **202** to bundle and to secure the tubes **740** together.

(143) FIG. **7**F shows a cross-sectional view of the fastening assembly **750**, taken at detail **7**F-**7**F in FIG. **7**D, according to an embodiment of the present disclosure. FIG. **7**F shows the clamping element **752** engages with respective tubes **740**. For example, the cushion **796** and the cushion **770** (FIG. **7**E) engage with the positioning fitting member **202** or with a respective tube **740**. When the clamping element **752** is engaged with the tubes **740**, the clamping element **752** generates high radial compressive force on the tubes **740** to maintain the bundle of tubes **740** under operational loads while the positioning fitting member **202** maintains the clamping element **752** in the intended location and position. For example, the ribs **214** of the positioning fitting member **202** prevent the clamping elements **752** from sliding or moving axially about the tubes **740**, as detailed above.

(144) FIG. **7**F shows the weld notch **216** of the positioning fitting member **202**. The first tube **740***a* contacts the inner radial surface **217** of the weld notches **216** and the positioning fitting member **202** is welded to the first tube **740***a*, as detailed above. When the positioning fitting member **202** is coupled to the first tube **740***a*, the tapered surfaces **218** provide a smooth transition between the positioning fitting member **202** and the first tube **740***a* to reduce the stress concentration on the

coupling between the positioning fitting member **202** and the first tube **740***a* under operational loads on the tubes **740** during operation of the turbine engine **10** or the engineering assembly. During operation, the radial faces **762** may contact the ribs **214** to prevent the clamping element **752** from sliding or from moving axially about the tubes **740**.

(145) FIG. **7**G shows a cross-sectional view of the fastening assembly **750**, taken at detail **7**G-**7**G in FIG. **7**D, according to an embodiment of the present disclosure. FIG. **7**G shows the tubes **740** engage with the spacer element **790** such that the tubes **740** are spatially separated. The spacer element **790** is disposed between the ribs **214** of the positioning fitting member **202** such that the ribs **214** prevent the spacer element **790** from sliding or from moving axially beyond the ribs **214**.

(146) FIG. **8**A is an exploded view of another fastening assembly **850** for tubular structures, according to another embodiment of the present disclosure. FIG. **8**A shows a plurality of tubes **840** and a fastening assembly **850**. The fastening assembly **850** includes one or more positioning fitting members **202**, one or more clamping elements **852**, and one or more removable fastening mechanisms **854**. The plurality of tubes **840** is a bank of tubes and includes four tubes **840**. The tubes **840** include a first tube **840***a*, a second tube **840***b*, a third tube **840***c*, and a fourth tube **840***d*. Each tube **840** defines a tube outer surface **842**. For example, the first tube **840***a* includes a first tube outer surface **842***a*, the second tube **840***b* includes a second tube outer surface **842***b*, the third tube includes a third tube outer surface **842***c*, and the fourth tube **840***d* includes a fourth tube outer surface **842***d*. The positioning fitting members **202** include a first positioning fitting member **202***a* that is coupled to the first tube **840***a* such that the first positioning fitting member **202***a* forms a part of the first tube outer surface **842***a* of the first tube **840***a*. The positioning fitting members **202** include a second positioning fitting member **202***b* that is coupled to the fourth tube **840***d* such that the second positioning fitting member **202***b* forms a part of the fourth tube outer surface **842***d* of the fourth tube **840***d*. While the fastening assembly **850** includes two positioning fitting members **202**, any tube **840** may include a respective positioning fitting member **202**.

(147) The one or more clamping elements **852** includes a first clamping element **852***a* and a second clamping element **852***b*. The first clamping element **852***a* and the second clamping element **852***b* together form a single clamping element **852**. Each clamping element **852***a*, **852***b* includes a metallic band that forms a straight section **849** and a plurality of curved sections **851** disposed at respective ends of the straight section **849**. For example, each clamping element **852***a*, **852***b* includes a first curved section **851***a* extending from a first end of the straight section **849** and a second curved section **851***b* extending from a second end of the straight section **849**. The straight section **849** includes a plurality of lips **847** that extend from the straight section **849**. A cushion **870** is disposed within the clamping element **852**. The cushion **870** includes a first cushion **870***a* and a second cushion **870***b*. The first cushion **870***a* is coupled to the first clamping element **852***a* and secured by the lips **847** of the first clamping element **852***a*. The second cushion **870***b* is coupled to the second clamping element **852***b* and secured by the lips **847** of the second clamping element **852***b*. The cushion **870** may be coupled to the clamping element **852** by adhesive, mechanical bonding, chemical bonding, or the like. The cushion **870** includes one or more cradle surfaces **871** including a shape that generally corresponds to the shape of the tubes **840**. For example, the cushion **870** includes a first cradle surface **871***a*, a second cradle surface **871***b*, a third cradle surface **871***c*, and a fourth cradle surface **871***d*. In this way, the tubes **840** engage with the cradle surfaces **871** when the fastening assembly **850** is assembled.

(148) Each clamping element **852***a*, **852***b* forms a half of the clamping element **852** and each cushion **870***a*, **870***b* forms a half of the cushion **870**. The clamping element **852** can be closed to clamp around the tubes **840** such that the clamping elements **852***a*, **852***b* together form the clamping element **852**, as detailed further below. Each clamping element **852***a*, **852***b* includes a plurality of clamp arms **855**. Each clamp arm **855** is disposed at, and extends from, a respective end of the respective curved sections **851**. FIG. **8**A shows the clamping elements **852***a*, **852***b* each includes two clamp arms **855**, but the clamping elements **852***a*, **852***b* may include any number of

clamp arms **855** as desired. Each of the plurality of clamp arms **855** includes an aperture **857** disposed therein for receiving a respective removable fastening mechanism **854**. When the clamping element **852** is closed (e.g., the clamping elements **852***a*, **852***b* are mounted about the tube **840** and contact each other), the clamp arms **855** contact each other and the respective apertures **857** align with each other such that the respective removable fastening mechanisms **854** can be inserted therethrough. The removable fastening mechanisms **854** include a first fastening mechanism **854***a* that includes a first nut **858***a* and a first bolt **860***a* and a second fastening mechanism **854***b* that includes a second nut **858***b* and a second bolt **860***b*.

(149) FIG. **8**B shows an enlarged schematic view of the fastening assembly **850** of FIG. **8**A in an assembled state, according to an embodiment of the present disclosure. In FIG. **8**B, the cushion **870** spatially separates the tubes **840** and distributes stress in the fastening assembly **850**. For example, the tubes **840** are inserted into and contact the respective cradle surfaces **871** (FIG. **8**A). Thus, the cushion **870** of the clamping element **852** extends around at least a portion of the tube outer surfaces **842** of the tubes **840**.

(150) The cushion **870** (e.g., the first cradle surface **871***a* in FIG. **8**A) of the clamping element **852** is clamped to the first positioning fitting member **202***a* of the first tube **840***a* such that the clamping element **852** extends around at least a portion of the first positioning fitting member **202***a*. In this way, the clamping element **852** is positioned between the first rib **214***a* and the second rib **214***b* (FIG. **8**C) of the first positioning fitting member **202***a* when the fastening assembly **850** is assembled. The cushion **870** (e.g., the second cradle surface **871***b* in FIG. **8**A) of the clamping element **852** is clamped to the second tube **840***b* such that the clamping element **852** extends around at least a portion of the second tube outer surface **842***b* of the second tube **840***b*. The cushion **870** (e.g., the third cradle surface **871***c* in FIG. **8**A) of the clamping element **852** is clamped to the third tube **840***c* such that the clamping element **852** extends around at least a portion of the third tube outer surface **842***c* of the third tube **840***c*. The cushion **870** (e.g., the fourth cradle surface **871***d* in FIG. **8**A) of the clamping element **852** is clamped to the second positioning fitting member **202***b* of the fourth tube **840***d* such that the clamping element **852** extends around at least a portion of the second positioning fitting member **202***b*. In this way, the clamping element **852** is positioned between the first rib **214***a* and the second rib **214***b* (FIG. **8**C) of the second positioning fitting member **202***b* when the fastening assembly **850** is assembled.

(151) When the fastening assembly **850** is assembled, the clamp arms **855** of the respective clamping elements **852***a*, **852***b* contact each other and the removable fastening mechanisms **854** are inserted into the respective apertures **857** (FIG. **6**A) to fasten and to secure the clamping element **852** about the tubes **840**. Thus, the clamping element **852** extends around at least a portion of the positioning fitting members **202** and around at least a portion of the tube outer surfaces **842** of the tubes **840** to bundle and to fasten the tubes **840** together. The positioning fitting members **202** prevent the first tube **840***a* and the fourth tube **840***d* from sliding or from moving axially beyond the ribs **214** of the positioning fitting members **202**, as detailed above.

(152) FIG. **8**C shows a schematic side view of the fastening assembly **850**, according to an embodiment of the present disclosure. FIG. **8**C shows that the clamping element **852** includes a plurality of radial faces **862** including a first radial face **862***a* and a second radial face **862***b*. The radial faces **862** extend radially and define a portion of an outer surface of the clamping element **852**. For example, the radial faces **862** are faces of the cushion **870**. When the clamping element **852** is clamped to the positioning fitting members **202** of the first tube **840***a* and the fourth tube **840***d* (FIG. **8**B), the radial faces **862** are spaced from the ribs **214** of the positioning fitting members **202**. During operation of the turbine engine or of the engineering assembly, the tubes **840** may move axially, circumferentially, or radially due to vibrations and relative motion of the various tubes and other assemblies. The positioning fitting members **202** prevent the clamping element **852** from sliding or moving axially with respect to the tubes **840**. When the clamping element **852** begins to slide or to move axially, the radial faces **862** contact the ribs **214** of the positioning fitting

members **202** such that the clamping element **852** is prevented from sliding or moving axially beyond the ribs **214**. For example, the first radial face **862***a* may contact the first rib **214***a* of the first positioning fitting member **202***a* if the clamping elements **852** or the first tube **840***a* slide or move in a first axial direction, and the second radial face **862***b* may contact the second rib **214***b* of the first positioning fitting member **202***a* if the clamping element **852** or the first tube **840***a* slide or move in a second axial direction opposite the first axial direction. Likewise, the first radial face **862***a* may contact the first rib **214***a* of the second positioning fitting member **202***b* if the clamping elements **852** or the fourth tube **840***d* slide or move in the first axial direction, and the second radial face **862***b* may contact the second rib **214***b* of the second positioning fitting member **202***b* if the clamping element **852** or the fourth tube **840***d* slide or move in the second axial direction.

