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A composite firearm barrel

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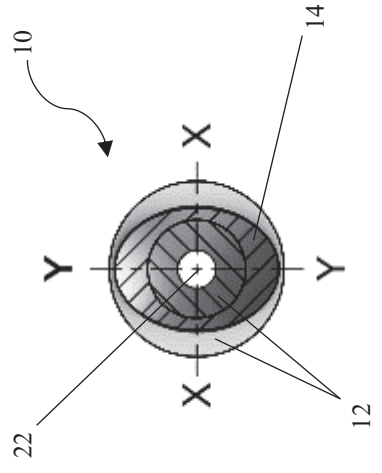
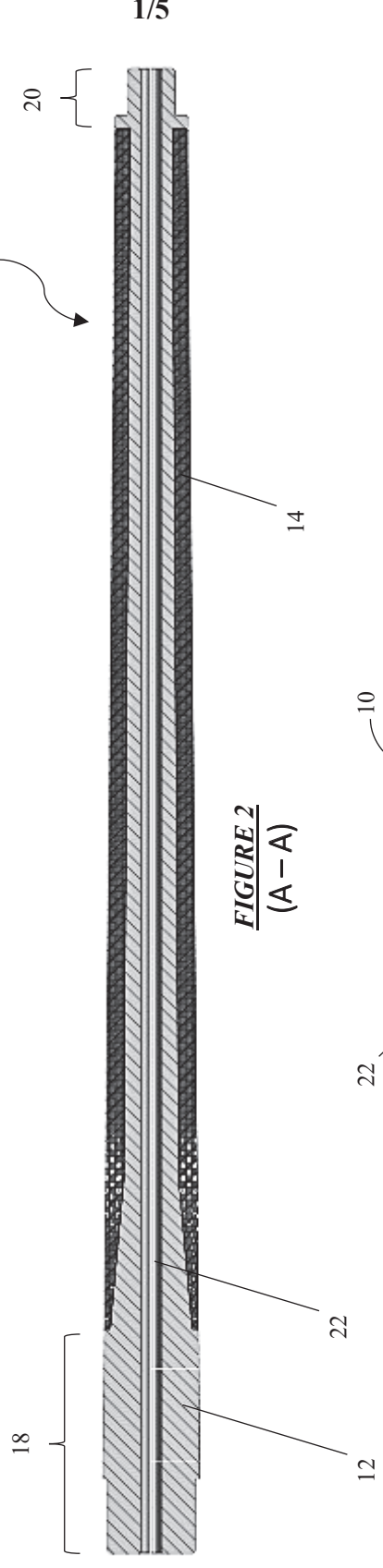
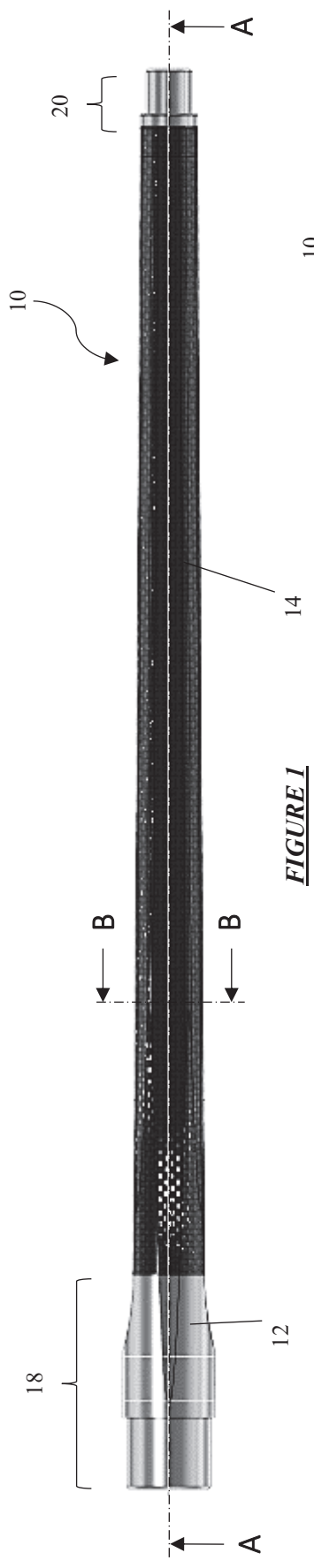
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ABSTRACT

A firearm barrel comprising: a metal elongate core member having a central longitudinal bore; and a sheath formed of a composite material, wherein the sheath is injection moulded over at least a substantial length of an outer surface of said core member, the sheath is formed to have a non-circular cross-section along at least a part said length, the non-circular cross-section adapted to provide an optimal stiffness to the firearm barrel.



A Composite Firearm Barrel

RELATED APPLICATION

[0001] The content of Australian provisional patent application no. 2024902747 as filed is hereby incorporated in its entirety by reference.

TECHNICAL FIELD

[0002] The invention relates to a firearm barrel, more specifically to a composite firearm barrel and a method of manufacturing a composite firearm barrel.

BACKGROUND

[0003] In both military and civilian use, it is advantageous to provide firearms which are lightweight; to ease transportation of the firearm and to reduce strain of the operator, especially when a firearm is held in position for an extended period of time. Endeavors to reduce the mass/weight of firearms have been attempted in both military and civilian applications.

[0004] Firearms comprise firearm barrels which include hollow tubes through which a projectile or bullet is propelled by explosive forces when the firearm is fired. Traditionally, firearm barrels are formed from thick metal tubes in order to cope with the forces exerted by the explosive which propels the projectile through it. Whilst a thicker and therefore stiffer barrel can provide better barrel harmonics, with decreased vibration amplitudes, in comparison to thinner barrels, their weight provides an obstacle to operators. Previous endeavors to reduce the weight of metal barrels have resulted in increased barrel deflection and thus decreased shooting accuracy. The use of metal firearm barrels further results in firearm barrels prone to heat effects and to uneven cooling which can cause warp or flex of the barrel, resulting in reduced shooting accuracy or even catastrophic failure of the barrel and firearm.

[0005] Previous attempts have been made to reduce the weight of firearm barrels using alternative materials to steel. Processes such as carbon fiber wrapping or carbon fiber filament winding over a barrel have been used to reduce mass of a firearm, however issues remain in the barrels ability to withstand vibration and maintain barrel stiffness during firing. Process such as the aforementioned tend to be labor intensive, slow, and expensive. In most cases, composite barrels formed by these processes require post process lathe turning and/or machine finishing, sanding, and sealing.

SUMMARY

[0006] In a first aspect, the invention provides a firearm barrel comprising: a metal elongate core member having a central longitudinal bore; and a sheath formed of a composite material, wherein the sheath is injection moulded over at least a substantial length of an outer surface of said core member, the sheath being formed to have a non-circular cross-section along at least a part said length, the non-circular cross-section adapted to provide an optimal stiffness to the firearm barrel.

[0007] In some embodiments, the composite material is a reinforced polymer. The composite material may be a carbon fiber reinforced polymer. The non-circular cross-section of the sheath may vary along the length. The non-circular cross-section of the sheath may have a stiffness greater around a horizontal axis than around a vertical axis of the sheath. The non-circular cross-section of the sheath may be shaped to optimise a stiffness ratio between the horizontal and vertical axes of the sheath section. In this context, horizontal and vertical axes of the firearm barrel correspond to the firearm being oriented with its barrel lying in a horizontal plane and with the firearm held upright in a conventional orientation for aiming and firing (e.g. with the aiming sights oriented on the top of the firearm).

[0008] In some embodiments, the sheath further comprises a fastening means for removably attaching firearm accessories to the firearm barrel. Said fastening means may be integrally moulded with the sheath. Said fastening means may be provided by machining of the sheath after the injection moulding thereof. The fastening means may comprise at least one mounting hole having internal threads. The fastening means may comprise a rail. The fastening means may be adapted to provide for attachment to the firearm barrel of any one or more of an optic; rest; rail; cover; grip and sling. In some embodiments, the core member is made from steel. The core member may have a first end and an opposite second end, the first end of the core member may be configured to removably attach to a breech of a firearm. The second end of the core member may be configured for removable attachment of a muzzle brake and/or suppressor of a firearm.

[0009] In a second aspect, the invention provides a firearm barrel comprising: a metal elongate core member having a central longitudinal bore; and a sheath formed over at least a substantial length of the core member outer surface, the sheath comprising a composite material being subsequently machined to provide a non-circular cross-section along at least a part said length, the non-circular cross-section adapted to provide an optimal stiffness to the firearm barrel.

[0010] In a third aspect, the invention provides a method of manufacturing a firearm barrel, the method comprising: providing a metal elongate core member having a central longitudinal bore; and injection moulding a composite material to form a sheath over at least a substantial

length of an outer surface of said core member, wherein the sheath has a non-circular cross-section along at least a part of said length, the non-circular cross-section adapted to provide an optimal stiffness to the firearm barrel.

[0011] In some embodiments, the non-circular cross-section of the sheath varies along the length. The non-circular cross-section of the sheath may have a diameter greater across a vertical axis than across a horizontal axis of the sheath. The non-circular cross-section of the sheath may be substantially ovular or substantially polygonal.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] Further aspects and features of the invention may be better understood from the following detailed description, presented by way of non-limiting example only and with reference to the accompanying drawings, in which:

Figure 1 shows a side profile view of a firearm barrel in accordance with an embodiment of the present invention;

Figure 2 is a cross-sectional view of the firearm barrel shown in Figure 1, taken across the section line A-A;

Figure 3 is a cross-sectional view of the firearm barrel shown in Figure 1, taken across the section line B-B;

Figure 4 shows a side profile view of a firearm barrel in accordance with another embodiment of the present invention;

Figure 5 is a cross-sectional view of the firearm barrel shown in Figure 4, taken across the section line C-C;