(153) FIG. **8**D shows a schematic front view of the fastening assembly **850**, according to an embodiment of the present disclosure. FIG. **8**D shows the cradle surfaces **871** of the cushion **870** spatially separates the tubes **840** and the tubes **840** engage with the cradle surfaces **871**. The cushion **870** provides friction damping between the clamping element **852** and a respective tube **840**. The cushion **870** is made from a polymer composite material or a similar material, as detailed above, for providing friction damping. The lips **847** of the clamping element **852** prevent the cushion **870** from moving or sliding axially with respect to the clamping elements **852***a*, **852***b*.

(154) FIG. **8**E shows a cross-sectional view of the fastening assembly **850**, taken at detail **8**E-**8**E in FIG. **8**C, according to an embodiment of the present disclosure. FIG. **8**C shows the clamping element **852** includes a clamp body **872**. The clamp body **872** defines a size and a shape of the clamping element **852**. For example, the clamp body **872** includes a first clamp body **872***a* that defines the first clamping element **852***a* and a second clamp body **872***b* that defines the second clamping element **852***b*. The clamp body **872** is made of any material such as, for example, metal, alloys, composites, or the like. The cushion **870** is coupled to, and disposed within, the clamp body **872** and forms a shape corresponding to the shape of the clamp body **872**. Thus, the cushion **870** defines an interior surface of the clamping element **852** and engages with the tubes **840** or with the positioning fitting members **202** to bundle and to secure the tubes **840** together.

(155) FIG. **8**F shows a cross-sectional view of the fastening assembly **850**, taken at detail **8**F-**8**F in FIG. **8**D, according to an embodiment of the present disclosure. FIG. **8**F shows the cushion **870** of the clamping element **852** engages with respective tubes **840**. When the clamping element **852** is engaged with the tubes **840**, the clamping element **852** generates high radial compressive force on the tubes **840** to maintain the bundle of tubes **840** under operational loads while the positioning fitting members **202** maintain the clamping element **852** in the intended location and position on the tubes **840**. For example, the ribs **214** of the positioning fitting members **202** prevent the clamping element **852** from sliding or moving axially about the tubes **840**, as detailed above.

(156) FIG. **8**F shows the weld notch **216** of the positioning fitting members **202***a*, **202***b*. The first tube **840***a* and the fourth tube **840***d* contact the inner radial surface **217** of the weld notches **216** and the positioning fitting members **202***a*, **202***b* are welded to the first tube **840***a* and the fourth tube **840***d*, respectively, as detailed above. When the positioning fitting members **202***a*, **202***b* are coupled to the first tube **840***a* and the fourth tube **840***d*, the tapered surfaces **218** provide a smooth transition between the positioning fitting members **202***a*, **202***b* and the tubes **840***a*, **840***d* to reduce the stress concentration on the coupling between the positioning fitting members **202***a*, **202***b* and the tubes **840***a*, **840***d* under operational loads on the tubes **840** during operation of the turbine engine **10** or the engineering assembly. During operation, the radial faces **862***a*, **862***b* may contact the ribs **214** of the respective positioning fitting members **202***a*, **202***b* to prevent the clamping element **852** from sliding or from moving axially about the tubes **840**.

(157) FIG. **9** shows an enlarged schematic view of another fastening assembly **950** in an assembled state, according to another embodiment of the present disclosure. FIG. **9** shows a plurality of tubes **940** and the fastening assembly **950**. The fastening assembly **950** includes one or more positioning fitting members **502**, one or more clamping elements **952**, and one or more removable fastening

mechanisms **954**. The plurality of tubes **940** is a bank of tubes and includes four tubes **940**. The tubes **940** include a first tube **940***a*, a second tube **940***b*, a third tube **940***c*, and a fourth tube **940***d*. Each tube **940** defines a tube outer surface **942**. For example, the first tube **940***a* includes a first tube outer surface **942***a*, the second tube **940***b* includes a second tube outer surface **942***b*, the third tube includes a third tube outer surface **942***c*, and the fourth tube **940***d* includes a fourth tube outer surface **942***d*. The positioning fitting members **502** include a first positioning fitting member **502***a* that is coupled to the first tube **940***a* such that the first positioning fitting member **502***a* forms a part of the first tube outer surface **942***a* of the first tube **940***a*. The positioning fitting members **502** include a second positioning fitting member **502***b* that is coupled to the fourth tube **940***d* such that the second positioning fitting member **502***b* forms a part of the fourth tube outer surface **942***d* of the fourth tube **940***d*. While the fastening assembly **950** includes two positioning fitting members **502**, any tube **940** may include a respective positioning fitting member **502**. The removable fastening mechanisms **954** include a first removable fastening mechanism **954***a* and a second removable fastening mechanism **954***b*.

(158) The clamping element **952** is substantially similar to the clamping element **852** (FIG. **8**B). For example, the clamping element **952** includes a first clamping element **952***a* and a second clamping element **952***b*. The clamping element **952**, however, does not include a cushion. In this way, the clamping element **952** is entirely metallic. Thus, the fastening assembly **950** includes the positioning fitting member **502** including a clamping surface with a greater thickness. The fastening assembly **950** also includes wear sleeves **920** on one or more tubes **940**. For example, the wear sleeves **920** include a first wear sleeve **920***a* coupled to the second tube **940***b* and a second wear sleeve **920***b* coupled to the third tube **940***c*. Thus, the wear sleeves **920** may protect the second tube **940***b* and the third tube **940***c* from wear during operation due to the metal-to-metal contact between the clamping element **952** and the tubes **940**, as detailed above. The clamping element **952** may provide improved stiffness and temperature resistance but less friction damping as compared to the clamping element **852** that includes a cushion **870** (FIG. **8**A).

(159) FIG. **10**A is an exploded view of another fastening assembly **1050** for tubular structures, according to another embodiment of the present disclosure. FIG. **10**A shows a plurality of tubes **1040** and the fastening assembly **1050**. The fastening assembly **1050** is substantially similar to the fastening assembly **850** (FIG. **8**A). The fastening assembly **1050** includes one or more positioning fitting members **202**, one or more clamping elements **1052**, and one or more removable fastening mechanisms **1054**. The plurality of tubes **1040** is a bank of tubes and includes four tubes **1040**. The tubes **1040** include a first tube **1040***a*, a second tube **1040***b*, a third tube **1040***c*, and a fourth tube **1040***d*. Each tube **1040** defines a tube outer surface **1042**. For example, the first tube **1040***a* includes a first tube outer surface **1042***a*, the second tube **1040***b* includes a second tube outer surface **1042***b*, the third tube includes a third tube outer surface **1042***c*, and the fourth tube **1040***d* includes a fourth tube outer surface **1042***d*. The positioning fitting members **202** include a first positioning fitting member **202***a* that is coupled to the first tube **1040***a* such that the first positioning fitting member **202***a* forms a part of the first tube outer surface **1042***a* of the first tube **1040***a*. The positioning fitting members **202** include a second positioning fitting member **202***b* that is coupled to the fourth tube **1040***d* such that the second positioning fitting member **202***b* forms a part of the fourth tube outer surface **1042***d* of the fourth tube **1040***d*. While the fastening assembly **1050** includes two positioning fitting members **202**, any tube **1040** may include a respective positioning fitting member **202**.

(160) The one or more clamping elements **1052** includes a first clamping element **1052***a* and a second clamping element **1052***b*. The first clamping element **1052***a* and the second clamping element **1052***b* are coupled together at a hinge **1053** and form a single clamping element **1052**. In this way, the clamping element **1052** can be opened (FIG. **10**A) and closed (FIG. **10**B). Each clamping element **1052***a*, **1052***b* includes a metallic band, as detailed above, and includes the same or similar components as the clamping elements **852***a*, **852***b* (FIG. **8**A). The clamping element

1052 includes one or more cradle surfaces **1071** including a shape that generally corresponds to the shape of the tubes **1040**. For example, the clamping element **1052** includes a first cradle surface **1071***a*, a second cradle surface **1071***b*, a third cradle surface **1071***c*, and a fourth cradle surface **1071***d*. In this way, the tubes **1040** engage with the cradle surfaces **1071** when the fastening assembly **1050** is assembled.

(161) Each clamping element **1052***a*, **1052***b* forms a half of the clamping element **1052** and forms a half of the respective cradle surfaces **1071**. The clamping element **1052** can be closed to clamp around the tubes **1040** such that the clamping elements **1052***a*, **1052***b* together form the clamping element **1052**, as detailed further below. Each clamping element **1052***a*, **1052***b* includes a plurality of clamp arms **1055**, as detailed above. Each of the plurality of clamp arms **1055** includes an aperture **1057** disposed therein for receiving the removable fastening mechanism **1054**. When the clamping element **1052** is closed, the clamp arms **1055** contact each other and the respective apertures **1057** align with each other such that the removable fastening mechanisms **1054** can be inserted therethrough. The removable fastening mechanisms **1054** includes a nut **1058** and a bolt **1060**, as detailed above.

(162) FIG. **10**B shows an enlarged schematic view of the fastening assembly **1050** of FIG. **10**A in an assembled state, according to an embodiment of the present disclosure. In FIG. the cradle surfaces **1071** spatially separate the tubes **1040** and distribute stress in the fastening assembly **1050**. For example, the tubes **1040** are inserted into and contact the respective cradle surfaces **1071** (FIG. **10**A). Thus, the clamping element **1052** extends around at least a portion of the tube outer surfaces **1042** of the tubes **1040**.