Figure 6 shows three cross-sectional views of the firearm barrel shown in Figure 4, taken across the section lines D-D, E-E and F-F;

Figure 7 shows a cross-sectional view of a firearm barrel in accordance with yet another embodiment of the present invention;

Figure 8 is a cross-sectional view of the firearm barrel shown in Figure 7, taken across the section line G-G;

Figure 9 shows three cross-sectional views of the firearms barrel shown in Figure 7, representing views through respective section lines $H_1 - H_1$, $H_2 - H_2$ and $H_3 - H_3$;

Figure 10 shows a side profile view of a firearm barrel in accordance with yet another embodiment of the present invention;

Figure 11 is a cross-sectional view of the firearm barrel shown in Figure 10, taken across the section line I-I;

Figure 12 is a cross-sectional view of the firearm barrel shown in Figure 10, taken across the section line J-J; and

Figure 13 schematically illustrates a method of manufacturing a firearm barrel in accordance with an embodiment of the present invention.

DETAILED DESCRIPTION

[0013] In general terms, the firearm barrel shown in the Figures comprises a metal elongate core member having a central longitudinal bore; and a sheath formed of a composite material, wherein the sheath is injection moulded over at least a substantial length of an outer surface of said core member, the sheath is formed to have a non-circular cross-section along at least a part said length, the non-circular cross-section adapted to provide an enhanced, preferably optimal stiffness to the firearm barrel.

[0014] An embodiment of the present invention in the form of a composite firearm barrel 10 is illustrated in Figure 1. Internally and centrally, a core member 12 extends through the entirety of the length of the firearm barrel 10. The length of the barrel 10 being thereby dictated by the length of the core member 12. The core member 12 includes a central longitudinal bore 22, the bore 22 providing a hollow tube for firing a projectile. Accordingly, the core member 12 and bore 22 are sized and specified to withstand the heat and pressure resulting in firearm discharge (which is due to the rapid expansion of high-pressure gas from the corresponding firing chamber of a firearm into the firearm barrel 10). In consideration of issues such as thermal expansion, reduced strength, and reduced accuracy exacerbated by high rates of fire, the core member 12 is preferably formed of a suitably hard, high-strength metal. In this embodiment, such metal is martensitic stainless steel but may also or alternatively comprise other high strength alloy steels such as 4140, 4150, 32CrMoV12-10 or similar. The core member 12 may instead be formed of a non-metallic material, provided said material is at least each of heat, heat erosion and corrosion resistant.

[0015] Those of skill in the art will recognize that a suitable wall thickness for a firearm barrel will depend on many things but will generally scale in some way with the bore diameter – thicker walls for larger bore diameters. Thicker walls on a firearm barrel are able to withstand greater dynamic pressures from the firearm discharges and also tend to reduce unwanted vibrations in the barrel during use. However, a barrel with larger wall thickness can make the firearm unwieldy and difficult to handle and carry in practice.

[0016] Naturally the core member 12 has a bore diameter suited to the calibre of projectile the barrel is manufactured to fire. Moreover, since additional strength and stiffness is provided, in embodiments of the invention, by the sheath formed over the core member the wall thickness of the core member 12 can be relatively thin, compared to a conventional firearm barrel. This permits maintaining a relatively low-weight in the barrel 10 because the composite material of the sheath is substantially less dense than the metal from which the core member is constructed. By way of example, the diameter of projectiles used in handheld or shoulder-held firearms typically range from 4.37mm (0.172”) to 13mm (0.51”), although projectile diameters, and therefore bore diameters, outside that range are also possible. The wall thickness of the core member is preferably between about 1mm and about 20mm, with a greater wall thickness preferred for a larger diameter bore in order to withstand potentially greater stresses that may be experienced in use.

[0017] Preferably, the core member 12 is monolithic, and is formed from a billet of the relevant material. The core member 12 may, however, be formed from a number of parts, for example by fixing or assembling an inner and outer portion of the core member 12 together, without departure from the present invention. The core member 12 includes a "breech end" 18, being relative to the end of the barrel 10 that, when installed on a firearm, is the end closest to the breech of that firearm. At the opposite end is the "muzzle end" 20 of the core member 12. In some embodiments, the core member 12 may have a substantially constant diameter cylindrical outer shape. Preferably, however, the core member 12 is formed with differing diameters at each end 18, 20 in order to optimize the mass distribution of the core. In particular, the diameter of the core member 12 may be reducing towards the muzzle end, having respect to the reducing internal pressures within the core member during firing. Preferably, the breech end 18 is of a greater external diameter than the central portion of the core member 12, and the muzzle end 20 is of a smaller diameter. In core members 12 having the described differing diameters at either of the ends 18, 20, the increase or reduction of diameter may include a fillet, step or rounding transition.