(163) The first cradle surface **1071***a* (FIG. **10**A) of the clamping element **1052** is clamped to the first positioning fitting member **202***a* of the first tube **1040***a* such that the clamping element **1052** extends around at least a portion of the first positioning fitting member **202***a*. In this way, the clamping element **1052** is positioned between the first rib **214***a* and the second rib **214***b* (FIG. **10**C) of the first positioning fitting member **202***a* when the fastening assembly **1050** is assembled. The second cradle surface **1071***b* of the clamping element **1052** is clamped to the second tube **1040***b* such that the clamping element **1052** extends around at least a portion of the second tube outer surface **1042***b* of the second tube **1040***b*. The third cradle surface **1071***c* of the clamping element **1052** is clamped to the third tube **1040***c* such that the clamping element **1052** extends around at least a portion of the third tube outer surface **1042***c* of the third tube **1040***c*. The fourth cradle surface **1071***d* (FIG. **10**A) of the clamping element **1052** is clamped to the second positioning fitting member **202***b* of the fourth tube **1040***d* such that the clamping element **1052** extends around at least a portion of the second positioning fitting member **202***b*. In this way, the clamping element **1052** is positioned between the first rib **214***a* and the second rib **214***b* (FIG. **10**C) of the second positioning fitting member **202***b* when the fastening assembly **1050** is assembled.

(164) When the fastening assembly **1050** is assembled, the clamp arms **1055** of the respective clamping elements **1052***a*, **1052***b* contact each other and the removable fastening mechanism **1054** is inserted into the respective apertures **1057** (FIG. **10**A) to fasten and to secure the clamping element **1052** about the tubes **1040**. Thus, the clamping element **1052** extends around at least a portion of the positioning fitting members **202** and around at least a portion of the tube outer surfaces **1042** of the tubes **1040** to bundle and to fasten the tubes **1040** together. The positioning fitting members **202** prevent the first tube **1040***a* and the fourth tube **1040***d* from sliding or from moving axially beyond the ribs **214** of the positioning fitting members **202**, as detailed above. The second tube **1040***b* and the third tube **1040***c* may slide or move axially with respect to the clamping element **1052**.

(165) FIG. **10**C shows a schematic side view of the fastening assembly **1050**, according to an embodiment of the present disclosure. FIG. **10**C shows that the clamping element **1052** includes a plurality of radial faces **1062** including a first radial face **1062***a* and a second radial face **1062***b*. The radial faces **1062** extend radially and define a portion of an outer surface of the clamping

element **1052**. When the clamping element **1052** is clamped to the positioning fitting members **202** of the first tube **1040***a* and the fourth tube **1040***d* (FIG. **10**B), the radial faces **1062** are spaced from the ribs **214** of the positioning fitting members **202**. During operation of the turbine engine or of the engineering assembly, the tubes **1040** may move axially, circumferentially, or radially due to vibrations and relative motion of the various tubes and other assemblies. The positioning fitting members **202** prevent the clamping element **1052** from sliding or moving axially with respect to the tubes **1040**. When the clamping element **1052** begins to slide or to move axially, the radial faces **1062** contact the ribs **214** of the positioning fitting members **202** such that the clamping element **1052** is prevented from sliding or moving axially beyond the ribs **214**. For example, the first radial face **1062***a* may contact the first rib **214***a* of the first positioning fitting member **202***a* if the clamping elements **1052** or the first tube **1040***a* slide or move in a first axial direction, and the second radial face **1062***b* may contact the second rib **214***b* of the first positioning fitting member **202***a* if the clamping element **1052** or the first tube **1040***a* slide or move in a second axial direction opposite the first axial direction. Likewise, the first radial face **1062***a* may contact the first rib **214***a* of the second positioning fitting member **202***b* (FIG. **10**B) if the clamping elements **1052** or the fourth tube **1040***d* (FIG. slide or move in the first axial direction, and the second radial face **1062***b* may contact the second rib **214***b* of the second positioning fitting member **202***b* (FIG. **10**B) if the clamping element **1052** or the fourth tube **1040***d* (FIG. **10**B) slide or move in the second axial direction.

(166) FIG. **10**D shows a schematic front view of the fastening assembly **1050**, according to an embodiment of the present disclosure. FIG. **10**D shows the cradle surfaces **1071** spatially separate the tubes **1040** and the tubes **1040** engage with the cradle surfaces **1071**. The clamping element **1052** includes one or more cushions **1070** that provide friction damping between the clamping element **1052** and a respective tube **1040**. The cushions **1070** are made from a polymer composite material or similar material, as detailed above, for providing friction damping. Each cradle surface **1071** includes a cushion **1070** disposed therein. Each cushion **1070** includes a shape that generally corresponds to a shape of the cradle surfaces **1071** and may be coupled to the cradle surfaces **1071** by adhesive, mechanical bonding, chemical bonding, or the like.

(167) FIG. **10**E shows a cross-sectional view of the fastening assembly **1050**, taken at detail **10**E-**10**E in FIG. **10**C, according to an embodiment of the present disclosure. FIG. **10**C shows the clamping element **1052** includes a clamp body **1072**. The clamp body **1072** defines a size and a shape of the clamping element **1052**. For example, the clamp body **1072** includes a first clamp body **1072***a* that defines the first clamping element **1052***a* and a second clamp body **1072***b* that defines the second clamping element **1052***b*. The clamp body **1072** is made of any material such as, for example, metal, alloys, composites, or the like, as detailed above.

(168) FIG. **10**F shows a cross-sectional view of the fastening assembly **1050**, taken at detail **10**F-**10**F in FIG. **10**D, according to an embodiment of the present disclosure. FIG. **10**F shows the cushions **1070** of the clamping element **1052** engage with the respective tubes **1040**. When the clamping element **1052** is engaged with the tubes **1040**, the clamping element **1052** generates high radial compressive force on the tubes **1040** to maintain the bundle of tubes **1040** under operational loads while the positioning fitting members **202** maintain the clamping element **1052** in the intended location and position on the tubes **1040**. For example, the ribs **214** of the positioning fitting members **202** prevent the clamping element **1052** from sliding or moving axially about the tubes **1040**, as detailed above.

(169) FIG. **10**F shows the weld notch **216** of the positioning fitting members **202***a*, **202***b*. The first tube **1040***a* and the fourth tube **1040***d* contact the inner radial surface **217** of the weld notches **216** and the positioning fitting members **202***a*, **202***b* are welded to the first tube **1040***a* and the fourth tube **1040***d*, respectively, as detailed above. When the positioning fitting members **202***a*, **202***b* are coupled to the first tube **1040***a* and the fourth tube **1040***d*, the tapered surfaces **218** provide a smooth transition between the positioning fitting members **202***a*, **202***b* and the tubes **1040***a*, **1040***d*

to reduce the stress concentration on the coupling between the positioning fitting members **202***a*, **202***b* and the tubes **1040***a*, **1040***d* under operational loads on the tubes **1040** during operation of the turbine engine **10** or the engineering assembly. During operation, the radial faces **1062***a*, **1062***b* may contact the ribs **214** of the respective positioning fitting members **202***a*, **202***b* to prevent the clamping element **1052** from sliding or from moving axially about the tubes **1040**.

(170) FIG. **11**A is an exploded view of another fastening assembly for tubular structures, according to another embodiment of the present disclosure. FIG. **11**A shows a plurality of tubes **1140** and a fastening assembly **1150**. The fastening assembly **1150** includes a positioning fitting member **502**, one or more clamping elements **1152**, a spacer element **1190**, and a removable fastening mechanism **1154**. The plurality of tubes **1140** is a bank of tubes that includes four tubes **1140**. The plurality of tubes **1140** includes a first tube **1140***a*, a second tube **1140***b*, a third tube **1140***c*, and a fourth tube **1140***d*. Each tube **1140** defines a tube outer surface **1142**. For example, the first tube **1140***a* includes a first tube outer surface **1142***a*, the second tube **1140***b* includes a second tube outer surface **1142***b*, the third tube **1140***c* includes a third tube outer surface **1142***c*, and the fourth tube **1140***d* includes a fourth tube outer surface **1142***d*. The positioning fitting member **502** is coupled to the first tube **1140***a* such that the positioning fitting member **502** forms a part of the first tube outer surface **1142***a* of the first tube **1140***a*. The second tube **1140***b*, the third tube **1140***c*, and the fourth tube **1140***d* each includes a wear sleeve **1120** coupled thereto. The wear sleeves **1120** are metal sleeves that provide additional material for a metal-to-metal contact between the clamping element **1152** and the tubes **1140***b*, **1140***c*, **1140***d*. In this way, the wear sleeves **1120** may wear as the tubes **1140***b*, **1140***c*, **1140***d* slide or move axially within the clamping element **1152** such that the wear sleeves **1120** protect the tubes **1140***b*, **1140***c*, **1140***d* from wear.

(171) In FIG. **11**A, the one or more clamping elements **1152** includes a single clamping element. The clamping element **1152** includes a metallic band that forms a plurality of straight sections **1149** and a plurality of looped sections **1151**. Thus, the fastening assembly **1150** includes the positioning fitting member **502** including a clamping surface with a greater thickness, as detailed above. The clamping element **1152** includes a first looped section **1151***a*, a second looped section **1151***b*, a third looped section **1151***c*, and a fourth looped section **1151***d*. The first looped section **1151***a* and the second looped section **1151***b* are disposed at opposite ends of a first straight section **1149***a*. The third looped section **1151***c* and the fourth looped section **1151***d* are disposed at opposite ends of a second straight section **1149***b*. The first looped section **1151***a* and the third looped section **1151***c* are coupled together at a first end by a hinge **1153** such that clamping element **1152** can be opened (FIG. **11**A) and closed (FIG. **11**B). The looped sections **1151** include a size and a shape that generally corresponds to a size and a shape of the tubes **1140**. In this way, the clamping element **1152** can be closed to clamp around, and engage with, the tubes **1140**, as detailed further below. The clamping element **1152** includes a plurality of clamp arms **1155**. Each clamp arm **1155** is disposed at, and extends from, a second end of the second looped section **1151***b* and a second end of the fourth looped section **1151***d*. FIG. **11**A shows the clamping element **1152** includes two clamp arms **1155**, but the clamping element **1152** may include any number of clamp arms **1155** as desired. Each of the plurality of clamp arms **1155** includes an aperture **1157** disposed therein for receiving the removable fastening mechanism **1154**. When the clamping element **1152** is closed, the clamp arms **1155** contact each other and the respective apertures **1157** align with each other such that the removable fastening mechanism **1154** can be inserted therethrough. The removable fastening mechanism **1154** includes a nut **1158** and a bolt **1160**, as detailed above.

(172) The spacer element **1190** includes a body having one or more cradle brackets **1191** that define contact faces of the spacer element **1190**. The cradle brackets **1191** are concave to correspond to a shape of the tubes **1140**. The cradle brackets **1191** may include any shape that corresponds to respective tubes, conduits, pipes, etc. The spacer element **1190** includes four cradle brackets **1191**. The spacer element **1190** may include any number of cradle brackets **1191** to hold a number of tubes **1140** as desired. The spacer element **1190** includes a core part **1193** and a plurality of radial

arms **1195** extending radially outward from the core part **1193**. The plurality of radial arms **1195** include a first radial arm **1195***a*, a second radial arm **1195***b*, a third radial arm **1195***c*, and a fourth radial arm **1195***d*. The radial arms **1195** define a portion of the cradle brackets **1191**. The core part **1193** and the radial arms **1195** may be integral and unitary or may be separate components coupled together. The spacer element **1190** may include any number of radial arms **1195** and cradle brackets **1191** as desired. The spacer element **1190** includes raised edges **1194** extending radially outwardly from radial arms **1195** to provide a secure or a snug seating arrangement for the clamping element **1152**. In this way, the raised edges **1194** prevent the clamping element **1152** from sliding axially beyond the raised edges **1194**.

(173) FIG. **11**B shows an enlarged schematic side view of the fastening assembly **1150** of FIG. **11**A in an assembled state, according to an embodiment of the present disclosure. In FIG. **11**B, the spacer element **1190** spatially separates the tubes **1140** and distributes stress in the fastening assembly **1150**. For example, the tubes **1140** are inserted into and contact the respective cradle brackets **1191** (FIG. **11**A). The clamping element **1152** extends around at least a portion of the tube outer surfaces **1142** of the tubes **1140**. The clamping element **1152** extends about and contacts an outer surface of each radial arm **1195** of the spacer element **1190** between the raised edges **1194**.

(174) The second looped section **1151***b* of the clamping element **1152** is clamped to the positioning fitting member **502** of the first tube **1140***a* such that the clamping element **1152** extends around at least a portion of the positioning fitting member **502**. In this way, the clamping element **1152** is positioned between the first rib **514***a* and the second rib **514***b* of the positioning fitting member **502** when the fastening assembly **1150** is assembled. The first looped section **1151***a* is clamped to the wear sleeve **1120** of the second tube **1140***b* such that the clamping element **1152** extends around at least a portion of the wear sleeve **1120** of the second tube **1140***b*. The third looped section **1151***c* is clamped to the wear sleeve **1120** of the third tube **1140***c* such that the clamping element **1152** extends around at least a portion of the wear sleeve **1120** of the third tube **1140***c*. The fourth looped section **1151***d* is clamped to the wear sleeve **1120** of the fourth tube **1140***d* such that the clamping element **1152** extends around at least a portion of the wear sleeve **1120** of the fourth tube **1140***d*. Thus, each tube **1140** is disposed between the clamping element **1152** and the spacer element **1190**. When the fastening assembly **1150** is assembled, the clamp arms **1155** contact each other and the removable fastening mechanism **1154** is inserted into the respective apertures **1157** (FIG. **11**A) to fasten and to secure the clamping element **1152** about the tubes **1140**. Thus, the clamping element **1152** extends around at least a portion of the positioning fitting member **502** and around at least a portion of the tube outer surfaces **1142** of the tubes **1140** to bundle and to fasten the tubes **1140** together. The positioning fitting member **502** prevents the first tube **1140***a* from sliding or from moving axially beyond the ribs **514** of the positioning fitting member **502**, as detailed above.

(175) FIG. **11**C shows a schematic side view of the fastening assembly **1150**, according to an embodiment of the present disclosure. FIG. **11**C shows that the clamping element **1152** includes a plurality of radial faces **1162** including a first radial face **1162***a* and a second radial face **1162***b*. The radial faces **1162** extend radially and define a portion of an outer surface of the clamping element **1152**. When the clamping element **1152** is clamped to the positioning fitting member **502** of the first tube **1140***a*, the radial faces **1162** are spaced from the ribs **514** of the positioning fitting member **502**. During operation of the turbine engine or of the engineering assembly, the tubes **1140** may move axially, circumferentially, or radially due to vibrations and relative motion of the various tubes and other assemblies. The positioning fitting member **502** prevents the clamping element **1152** and the spacer element **1190** from sliding or moving axially with respect to the tubes **1140**. When the clamping element **1152** begins to slide or to move axially, the radial faces **1162** contact the **514** of the positioning fitting member **502** such that the clamping element **1152** is prevented from sliding or moving axially beyond the ribs **514**. For example, the first radial face **1162***a* may contact the first rib **514***a* if the clamping elements **1152** or the first tube **1140***a* slide or move in a first axial direction, and the second radial face **1162***b* may contact the second rib **514***b* if the

clamping elements **1152** or the first tube **1140***a* slide or move in a second axial direction opposite the first axial direction.

(176) FIG. **11**D shows a schematic front view of the fastening assembly **1150**, according to an embodiment of the present disclosure. FIG. **11**D shows the spacer element **1190** spatially separates the tubes **1140** and the tubes **1140** engage with the cradle brackets **1191**. The clamping element **1152** is disposed on the outer surfaces of the radial arms **1195***a*, **1195***b*, **1195***c*, **1195***d* of the spacer element **1190** such that the clamping element **1152** is disposed radially within the raised edges **1194**.

(177) FIG. **11**E shows a cross-sectional view of the fastening assembly **1150**, taken at detail **11**E-**11**E in FIG. **11**C, according to an embodiment of the present disclosure. FIG. **11**C shows the clamping element **1152** includes a clamp body **1172**. The clamp body **1172** defines a size and a shape of the clamping element **1152**. For example, the clamp body **1172** defines the looped sections **1151** and the clamp arms **1155** of the clamping element **1152**. Each clamp arm **1155** is integrally formed with a respective looped section **1151** such that the respective looped sections **1151** and the respective clamp arms **1155** together form a single unitary structure. The clamp body **1172** is made of any material such as, for example, metal, alloys, composites, or the like. The clamping element **1152** does not include a cushion. In this way, the clamping element **1152** can be used in high temperature environments and includes a greater stiffness as compared with the clamping elements that include cushions, as detailed above.

(178) FIG. **11**F shows a cross-sectional view of the fastening assembly **1150**, taken at detail **11**F-**11**F in FIG. **11**D, according to an embodiment of the present disclosure. FIG. **11**F shows the clamping element **1152** engages with respective tubes **1140**. When the clamping element **1152** is engaged with the tubes **1140**, the clamping element **1152** generates high radial compressive force on the tubes **1140** to maintain the bundle of tubes **1140** under operational loads while the positioning fitting member **502** maintains the clamping element **1152** in the intended location and position on the tubes **1140**. For example, the ribs **514** of the positioning fitting member **502** prevent the clamping element **1152** from sliding or moving axially about the tubes **1140**, as detailed above.

(179) FIG. **11**F shows the weld notch **516** of the positioning fitting member **502**. The first tube **1140***a* contacts the inner radial surface **517** of the weld notches **516** and the positioning fitting member **502** is welded to the first tube **1140***a*, as detailed above. When the positioning fitting member **502** is coupled to the first tube **1140***a*, the tapered surfaces **518** provide a smooth transition between the positioning fitting member **502** and the first tube **1140***a* to reduce the stress concentration on the coupling between the positioning fitting member **502** and the first tube **1140***a* under operational loads on the tubes **1140** during operation of the turbine engine **10** (FIG. **1**) or the engineering assembly. During operation, the radial faces **1162** may contact the ribs **514** to prevent the clamping element **1152** from sliding or from moving axially about the tubes **1140**.

(180) FIG. **12** shows an enlarged schematic side view of another fastening assembly **1250** in an assembled state, according to another embodiment of the present disclosure. The fastening assembly **1250** includes many of the same components as the fastening assembly **350** (FIG. **3**B). The fastening assembly **1250**, however, includes a first clamping element **352***a*, a second clamping element **352***b*, a third clamping element **352***c*, and a fourth clamping element **352***d* for bundling together a plurality of tubes **1240**. The plurality of tubes **1240** includes four tubes including a first tube **1240***a*, a second tube **1240***b*, a third tube **1240***c*, and a fourth tube **1240***d*. The first tube **1240***a* includes a first positioning fitting member **202***a* and the third tube **1240***c* includes a second positioning fitting member **202***b*. The first clamping element **352***a* and the second clamping element **352***b* bundle together the first tube **1240***a* and the second tube **1240***b* in a similar orientation to that of FIG. **4**B. The third clamping element **352***c* and the fourth clamping element **352***d* bundle together the third tube **1240***c* and the fourth tube **1240***d* in a mirrored orientation to that of FIG. **4**B. The clamp arms **355** of each clamping element **352***a*, **352***b*, **352***c*, **352***d* are positioned together when the fastening assembly **1250** is assembled and a fastening mechanism

1254 is inserted therein to couple the clamping elements **352** together. A support bracket **1230** mounts and supports the first clamping element **352***a* and the second clamping element **352***b* with the third clamping element **352***c* and the fourth clamping element **352***d*. Thus, the clamping elements **352** bundle and secure the tubes **1240** together and the positioning fitting members **202***a*, **202***b* prevent the clamping elements **352** from sliding or moving axially, as detailed above.

(181) FIG. **13**A is an exploded view of another fastening assembly **1350** for tubular structures, according to another embodiment of the present disclosure. FIG. **13**A shows a plurality of tubes **1340** and the fastening assembly **1350**. The fastening assembly **1350** includes a positioning fitting member **202**, one or more clamping elements **1352**, a spacer element **1390**, a mounting bracket **1335**, and one or more removable fastening mechanisms **1354**. The plurality of tubes **1340** includes three tubes that includes a first tube **1340***a*, a second tube **1340***b*, and a third tube **1340***c*. Each tube **1340** defines a tube outer surface **1342**. For example, the first tube **1340***a* includes a first tube outer surface **1342***a*, the second tube **1340***b* includes a second tube outer surface **1342***b*, and the third tube **1340***c* includes a third tube outer surface **1342***c*. The positioning fitting member **202** is coupled to the first tube **1340***a* such that the positioning fitting member **202** forms a part of the first tube outer surface **1342***a* of the first tube **1340***a*.