[0018] Exemplary embodiments include a core member 12 having rifling in/on its internal bore 22. The rifling is preferably in the form of helical grooves configured to impart a spinning motion to the projectile upon firing. Said rifling is adapted to improve the stability and accuracy of the projectile fired from the firearm. The projectile may be any one of a bullet, shot, or slug, or any other object fireable from a firearm. At the breech end 18, the core member 12 is configured to provide attachment of the firearm barrel 10 to a firearm breech or receiver. This attachment is typically provided for by the inclusion of a male thread proximate the breech end 18 of the core member 12 which is fastenable against a corresponding female thread of the breech or receiver of the firearm. Alternatively, the breech end 18 of the core member 12 may form an unthreaded cylindrical extension or trunnion, configured to slidably engage a corresponding sleeve in the breech or receiver of the firearm. The extension and corresponding sleeve are then held together by a clamping force provided by fasteners, pins or other locking mechanisms. At said muzzle end 20, the core member 12 is configured to provide for attachment of firearm accessories thereto. In preferred embodiments, the firearm attachments are removably attachable, and include, for example, muzzle brakes and sound suppressors. It is understood, however, that any relevant firearm accessory may be attached thereto.

[0019] A sheath 14 can be seen to extend between each of the breech and muzzle ends 18, 20 of the core member 12. The sheath 14 preferably covers a substantial, continuous length of the core member 12 but need not extend fully to abut either end 18, 20. Shown in the Figure 1 embodiment, both the breech and muzzle ends 18, 20 of the core member extend beyond the sheath 14, so to provide for the described respective attachments. Figure 2 shows a section view of the firearm barrel 10 of Figure 1 across section line A-A, being along its central bore axis. In this section view, the bore 22 of the core member 12 is visible. Further shown is sheath 14 formed across a substantial length of core member 12. In this illustrated embodiment the sheath has a substantially uniform cross section across its length, but may instead include tapering or variance therealong. Figure 3 shows a cross section of Figure 1 taken along section line B-B and viewed from the muzzle end of the core member 12.

[0020] The sheath 14 is formed of a composite material. Preferably, the composite material comprises carbon fiber "chopped" strands suspended in a thermoplastic polymeric matrix. The carbon fiber strand length of the composite material affects the physical properties of the matrix, including its stiffness. In embodiments of the present invention, the length of the strands can be optimized so to provide the required stiffness of the barrel, taking into account its geometric properties and intended use. It is understood that, while a carbon fiber based composite material is preferred, the carbon fiber may be substituted with any one of: glass; ceramic; a refractory

material; synthetic fibres such as Kevlar, polymers; or metals, without departure from the invention. Correspondingly, the matrix may be any suitable resin, including one of polyamide 6/6 (PA6/6), polyphthalamide (PPA), polyetherimide (PEI), polyphenylene sulfide (PPS), polyetheretherketone (PEEK) and polyaryletherketone (PAEK) or the like, for example. Advantageously, composite materials such as the carbon fiber polymer described, are extremely lightweight in comparison to metal materials such as steel, and can be manufactured to provide the required stiffness of the firearm barrel.

[0021] In a preferred embodiment of the present invention, the sheath 14 is injection overmoulded onto the core member 12. Overmoulding is a multi-step moulding process wherein a primary part is placed inside a mould to be directly moulded 'over', such that, when cured, a composite part is formed. In this case, the primary part is the core member 12, and the overmoulded portion is the sheath 14. Overmoulding provides advantages including reduced need for product assembly, and strong connection between the primary part and the overmoulded portion. Injection moulding is a manufacturing process whereby parts are produced by injection of a material into a mould or die. Injection moulding processes produce parts with low scrap rates, and is capable of producing parts with complex geometries. Overmoulded injection moulded parts may be produced by providing a primary part to the die of an injection moulding machine, such that the die is injected with typically polymeric material and the primary part moulded over. Once cured, the secondary part is completed, with the overmoulded portion introduced via injection moulding bonded to the primary part. Alternative methods may also be employed in the manufacturing of the sheath 14, such as by insert moulding, hand lay-up of the composite material (using either of a wet-lay method or by use of pre-impregnated composites), or through filament winding. Advantageously, injection moulding eliminates the requirement for subsequent machining operations. In the case of these alternative methods, subsequent machining, such as asymmetrical fluting and non-rotary (where the barrel is not rotated or turned (like on a lathe) around its longitudinal axis against the cutting tool, but where the rotating cutting tool is moved on multiple axes relative to the stationary barrel) machining methods, can provide the required geometries of the sheath 14 by removal of excess material. The use of such composites provides a high rigidity and stiffness in the sheath 14, as well as vibration dampening and harmonic reduction effects.

[0022] The sheath 14 is formed to have a non-circular cross section. Such a cross-section is adapted to further improve the stated qualities of the composite sheath, and to provide allowance for the use of the thin core member 12 as described without detriment to the firearm barrel's 10 stiffness. As used herein, the term 'non-circular' refers to any shape which is not circular. It is

inherent the firearm barrels require stiffness and vibration damping abilities. Such abilities are dependent upon the thickness, or cross sectional width, of the barrel. Non-circular, in this regard, refers to the sheath being non-uniform across in its cross-section along at least a, but preferably multiple, points of its length.

[0023] Optimization of this non-circularity is provided by altering the geometry of the barrel 10 to result in a cross sectional shape which provides the required material characteristics for the barrel. Further, such optimization provides for a reduction of unnecessary material; material which does not positively affect this optimization and which may contribute adversely to increasing the weight of the firearm barrel 10. With reference to Figure 3, the sheath 14 can be seen to have a greater cross sectional width along the Y axis direction, and a lesser cross sectional width in the X axis direction, correspondingly providing a stiffness ratio (being the amount of stiffness at a point in the barrel relative to the difference between the X axis and Y axis directions) which provides increased stiffness in a direction around the X axis. In this and the embodiments that follow, the Y axis represents the direction normally vertical relative the firearm barrel 10, and the X axis represents the direction normally horizontal relative the firearm barrel 10. In Figure 3, the cross sectional shape is ovular, providing curvature between each of the greater Y axis cross sectional width and the lesser X axis cross sectional width. This sheath 14 cross sectional shape is substantially uniform across the length of the firearm barrel 10.

[0024] Figure 4 shows a broken section view of a firearm barrel according to an embodiment of the present invention, wherein the sheath 14 varies in geometry across the length of the firearm barrel 10. Further optimization of the barrel 10 characteristics can be achieved through variance of the cross sectional shape along the length of the sheath 14. Figure 6 shows three cross sectional views of the firearm barrel of Figure 4 as viewed from the muzzle end of the firearm, at section lines D-D, E-E, and F-F, each section line taken at varying points along the length of firearm barrel 10. With reference to Figure 6, it can be seen that the difference between the Y axis width and X axis width increases from the F-F cross section to the D-D cross section. This difference provides a second stiffness ratio (being the amount of stiffness at a point in the barrel which is relative to this difference) that is sufficiently high toward the breech end 18 of the core member 12 where the forces associated with firing a projectile through the barrel 10 are greatest. Further, it provides a reduced size and therefore less material and less weight at the muzzle end 20. It is noted that, toward the F-F section of the sheath 14, the stiffness ratio and difference are almost zero – providing an approximately circular barrel here where the barrel may be required to be shaped in such a way so as to provide for muzzle end 20 attachments, and where there is no requirement nor advantage to the inclusion of non-circular cross sectional shape in the barrel

10. The stiffness ratio is optimized at the point at which the non-circular shape of the sheath 14 provides the required amount of stiffness with as little additional material (caused by the non-circular geometry) as possible. Figure 5 shows a section view across section line C-C of the firearm barrel 10 of Figure 4, further illustrating the varying non-circular geometry of the sheath 14 across the length of firearm barrel 10.

[0025] While the non-circular cross-sectional shape of the firearm barrel 10 according to embodiments of the present invention as previously described herein have been substantially ovular in shape, alternative embodiments are provided which encompass other non-circular cross sectional shapes. Turning now to Figures 7, 8 and 9, each cross section H1-H1, H2-H2 and H3-3 feature an irregular polygonal shape comprising a combination of linear and curved sides, in this case being 4 linear sides and 4 curved sides. This variant provides the same geometric advantages of the ovular barrel of Figure 1 through 5, with the further advantage of flat surfaces parallel to the X and Y axes of the barrel. Such flat surfaces assist in the mounting and inclusion of fastening means as will described below. It is understood that the cross section of the sheath 14 may instead be a polygonal shape having linear sides only, or may instead be any one, or combination, of: conic; elliptical; parabolic; hyperbolic; or any other such shape that provides a stiffness ratio as described, such as, for example, an I-beam. Similarly to Figures 4, 5 and 6, the embodiment shown in Figures 7, 8 and 9 comprises a firearm barrel 10 with a varying cross section of its sheath 14 along the length thereof.

[0026] Looking to Figures 10 and 11, the sheath 14 can be seen to further comprise at least one fastening means 16. The fastening means 16 provides for attachment of firearm accessories or components to the firearm barrel 10. Such accessories may include an optic, rest, rail, cover, grip and/or sling, or any other known firearm accessory. The fastening means 16 is preferably integrally formed with the sheath 14 of the firearm barrel 10. Accordingly, the fastening means 16 may be an indirect coupling 24 such as one or more of slots, holes, or any geometries capable of providing for attachment of firearm accessories. The fastening means 16 is preferably a series of inline apertures 30 provided adjacent the lower portion of the sheath 14, parallel the X axis of the core member 12, as is shown in Figure 11. In preferred embodiments the apertures 30 of an indirect coupling 24 fastening means 16 include internal threads allowing attachment of the accessory to the sheath 14 using fasteners. Alternatively, the indirect coupling 24 may provide smooth internal apertures 30 for use with circlips, locking pins or the like.