(182) The one or more clamping elements **1352** includes a single clamping element. The clamping element **1352** includes a generally triangular shape. The clamping element **1352** includes a metallic band that is formed in the generally triangular shape. The clamping element **1352** includes a plurality of clamp arms **1355**. Each clamp arm **1355** is disposed at respective ends of the band. FIG. **13**A shows the clamping element **1352** includes two clamp arms **1355**, but the clamping element **1352** may include any number of clamp arms **1355** as desired. Each of the plurality of clamp arms **1355** includes an aperture **1357** disposed therein for receiving the removable fastening mechanism **1354**. When the clamping element **1352** is closed, the clamp arms **1355** contact the mounting bracket **1335** and the respective apertures **1357** align with respective apertures **1337** of the mounting bracket **1335**. In this way, a first removable fastening mechanism **1354***a* and a second removable fastening mechanism **1354***b* can be inserted therethrough. The removable fastening mechanisms **1354** each includes the mounting bracket **1335** and a bolt **1360** (e.g., threaded into apertures **1337**), as detailed above.

(183) The spacer element **1390** includes a first spacer element **1390***a* and a second spacer element **1390***b*. Each spacer element **1390***a*, **1390***b* includes a body having one or more cradle brackets **1391** that define contact faces of the spacer element **1390**. The cradle brackets **1391** are concave to correspond to a shape of the tubes **1340**. The cradle brackets **1391** may include any shape that corresponds to respective tubes, conduits, pipes, etc. The first spacer element **1390***a* includes three cradle brackets **1391**. For example, the first spacer element **1390***a* includes one cradle bracket **1391** on a first side of the first spacer element **1390***a* and two cradle brackets **1391** on a second side of the first spacer element **1390***a*. The second spacer element **1390***b* includes two cradle brackets **1391** that align with the two cradle brackets **1391** of the first spacer element **1390***a* when the fastening assembly **1350** is assembled. The cradle bracket **1391** on the first side of the first spacer element **1390***a* aligns with a corresponding portion of the clamping element **1352** when fastening assembly **1350** is assembled. Each cradle bracket **1391** includes a cushion **1396**. The cushions **1396** include a shape that generally corresponds to a shape of the cradle brackets **1391**. In this way, the tubes **1340** engage with the cushions **1396** and the cushions **1396** provide friction damping similar to the cushions detailed above. A third removable fastening element **1354***c* is inserted through a respective aperture **1337** of the mounting bracket **1335**, a respective aperture **1397** of the second spacer element **1390***b*, and a respective aperture **1399** (FIG. **13**E) to mount the spacer element **1390** to the mounting bracket **1335**. The mounting bracket **1335** may be mounted to a static component of the turbine engine or of the engineering assembly.

(184) FIG. **13**B shows an enlarged schematic side view of the fastening assembly **1350** of FIG. **13**A in an assembled state, according to an embodiment of the present disclosure. In FIG. **13**B, the

spacer element **1390** spatially separates the tubes **1340** and distributes stress in the fastening assembly **1350**. For example, the tubes **1340** are inserted into and contact the respective cradle brackets **1391** (FIG. **7**A). The clamping element **1352** extends around at least a portion of the tube outer surfaces **1342** of the tubes **1340**. The clamping element **1352** extends about and contacts outer surfaces of the spacer elements **1390***a*, **1390***b*. The clamping element **1352** is mounted and secured to the mounting bracket **1335** to mount and to secure the tubes **1340** to the mounting bracket **1335**. In this way, the tubes **1340** are bundled and secured to a static component of the turbine engine **10** or of the engineering assembly.

(185) When the clamping element **1352** is mounted to the mounting bracket **1335**, the clamping element **1352** forms a shape at an apex thereof that generally corresponds to a shape of the first tube **1340***a* and thus clamps to the positioning fitting member **202** of the first tube **1340***a*. In this way, the clamping element **1352** is positioned between the first rib **214***a* and the second rib **214***b* of the positioning fitting member **202** when the fastening assembly **1350** is assembled. The first tube **1340***a* is engaged between the clamping element **1352** and the cradle bracket **1391** (FIG. **13**A) on the first side of the first spacer element **1390***a*. The second tube **1340***b* and the third tube **1340***c* are each clamped and engaged between respective cradle brackets **1391** of the first spacer element **1390***a* and the second spacer element **1390***b*. When the fastening assembly **1350** is assembled, the clamp arms **1355** contact the mounting bracket **1335** and the removable fastening mechanisms **1354***a*, **1354***b* are inserted into the respective apertures **1357** (FIG. **13**A) to fasten and to secure the clamping element **1352** about the tubes **1340** and to the mounting bracket **1335**. Thus, the clamping element **1352** extends around at least a portion of the positioning fitting member **202** and around at least a portion of the tube outer surfaces **1342** of the tubes **1340** to bundle and to fasten the tubes **1340** together. The positioning fitting member **202** prevents the first tube **1340***a* from sliding or from moving axially beyond the ribs **214** of the positioning fitting member **202**, as detailed above.

(186) FIG. **13**C shows a schematic side view of the fastening assembly **1350**, according to an embodiment of the present disclosure. FIG. **13**C shows that the clamping element **1352** includes a plurality of radial faces **1362** including a first radial face **1362***a* and a second radial face **1362***b*. The radial faces **1362** extend radially and define a portion of an outer surface of the clamping element **1352**. For example, the radial faces **1362** are faces of the spacer element **1390**. When the clamping element **1352** is clamped to the positioning fitting member **202** of the first tube **1340***a*, the radial faces **1362** are spaced from the ribs **214** of the positioning fitting member **202**. During operation of the turbine engine or of the engineering assembly, the tubes **1340** may move axially, circumferentially, or radially due to vibrations and relative motion of the various tubes and other assemblies. The positioning fitting member **202** prevents the first tube **1340***a* from sliding or moving axially with respect to clamping element **1352**. When the first tube **1340***a* begins to slide or to move axially, the ribs **214** of the positioning fitting member **202** contact the radial faces **1362** such that the first tube **1340***a* is prevented from sliding or moving axially. For example, the first rib **214***a* may contact the first radial face **1362***a* if the first tube **1340***a* slides or moves in a first axial direction, and the second rib **214***b* may contact the second radial face **1362***b* if the first tube **1340***a* slides or moves in a second axial direction opposite the first axial direction.

(187) FIG. **13**D shows a schematic front view of the fastening assembly **1350**, according to an embodiment of the present disclosure. FIG. **13**D shows the spacer element **1390** spatially separates the tubes **1340** and the tubes **1340** engage with the cradle brackets **1391**. The clamping element **1352** is disposed about the outer surfaces of the spacer elements **1390**. FIG. **13**D shows that the cushions **1396** engage the tubes **1340**. The cushions **1396** provide friction damping between the clamping element **1352** and a respective tube **1340**. The cushions **1396** are made from a polymer composite material or similar material, as detailed above, for providing friction damping.

(188) FIG. **13**E shows a cross-sectional view of the fastening assembly **1350**, taken at detail **13**E-**13**E in FIG. **13**C, according to an embodiment of the present disclosure. FIG. **13**C shows the clamping element **1352** includes a clamp body **1372**. The clamp body **1372** defines a size and a

shape of the clamping element **1352**. For example, the clamp body **1372** defines the triangular shape of the clamping element **1352** and defines the clamp arms **1355**. The clamp body **1372** is generally triangular but may include any shape as desired. The clamp body **1372** is made of any material such as, for example, metal, alloys, composites, or the like. The spacer elements **1390***a*, **1390***b* are disposed within the clamping element **1352** when the fastening assembly **1350** is assembled. The cushions **1396** of the spacer elements **1390***a*, **1390***b* define an interior surface of the clamping element **1352** and engage with a respective tube **1340** or with a positioning fitting member **202** to bundle and to secure the tubes **1340** together.

(189) FIG. **13**F shows a cross-sectional view of the fastening assembly **1350**, taken at detail **13**F-**13**F in FIG. **13**D, according to an embodiment of the present disclosure. FIG. **13**F shows the clamping element **1352** engages with respective tubes **1340**. For example, the cushions **1396** engage with the positioning fitting member **202** or with a respective tube **1340**. When the clamping element **1352** is engaged with the tubes **1340**, the clamping element **1352** generates a high radial compressive force on the tubes **1340** to maintain the bundle of tubes **1340** under operational loads while the positioning fitting member **202** maintains the clamping element **1352** in the intended location and position. For example, the ribs **214** of the positioning fitting member **202** prevent the first tube **1340***a* from sliding or moving axially, as detailed above. The second tube **1340***b* and the third tube **1340***c* may slide or move axially with respect to the clamping element **1352**.

(190) FIG. **13**F shows the weld notches **216** of the positioning fitting member **202**. The first tube **1340***a* contacts the inner radial surface **217** of the weld notches **216** and the positioning fitting member **202** is welded to the first tube **1340***a*, as detailed above. When the positioning fitting member **202** is coupled to the first tube **1340***a*, the tapered surfaces **218** provide a smooth transition between the positioning fitting member **202** and the first tube **1340***a* to reduce the stress concentration on the coupling between the positioning fitting member **202** and the first tube **1340***a* under operational loads on the tubes **1340** during operation of the turbine engine **10** or the engineering assembly. During operation, the ribs **214** may contact the radial faces **1362** to prevent the first tube **1340***a* from sliding or from moving axially with respect to the clamping element **1352**.