[0027] Figure 11 additionally exhibits another fastening means 16, in the form of a direct coupling 26. The direct coupling 26 fastening means 16 allows for direct attachment of the firearm

accessory, being attachment without the use of external fasteners or locking pins. In the preferred embodiment, the direct coupling 26 is in the form of a rail and includes a substantially planar extension 28 above the outer surface of sheath 14, seen provided adjacent the upper portion of the sheath 14, parallel the X axis of the core member 12, as is shown in Figure 11. The extension 28 comprises a flat upper surface indented with teeth and configured to slidably receive a corresponding rail of a firearm attachment. In particular, Figure 11 shows is "Picatinny (MIL-STD 1913)" or "NATO STANAG 4694" rail shape, such shape being common in the use of both military and commercial firearms for the mounting of optics. The direct coupling 26 may, however, be of any other shape so to provide said slidable receipt of firearm attachments without departure from the present invention.

[0028] In either embodiment, the fastening means 16 is preferably monolithic. Alternatively, either fastening means 16 embodiment may comprise a multitude of parts which act together to provide attachment of firearm accessories. In an alternate embodiment, the fastening means 16 is not integrally formed with the sheath 14. Instead, the sheath 14 may comprise only an (or more than one) indirect coupling 24, which provides attachment of a direct coupling 26 thereto. The relevant firearm accessory can then be attached to the direct coupling 26. The fastening means is preferably located proximate the breech end 18 of the core member 12. It is understood, however, that the fastening means 16 may be positioned anywhere along the length of the sheath 14, or overhanging the ends of the sheath, and parallel either of the X or Y axis without detriment. The fastening means 16 may be formed during the injection moulding, or otherwise manufacture, of the sheath 14. On the other hand, the fastening means 16 may be subsequently machined into the sheath 14.

[0029] A method 100 of manufacturing the composite firearm barrel 10 will now be described with reference to Figure 13.

[0030] Firstly, step 110 of the method 100 provides an elongate core member 12 as described. The core member 12 is preferably manufactured from a billet stainless steel. Such manufacturing typically includes lathe operations, but need not, and any manufacturing operation that provides a core member 12 as described is suitable. At any point in the manufacture of the core member 12, a longitudinal bore is machined into the center of the core member 12.

[0031] The core member 12 can then positioned within a die. The die is a container for use in the injection moulding of the sheath 14. In preferred embodiments, the die comprises two joinable parts and is manufactured from a heat-safe polymer or metal. The die provides locating pins for positioning the core member 12 in a central portion of the die. The die is sized such that

the portions of ends 18, 20 of the core member 12 which will extend beyond the sheath are located outside of the die. This method additionally prevents the composite material from entering the bore 22 of the core member 12 during moulding. Alternatively, in the case that the sheath extends to abut or meet the ends 18, 20 of the core member such that the die fully encompasses the core member 12, the bore 22 may be sealed (for example, with plugs) or filled entirely with a filler material to be removed upon completion of manufacturing. Such a filler material may comprise the insertion of a rod or tube into the bore 22 of the core member 12, the rod or tube having a high stiffness so to provide the additional advantage of increasing the stiffness, and thus reducing any possible deflection, of the barrel during manufacture. In exemplary embodiments, the core member may be placed under a longitudinal tension once fitted to the die, this pre-tensioning provided to reduce deflection of the core member 12 during manufacture, and to mitigate the effect of the moulded material shrinking away from the core member 12, particularly its ends 18, 20, during curing. With the core member 12 positioned in the die, the die provides a cavity between itself and the core member 12 representing the desired sheath geometry to be moulded. The die further includes at least one sprue (the sprue being the channel through which the polymeric material fills the mould) providing a fluid passage between the cavity and the exterior of the die.

[0032] Upon providing the core member 12 to the die, the joinable parts of the die are clamped shut with in method step 120. Clamping of the die parts is provided by a hydraulic clamping arm which forces the parts together, preventing separation (even under pressure). Advantageously, the die is customisable to specific geometries such that the shape of the sheath dictated by the cavity of the die can be optimized for the intended stiffness and other characteristics of the firearm barrel 10. Additionally, the die may include geometries corresponding to fastening means 16 of the sheath 14.

[0033] Next, in step method step 130, the injection moulding takes place. In this step, the die is associated with an injection moulding machine. The machine includes an injector which holds the composite material. Importantly, the material at this stage is uncured and in liquid form. The injector then injects the polymeric material, such as carbon fiber thermoplastic material, into the die, by actuation of a set screw, through the sprue of the die. It is understood that the injection moulding step may instead be manually operated and that the set screw may be substituted with any other known injector or injection method. The pressure of the injection forces the uncured polymeric material to substantially fill the die from the sprue, ensuring that the material adheres completely to the surface of the core member 12, forming the sheath 14. In exemplary embodiments, the core member 12 is pre-heated to assist in material flow, prevent cold shuts and

to ensure adequate bonding of the material to the core member 12. Likewise, the material being moulded is pre-heated. The die further includes vents to accommodate evacuating air upon injection of the composite material. The die may include runners and/or gates, to ensure that the polymeric material is spread quickly throughout the mould upon injecting, to prevent uneven curing. Said runners and/or gates preferably being arranged evenly or symmetrically around the barrel to minimize uneven or asymmetrical forces and stresses acting on the barrel during either of the moulding or curing steps.