(191) FIG. **14** is a cross-sectional view of a positioning fitting member **1402** coupled to a tube **1440**, taken along a longitudinal centerline of the tube **1440**, according to an embodiment of the present disclosure. The positioning fitting member **1402** may be used in any of the fastening assemblies detailed above. The positioning fitting member **1402** is substantially similar to the positioning fitting member **202** (FIGS. **2**A-**13**F) described above and includes a plurality of ribs **1414**. The positioning fitting member **1402**, however, does not include weld notches and does not include tapered surfaces. In some examples, the positioning fitting member **1402** does include tapered surfaces. The positioning fitting member **1402** is non-metallic and includes a ceramic, a composite, or a similar material. The positioning fitting member **1402** is positioned over an outer surface of the tube **1440** and is chemically bonded to the tube **1440** using, for example, epoxy, composite, adhesive, or the like.

(192) FIG. **15** is a cross-sectional view of another positioning fitting member **1502** coupled to a tube **1540**, taken along a longitudinal centerline of the tube **1540**, according to another embodiment of the present disclosure. The positioning fitting member **1502** may be used in any of the fastening assemblies detailed above. The positioning fitting member **1502** is substantially similar to the positioning fitting member **202** (FIGS. **2**A-**13**F) described above and includes a plurality of ribs **1514** and a plurality of tapered surfaces **1518**. The positioning fitting member **1502**, however, does not include weld notches. The positioning fitting member **1502** is metallic. The positioning fitting member **1502** is positioned over an outer surface of the tube **1540** and is coupled to the tube **1540** by a thermal joint, such as by brazing.

(193) FIG. **16** is a cross-sectional view of the positioning fitting member **202** coupled to a tube **1640**, taken along a longitudinal centerline of the tube **1640**, according to an embodiment of the

present disclosure. FIG. **16** shows the positioning fitting member **202** welded to the tube **1640** at the weld notches **216**.

(194) FIG. **17** is a cross-sectional view of another positioning fitting member **1702** coupled to a tube **1740**, taken along a longitudinal centerline of the tube **1740**, according to another embodiment of the present disclosure. The tube **1740** includes a first tube section **1741** and a second tube section **1743**. The positioning fitting member **1702** may be used in any of the fastening assemblies detailed above. The positioning fitting member **1702** includes a plurality of ribs **1714** and a tapered surface **1718**. The positioning fitting member **1702** also includes a threaded portion **1719**. The positioning fitting member **1702** is welded at a weld notch **1716** to the second tube section **1743**. The positioning fitting member **1702** is threaded by the threaded portion **1719** to a corresponding threaded portion of the first tube section **1741**. In this way, the positioning fitting member **1702** functions as a coupling member to couple the first tube section **1741** and the second tube section **1743** and as a positioning fitting member as detailed above. Thus, the positioning fitting member **1702** is a one-piece machined fitting with one threaded end (e.g., the threaded portion **1719**).

(195) FIG. **18** is a cross-sectional view of another positioning fitting member **1802** coupled to a tube **1840**, taken along a longitudinal centerline of the tube **1840**, according to another embodiment of the present disclosure. The tube **1840** includes a first tube section **1841** and a second tube section **1843**. The positioning fitting member **1802** may be used in any of the fastening assemblies detailed above. The positioning fitting member **1802** includes a plurality of ribs **1814** and a plurality of threaded portions **1819** disposed at opposing ends of the positioning fitting member **1802**. The positioning fitting member **1802** does not include tapered surfaces of weld notches as the positioning fitting member **1802** is not welded or brazed to the tube **1840**. The positioning fitting member **1802** is threaded by a first threaded portion **1819***a* to a corresponding threaded portion of the first tube section **1841**. The positioning fitting member **1802** is threaded by a second threaded portion **1819***b* to a corresponding threaded portion of the second tube section **1843**. In this way, the positioning fitting member **1802** functions as a coupling member to couple the first tube section **1841** and the second tube section **1843**, and as a positioning fitting member as detailed above. Thus, the positioning fitting member **1802** is a one-piece machined fitting with two threaded ends (e.g., the first threaded portion **1819***a* and the second threaded portion **1819***b*).

(196) FIG. **19** is a cross-sectional view of another positioning fitting member **1902** coupled to a tube **1940**, taken along a longitudinal centerline of the tube **1940**, according to another embodiment of the present disclosure. The tube **1940** includes a first tube section **1941** and a second tube section **1943**. The positioning fitting member **1902** may be used in any of the fastening assemblies detailed above. In particular, the positioning fitting member **1902** is used in applications in which the tubes and the clamping elements are entirely metallic. Thus, the positioning fitting member **1902** includes a clamping surface with a greater thickness, as detailed above. The positioning fitting member **1902** includes a plurality of ribs **1914**, a plurality of weld notches **1916**, and a plurality of tapered surface **1918**. The positioning fitting member **1902** is welded at a weld notch **1916** to the second tube section **1943**. The positioning fitting member **1902** is welded at a weld notch **1916** to a coupling member **1920**. The coupling member **1920** includes a threaded portion **1919**. The coupling member **1920** is threaded by the threaded portion **1919** to a corresponding threaded portion of the first tube section **1941**. In this way, the positioning fitting member **1902** and the coupling member **1920** are separate components that are coupled together and that couple the first tube section **1941** and the second tube section **1943**. Thus, the positioning fitting member **1902** and the coupling member **1920** are considered to be a welded fitting with one threaded end (e.g., the threaded portion **1919**).

(197) FIG. **20** is a cross-sectional view of another positioning fitting member **2002** coupled to a tube **2040**, taken along a longitudinal centerline of the tube **2040**, according to another embodiment of the present disclosure. The tube **2040** includes a first tube section **2041** and a second tube section **2043**. The positioning fitting member **2002** may be used in any of the fastening assemblies detailed

above. In particular, the positioning fitting member **2002** is used in applications in which the tubes and the clamping elements are entirely metallic. Thus, the positioning fitting member **2002** includes a clamping surface with a greater thickness, as detailed above. The positioning fitting member **2002** includes a plurality of ribs **2014**, a plurality of weld notches **2016**, and a plurality of tapered surface **2018**. The positioning fitting member **2002** is welded at a first weld notch **2016***a* to a first coupling member **2020***a*. The positioning fitting member **2002** is welded at a second weld notch **2016***b* to a second coupling member **2020***b*. The positioning fitting member **2002** includes one or more threaded portions **2019**. The first coupling member **2020***a* includes a first threaded portion **2019***a* and the second coupling member **2020***b* includes a second threaded portion **2019***b*. The first coupling member **2020***a* is threaded by the first threaded portion **2019***a* to a corresponding threaded portion of the first tube section **2041**. The second coupling member **2020***b* is threaded by the second threaded portion **2019***b* to a corresponding threaded portion of the second tube section **2043**. In this way, the positioning fitting member **2002** and the coupling members **2020***a*, **2020***b* are separate components that are coupled together and that couple the first tube section **2041** and the second tube section **2043**. Thus, the positioning fitting member **2002** and the coupling members **2020***a*, **2020***b* are considered to be a welded fitting with two threaded ends (e.g., the first threaded portion **2019***a* and the second threaded portion **2019***b*).

(198) FIG. **21** is a schematic, partial cut away, cross-sectional view of another positioning fitting member **2102**, taken along a longitudinal centerline **2103** of the positioning fitting member **2102**, according to another embodiment of the present disclosure. The positioning fitting member **2102** may be used in any of the fastening assemblies detailed above. In particular, the positioning fitting member **2102** includes many of the same features and functionality as the positioning fitting member **202** and may be used in the turbine engine **10** (FIG. **1**).

(199) The positioning fitting member **2102** includes a clamping surface **2112** extending between a plurality of ribs **2114** including a first rib **2114***a* and a second rib **2114***b*. The plurality of ribs **2114** each include an indent **2119**. The indent **2119** provides for marking and differentiation between positioning fitting members of the same geometry, but made from different materials (e.g., a first positioning fitting member made from steel and a second positioning fitting member made from a nickel alloy). The indent **2119** also allows for the ribs **2114** to expand and contract due to, for example, heat or stress on the ribs **2114**. The indent **2119** extends about a circumference of the ribs **2114** and defines a portion of an outer surface of the ribs **2114**. The positioning fitting member **2102** also includes a plurality of weld notches **2116** including a first weld notch **2116***a* and a second weld notch **2116***b*. Each weld notch **2116** includes an inner radial surface **2117**. The positioning fitting member **2102** includes a plurality of tapered surfaces **2118** including a first tapered surface **2118***a* and a second tapered surface **2118***b*. A diameter of the plurality of tapered surfaces **2118** at the plurality of ribs **2114** is greater than a diameter of the clamping surface **2112**. In some examples, the diameter of the plurality of tapered surfaces **2118** at the plurality of ribs **2114** is equal to or less than the diameter of the clamping surface **2112**, as detailed above.

(200) FIG. **22** is a flow diagram of a method **2200** of bundling and fastening tubular structures in accordance with one embodiment of the present disclosure. The method **2200** of bundling tubular structures, such as the tubes detailed above, includes, in step **2205**, providing a plurality of tubular structures. In step **2210**, the method **2200** includes providing a positioning fitting member on at least one tubular structure of the plurality of tubular structures. In step **2215**, the method **2200** includes bundling the plurality of tubular structures together. In step **2220**, the method **2200** includes extending a clamping element around at least a portion of an outer surface of the plurality of tubular structures and around at least a portion of the positioning fitting member. In step **2225**, the method **2200** includes fastening the clamping element with a removable fastening mechanism to fasten the plurality of tubular structures such that the positioning fitting member prevents the at least one tubular structure with the positioning fitting member from sliding or from moving axially beyond the clamping element.