[0034] Upon injection of the composite material, step 140 provides that the die is then left to allow the composite material to cure or otherwise harden. In step 150, once the composite material is cured, the clamp is removed and the die is opened. The firearm barrel 10 can be removed, now having the sheath formed over at least a substantial length of the core member 12.

[0035] In an additional, but non-essential, step, the firearm barrel 10 comprising the core member 12 and sheath 14 may be post processed. Typically, excess polymeric material solidifies in the sprue passage, and must be removed after the part is cured. Post processing may include the removal of sprue, and material solidified in runners and/or gates, if included. Sprue, and runner and/or gate removal may be performed by mechanical means, or by a sprue picker, a sprue picker being a piece of automated machinery which picks the sprue out of an injection mould, usually as the parts are being ejected. If fastening means 16 are not formed integrally to the sheath 14 during injection over moulding, fastening means 16 may be machined after injection over moulding of the sheath 14 over the core member 12. Further post processing may include processes to improve the surface texture of the overmoulded portion of the firearm barrel 10, such as sanding, particle blasting, or polishing. Colored coatings may be applied to improve its aesthetic appearance.

[0036] The completed firearm barrel 10 may then be mounted to a firearm, and any accessories attached thereto.

[0037] Beneficially, embodiments of the invention disclosed herein provide a lightweight and inexpensive composite firearm barrel which allows for:

- Optimisability for vibration according to variable requirements across a length from breech to muzzle;
- Optimisability for stiffness according to variable requirements across a length from breech to muzzle;

- Flexibility in manufacturing and forming processes; and
- Customisability of firearm attachments and fastening means of firearm attachments.

[0038] The reference in this specification to any prior publication (or information derived from it), or to any matter which is known, is not, and should not be taken as an acknowledgment or admission or any form of suggestion that that prior publication (or information derived from it) or known matter forms part of the common general knowledge in the field of endeavor to which this specification relates.

[0039] Throughout this specification and the claims which follow, unless the context requires otherwise, the word 'comprise', and variations such as 'comprises' and 'comprising', will be understood to imply the inclusion of a stated integer or step or group of integers or steps but not the exclusion of any other integer or step or group of integers or steps.

LEGEND

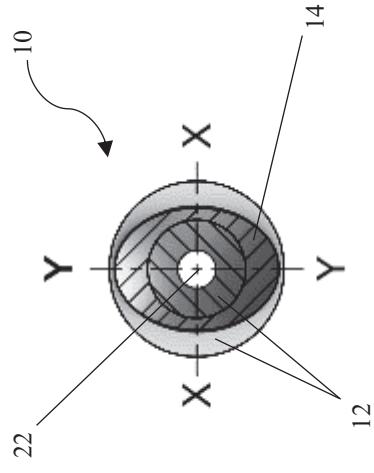
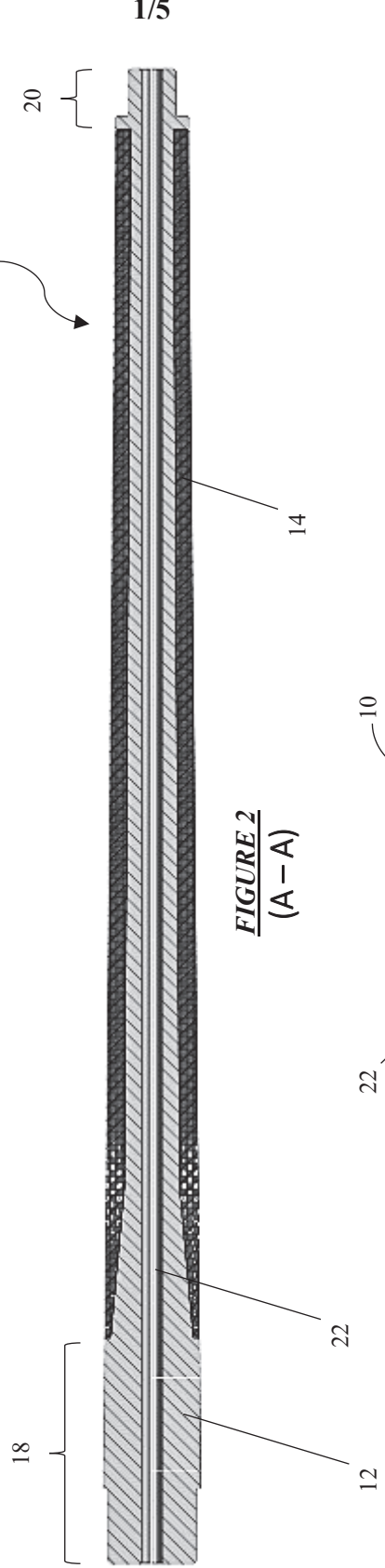
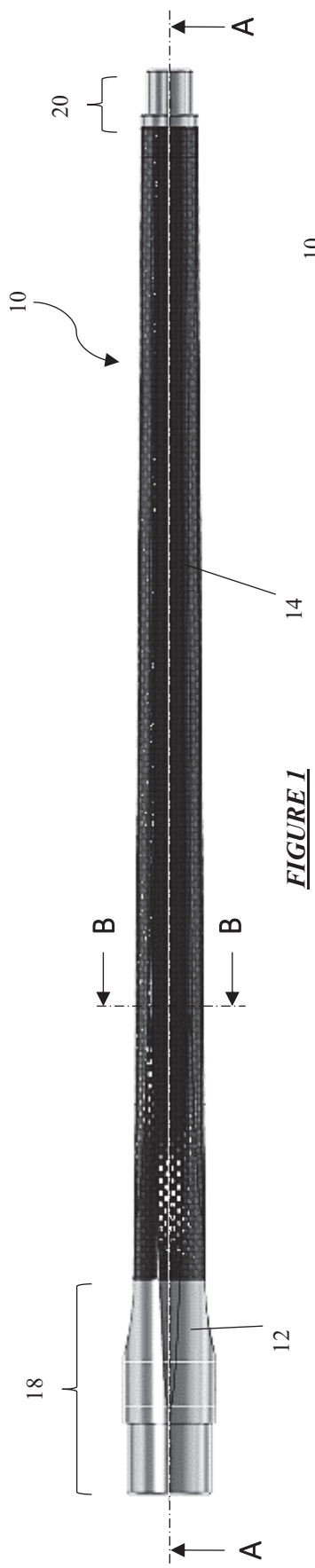
10	Firearm barrel	A-A	A-A section line
12	Core member	B-B	B-B section line
14	sheath	C-C	C-C section line
16	Fastening means	D-D	D-D section line
18	Breech end of core member	E-E	E-E section line
20	Muzzle end of core member	F-F	F-F section line
22	Bore	G-G	G-G section line
24	Indirect coupling	Hx-Hx	Hx-Hx section line
26	Direct coupling	X	X-axis
28	Extension	Y	Y-axis
30	Apertures		
100	Method		
110	Providing core member to die step		
120	Clamping die step		
130	Injection moulding step		
140	Curing step		
150	Removing barrel from die step		