(201) The embodiments disclosed herein provide for a fastening assembly including a positioning fitting member and a removable clamping element. The fastening assemblies disclosed herein provide for an improved stress concentration compared to assemblies without the benefit of the present disclosure while maintaining the clamping element in the correct location or position and thus reducing wear. Accordingly, the fastening assemblies of the present disclosure improves reliability of a tube bundle assembly compared to assemblies without the benefit of the present disclosure and allows for a compact tube bundling.
(202) Further aspects are provided by the subject matter of the following clauses.
(203) A fastening assembly for a plurality of tubular structures comprises a positioning fitting member and a clamping element. The positioning fitting member is coupled to a first tubular structure of the plurality of tubular structures such that the positioning fitting member forms a part of an outer surface of the first tubular structure. The positioning fitting member comprises a plurality of ribs. The clamping element extends around the plurality of tubular structures and around at least a portion of the positioning fitting member to bundle and to secure the plurality of tubular structures together. The clamping element is positioned between the plurality of ribs.
(204) The fastening assembly of the preceding clause, further comprising a removable fastening mechanism to fasten the clamping element.
(205) The fastening assembly of any preceding clause, the clamping element including a first portion that extends around the portion of the positioning fitting member and a second portion that extends around an outer surface of a second tubular structure of the plurality of tubular structures such that the second tubular structure moves axially with respect to the first tubular structure.
(206) The fastening assembly of any preceding clause, the positioning fitting member comprising a body including a shape that generally corresponds to a shape of the first tubular structure.
(207) The fastening assembly of any preceding clause, the positioning fitting member comprising a bore, the first tubular structure disposed through the bore.
(208) The fastening assembly of any preceding clause, the positioning fitting member comprising a clamping surface disposed between the plurality of ribs. The clamping element engages the clamping surface.
(209) The fastening assembly of any preceding clause, the plurality of ribs extending radially outwardly from the clamping surface.
(210) The fastening assembly of any preceding clause, the positioning fitting member comprising a tapered surface.
(211) The fastening assembly of any preceding clause, the tapered surface being tapered from a first rib of the plurality of ribs to the outer surface of the first tubular structure.
(212) The fastening assembly of any preceding clause, the positioning fitting member comprising a plurality of tapered surfaces.
(213) The fastening assembly of any preceding clause, the clamping element being a loop clamp.
(214) The fastening assembly of any preceding clause, the clamping element including a plurality of clamping elements.
(215) The fastening assembly of any preceding clause, the clamping element including a cushion disposed therein.
(216) The fastening assembly of any preceding clause, the cushion engaging the plurality of tubular structures.
(217) The fastening assembly of any preceding clause, the clamping element including a plurality of radial surfaces, the plurality of radial surfaces contacting the plurality of ribs when first tubular structure slides or moves axially.
(218) The fastening assembly of any preceding clause, the plurality of ribs of the positioning fitting member preventing the clamping element from sliding or moving axially beyond the plurality of ribs.
(219) The fastening assembly of any preceding clause, the clamping element including a clamp

body made of a metal, a composite, a polymer, a ceramic, alloys, or combinations thereof.
(220) The fastening assembly of any preceding clause, further including a spacer element to spatially separate the plurality of tubular structures.
(221) The fastening assembly of any preceding clause, the spacer element including a plurality of cradle brackets, the plurality of tubular structures engaging with the plurality of cradle brackets.
(222) The fastening assembly of any preceding clause, the spacer element including a plurality of raised edges, the clamping element disposed between the plurality of raised edges.
(223) The fastening assembly of any preceding clause, the spacer element being made of a metal, a composite, a polymer, a ceramic, or combinations thereof.
(224) The fastening assembly of any preceding clause, the spacer element including a cushion coupled to the spacer element.
(225) The fastening assembly of any preceding clause, the clamping element including a plurality of looped sections.
(226) The fastening assembly of any preceding clause, the clamping element including a plurality of straight sections.
(227) The fastening assembly of any preceding clause, the clamping element including a hinge to open and to close the clamping element.
(228) The fastening assembly of any preceding clause, the positioning fitting member being a first positioning fitting member, and further including a second positioning fitting member coupled to a second tubular structure.
(229) The fastening assembly of any preceding clause, a second tube of the plurality of tubes including a wear sleeve, and the clamping element engaging the wear sleeve.
(230) The fastening assembly of any preceding clause, the clamping element including a lip to hold the cushion.
(231) The fastening assembly of any preceding clause, the clamping element including a plurality of cradle surfaces disposed therein, the plurality of cradle surfaces including a shape generally corresponding to a shape of the plurality of tubular structures.
(232) The fastening assembly of any preceding clause, further including a plurality of clamping elements, and a support bracket coupling the plurality of clamping elements together.
(233) The fastening assembly of any preceding clause, further including a mounting bracket, the clamping element being secured to the mounting bracket to mount the plurality of tubular structures to the mounting brackets.
(234) The fastening assembly of any preceding clause, the spacer element including a plurality of spacer elements.
(235) The fastening assembly of any preceding clause, the positioning fitting member being chemically bonded to the first tubular structure.
(236) The fastening assembly of any preceding clause, the positioning fitting member being brazed to the first tubular structure.
(237) The fastening assembly of any preceding clause, the positioning fitting member being welded to the first tubular structure.
(238) The fastening assembly of any preceding clause, the positioning fitting member including a weld notch.
(239) The fastening assembly of any preceding clause, the positioning fitting member threaded to the first tubular structure by a threaded portion.
(240) The fastening assembly of any preceding clause, the positioning fitting member being machined with a coupling element.
(241) The fastening assembly of any preceding clause, the plurality of ribs each including an indent.
(242) A turbine engine comprises a plurality of tubular structures and a fastening assembly. The fastening assembly comprises a positioning fitting member and a clamping element. The

positioning fitting member is coupled to a first tubular structure of the plurality of tubular structures such that the positioning fitting member forms a part of an outer surface of the first tubular structure, the positioning fitting member comprising a plurality of ribs. The clamping element extends around the plurality of tubular structures and around at least a portion of the positioning fitting member to bundle and to secure the plurality of tubular structures together, the clamping element positioned between the plurality of ribs.
(243) The turbine engine of the preceding clause, the fastening assembly further comprising a removable fastening mechanism to fasten the clamping element.
(244) The turbine engine of any preceding clause, the clamping element including a first portion that extends around the portion of the positioning fitting member and a second portion that extends around an outer surface of a second tubular structure of the plurality of tubular structures such that the second tubular structure moves axially with respect to the first tubular structure.
(245) The turbine engine of any preceding clause, the positioning fitting member comprising a body including a shape that generally corresponds to a shape of the first tubular structure.
(246) The turbine engine of any preceding clause, the positioning fitting member comprising a bore, the first tubular structure disposed through the bore.
(247) The turbine engine of any preceding clause, the positioning fitting member comprising a clamping surface disposed between the plurality of ribs, and the clamping element engages the clamping surface.
(248) The turbine engine of any preceding clause, the plurality of ribs extending radially outwardly from the clamping surface.
(249) The turbine engine of any preceding clause, the positioning fitting member comprising a tapered surface.
(250) The turbine engine of any preceding clause, the tapered surface being tapered from a first rib of the plurality of ribs to the outer surface of the first tubular structure.
(251) The turbine engine of any preceding clause, the positioning fitting member comprising a plurality of tapered surfaces.
(252) The turbine engine of any preceding clause, the clamping element being a loop clamp.
(253) The turbine engine of any preceding clause, the clamping element including a plurality of clamping elements.
(254) The turbine engine of any preceding clause, the clamping element including a cushion disposed therein.
(255) The turbine engine of any preceding clause, the cushion engaging the plurality of tubular structures.
(256) The turbine engine of any preceding clause, the clamping element including a plurality of radial surfaces, the plurality of radial surfaces contacting the plurality of ribs when first tubular structure slides or moves axially.
(257) The turbine engine of any preceding clause, the plurality of ribs of the positioning fitting member preventing the clamping element from sliding or moving axially beyond the plurality of ribs.
(258) The turbine engine of any preceding clause, the clamping element including a clamp body made of a metal, a composite, a polymer, a ceramic, alloys, or combinations thereof.
(259) The turbine engine of any preceding clause, further including a spacer element to spatially separate the plurality of tubular structures.
(260) The turbine engine of any preceding clause, the spacer element including a plurality of cradle brackets, the plurality of tubular structures engage with the plurality of cradle brackets.
(261) The turbine engine of any preceding clause, the spacer element including a plurality of raised edges, the clamping element disposed between the plurality of raised edges.
(262) The turbine engine of any preceding clause, the spacer element being made of a metal, a composite, a polymer, a ceramic, or combinations thereof.

(263) The turbine engine of any preceding clause, the spacer element including a cushion coupled to the spacer element.
(264) The turbine engine of any preceding clause, the clamping element including a plurality of looped sections.
(265) The turbine engine of any preceding clause, the clamping element including a plurality of straight sections.
(266) The turbine engine of any preceding clause, the clamping element including a hinge to open and to close the clamping element.
(267) The turbine engine of any preceding clause, the positioning fitting member being a first positioning fitting member, and further including a second positioning fitting member coupled to a second tubular structure.
(268) The turbine engine of any preceding clause, a second tube of the plurality of tubes including a wear sleeve, and the clamping element engaging the wear sleeve.
(269) The turbine engine of any preceding clause, the clamping element including a lip to hold the cushion.
(270) The turbine engine of any preceding clause, the clamping element including a plurality of cradle surfaces disposed therein, the plurality of cradle surfaces including a shape generally corresponding to a shape of the plurality of tubular structures.
(271) The turbine engine of any preceding clause, the fastening assembly further including a plurality of clamping elements, and a support bracket coupling the plurality of clamping elements together.
(272) The turbine engine of any preceding clause, further including a mounting bracket, the clamping element being secured to the mounting bracket to mount the plurality of tubular structures to the mounting brackets.
(273) The turbine engine of any preceding clause, the spacer element including a plurality of spacer elements.
(274) The turbine engine of any preceding clause, the positioning fitting member being chemically bonded to the first tubular structure.
(275) The turbine engine of any preceding clause, the positioning fitting member being brazed to the first tubular structure.
(276) The turbine engine of any preceding clause, the positioning fitting member being welded to the first tubular structure.
(277) The turbine engine of any preceding clause, the positioning fitting member including a weld notch.
(278) The turbine engine of any preceding clause, the positioning fitting member being threaded to the first tubular structure by a threaded portion.
(279) The turbine engine of any preceding clause, the positioning fitting member being machined with a coupling element.
(280) The turbine engine of any preceding clause, the plurality of ribs each including an indent.
(281) A method comprising providing a plurality of tubular structures, providing a positioning fitting member on at least one tubular structure of the plurality of tubular structures, bundling the plurality of tubular structures together, extending a clamping element around the plurality of tubular structures and around at least a portion of the positioning fitting member, fastening the clamping element with a removable fastening mechanism to fasten the plurality of tubular structures such that the positioning fitting member prevents the at least one tubular structure with the positioning fitting member from sliding or from moving axially beyond the clamping element.
(282) The method of the preceding clause, further including allowing a second tubular structure to slide or to move axially with respect to the first tubular structure.
(283) The method of any preceding clause, the positioning fitting member including a body having a shape that generally corresponds to shape of the first tubular structure.

(284) The method of any preceding clause, further including disposing the positioning fitting member about an outer surface of the first tubular structure such that the first tubular structure is disposed within a bore of the positioning fitting member.
(285) The method of any preceding clause, further including engaging the clamping element to a clamping surface of the positioning fitting member.
(286) The method of any preceding clause, further including engaging the clamping element between a plurality of ribs of the positioning fitting member.
(287) The method of any preceding clause, further including reducing stress from the positioning fitting member to the first tubular structure by a tapered surface of the positioning fitting member.
(288) The method of any preceding clause, further including tapering the tapered surface from a first rib of the plurality of ribs to the outer surface of the first tubular structure.
(289) The method of any preceding clause, the positioning fitting member including a plurality of tapered surfaces.
(290) The method of any preceding clause, the clamping element being a loop clamp.
(291) The method of any preceding clause, further including providing a plurality of clamping elements.
(292) The method of any preceding clause, further including disposing a cushion within the clamping element.
(293) The method of any preceding clause, further including engaging the plurality of tubular structures with the cushion.
(294) The method of any preceding clause, further including causing the plurality of ribs to contact a plurality of radial surfaces of the clamping element when the first tubular structure slides or moves axially.
(295) The method of any preceding clause, further including preventing the clamping element from sliding or moving axially beyond the plurality of ribs.
(296) The method of any preceding clause, the clamping element including a clamp body made of a metal, a composite, a polymer, a ceramic, alloys, or combinations thereof.
(297) The method of any preceding clause, further including spatially separating the plurality of tubular structures with a spacer element.
(298) The method of any preceding clause, further including engaging the plurality of tubular structures with a plurality of cradle brackets of the spacer.
(299) The method of any preceding clause, further including disposing the clamping element between a plurality of raised edges of the spacer element.
(300) The method of any preceding clause, the spacer element being made of a metal, a composite, a polymer, a ceramic, or combinations thereof.
(301) The method of any preceding clause, further including providing a cushion coupled to the spacer element.
(302) The method of any preceding clause, further including providing the clamping element with a plurality of looped sections.
(303) The method of any preceding clause, further including providing the clamping element with a plurality of straight sections.
(304) The method of any preceding clause, further including providing the clamping element with a hinge to open and to close the clamping element.
(305) The method of any preceding clause, the positioning fitting member being a first positioning fitting member, and further including providing a second positioning fitting member coupled to a second tubular structure.
(306) The method of any preceding clause, further including providing a wear sleeve coupled to a second tube of the plurality of tubes, and engaging the clamping element with the wear sleeve.
(307) The method of any preceding clause, further including providing a lip of the clamping element to hold the cushion.

(308) The method of any preceding clause, the clamping element including a plurality of cradle surfaces disposed therein, and the plurality of cradle surfaces including a shape generally corresponding to a shape of the plurality of tubular structures.
(309) The method of any preceding clause, the fastening assembly further including a plurality of clamping elements, and further including providing a support bracket coupling the plurality of clamping elements together.
(310) The method of any preceding clause, further including securing the clamping element to a mounting bracket to mount the plurality of tubular structures to the mounting brackets.
(311) The method of any preceding clause, further including providing a plurality of spacer elements.
(312) The method of any preceding clause, the providing the positioning fitting member including chemically bonding the positioning fitting member to the first tubular structure.
(313) The method of any preceding clause, the providing the positioning fitting member including brazing the positioning fitting member to the first tubular structure.
(314) The method of any preceding clause, the providing the positioning fitting member including welding the positioning fitting member to the first tubular structure.
(315) The method of any preceding clause, further including welding the positioning fitting member to the first tubular structure at a weld notch of the positioning fitting member.
(316) The method of any preceding clause, further including threading the positioning fitting member to the first tubular structure.
(317) The method of any preceding clause, further including machining the positioning fitting member with a coupling element.
(318) The method of any preceding clause, further including providing an indent in each of the plurality of ribs.
(319) Although the foregoing description is directed to the preferred embodiments of the present disclosure, other variations and modifications will be apparent to those skilled in the art and may be made without departing from the spirit or the scope of the disclosure. Moreover, features described in connection with one embodiment of the present disclosure may be used in conjunction with other embodiments, even if not explicitly stated above.

Claims

1. A fastening assembly comprising: a plurality of tubular structures; a positioning fitting member coupled to a first tubular structure of the plurality of tubular structures such that the positioning fitting memberis in line with the first tubular structure, the first tubular structure having an outer surface and an inner surface, wherein the positioning fitting member comprises: a plurality of ribs; an outer surface and an inner surface, the inner surface being radially aligned with the inner surface of the first tubular structure; a clamping surface defined between the plurality of ribs; and a tapered surface having a first end and a second end, the tapered surface extending from at least one of the plurality of ribs at the first end toward the first tubular structure to the second end, wherein the tapered surface defines a portion of the outer surface of the positioning fitting member, the tapered surface having a diameter that decreases from the first end to the second end such that the tapered surface provides a smooth transition from the positioning fitting member to the first tubular structure; and one or more clamping elements including a first clamping element extending around at least a portion of the clamping surface of the positioning fitting member and a second clamping element extending around at least a portion of a second tubular structure of the plurality of tubular structures to bundle and to secure the plurality of tubular structures together such that the second tubular structure moves axially with respect to the first tubular structure, the first clamping element positioned between the plurality of ribs, wherein the second tubular structure is continuous and does not include a positioning fitting member.

2. The fastening assembly of claim 1, further comprising a removable fastening mechanism to fasten the one or more clamping elements.
3. The fastening assembly of claim 1, wherein the positioning fitting member comprises a body including a shape that generally corresponds to a shape of the first tubular structure.
4. The fastening assembly of claim 1, wherein the positioning fitting member comprises a bore, the first tubular structure disposed through the bore.
5. The fastening assembly of claim 1, wherein the plurality of ribs extends radially outwardly from the clamping surface.
6. The fastening assembly of claim 1, wherein the tapered surface is tapered from a first rib of the plurality of ribs to a distal end or to a proximal end of the positioning fitting member.
7. The fastening assembly of claim 1, wherein the positioning fitting member comprises a plurality of tapered surfaces.
8. A turbine engine comprising: a core turbine engine comprising a compressor section, a combustion section, and a turbine section; a plurality of tubular structures; and a fastening assembly comprising: a positioning fitting member coupled to a first tubular structure of the plurality of tubular structures such that the positioning fitting member is in line with the first tubular structure, the first tubular structure having an outer surface and an inner surface, wherein the positioning fitting member comprises: a plurality of ribs; an outer surface and an inner surface, the inner surface being radially aligned with the inner surface of the first tubular structure; a clamping surface defined between the plurality of ribs; and a tapered surface having a first end and a second end, the tapered surface extending from at least one of the plurality of ribs at the first end toward the first tubular structure to the second end, wherein the tapered surface defines a portion of the outer surface of the positioning fitting member, the tapered surface having a diameter that decreases from the first end to the second end such that the tapered surface provides a smooth transition from the positioning fitting member to the first tubular structure; and one or more clamping elements including a first clamping element extending around at least a portion of the clamping surface of the positioning fitting member and a second clamping element extending around at least a portion of a second tubular structure of the plurality of tubular structures to bundle and to secure the plurality of tubular structures together such that the second tubular structure moves axially with respect to the first tubular structure, the first clamping element positioned between the plurality of ribs, wherein the second tubular structure is continuous and does not include a positioning fitting member.
9. The turbine engine of claim 8, wherein the fastening assembly further comprises a removable fastening mechanism to fasten the one or more clamping elements.
10. The turbine engine of claim 8, wherein the positioning fitting member comprises a body including a shape that generally corresponds to a shape of the first tubular structure.
11. The turbine engine of claim 8, wherein the positioning fitting member comprises a bore, the first tubular structure disposed through the bore.
12. The turbine engine of claim 8, wherein the plurality of ribs extend radially outwardly from the clamping surface.
13. The turbine engine of claim 8, wherein the tapered surface is tapered from a first rib of the plurality of ribs to a distal end or to a proximal end of the positioning fitting member.
14. The turbine engine of claim 8, wherein the positioning fitting member comprises a plurality of tapered surfaces.
15. The fastening assembly of claim 1, wherein the first clamping element includes a looped section extending around at least a portion of the positioning fitting member and the second clamping element includes a looped section extending around the second tubular structure to bundle and to secure the plurality of tubular structures together, and the looped section of the first clamping element and the second clamping element includes a hinge extending from the looped section and allowing the looped section to be opened and closed.

16. The fastening assembly of claim 1, further comprising a cushion disposed within the first clamping element and defining an interior surface of the first clamping element, the cushion extending around and contacting the portion of the positioning fitting member to provide friction damping between the first clamping element and the positioning fitting member.
17. The fastening assembly of claim 1, wherein the positioning fitting member includes a weld notch that projects radially outward from the tapered surface and receives the first tubular structure therein.
18. The turbine engine of claim 8, wherein the positioning fitting member includes a weld notch that projects radially outward from the tapered surface and receives the first tubular structure therein.
19. The turbine engine of claim 8, wherein the first clamping element includes a looped section extending around at least a portion of the positioning fitting member and the second clamping element includes a looped section extending around the second tubular structure to bundle and to secure the plurality of tubular structures together, and the looped section of the first clamping element and the second clamping element includes a hinge extending from the looped section and allowing the looped section to be opened and closed.
20. The turbine engine of claim 8, further comprising a cushion disposed within the first clamping element and defining an interior surface of the first clamping element, the cushion extending around and contacting the portion of the positioning fitting member to provide friction damping between the first clamping element and the positioning fitting member.