THE INVENTION IS DEFINED BY THE CLAIMS AS FOLLOWS

1. A firearm barrel comprising:
 - a metal elongate core member having a central longitudinal bore; and
 - a sheath formed of a composite material,wherein the sheath is injection moulded over at least a substantial length of an outer surface of said core member, the sheath is formed to have a non-circular cross-section along at least a part of said length, the non-circular cross-section adapted to provide an optimal stiffness to the firearm barrel.
2. The firearm barrel according to claim 1, wherein the composite material is a reinforced polymer.
3. The firearm barrel according to claim 1 or 2, wherein the composite material is a carbon fiber reinforced polymer.
4. The firearm barrel according to any one of the preceding claims, wherein the non-circular cross-section of the sheath varies along the length.
5. The firearm barrel according to any one of the preceding claims, the non-circular cross-section of the sheath having a stiffness greater around a horizontal axis than around a vertical axis of the sheath.
6. The firearm barrel according to any one of the preceding claims, the non-circular cross-section of the sheath being shaped to optimise a stiffness ratio between the horizontal and vertical axes of the sheath section.
7. The firearm barrel according to any one of the preceding claims, the sheath further comprising a fastening means for removably attaching firearm accessories to the firearm barrel.
8. The firearm barrel according to claim 7, said fastening means being integrally moulded with the sheath.
9. The firearm barrel according to claim 7, said fastening means being provided by machining of the sheath after the injection moulding thereof.

10. The firearm barrel according to any one of claims 7 to 9, wherein the fastening means comprises at least one mounting hole having internal threads.
11. The firearm barrel according to any one of claims 7 to 10, wherein the fastening means comprises a rail.
12. The firearm barrel according to any one of claims 7 to 11, wherein the fastening means is adapted to provide for attachment to the firearm barrel of any one or more of an optic; rest; rail; cover; grip and sling.
13. The firearm barrel according to any one of the preceding claims, wherein the core member is made from steel.
14. The firearm barrel according to any one of the preceding claims, the core member having a first end and an opposite second end, the first end of the core member configured to removably attach to a breech of a firearm.
15. The firearm barrel according to any one of the preceding claims, the core member having a first end and an opposite second end, the second end of the core member configured for removable attachment of a muzzle brake and/or suppressor of a firearm.
16. A firearm barrel comprising:
 - a metal elongate core member having a central longitudinal bore; and
 - a sheath formed over at least a substantial length of the core member outer surface, the sheath comprising a composite material being subsequently machined to provide a non-circular cross-section along at least a part said length, the non-circular cross-section adapted to provide an optimal stiffness to the firearm barrel.
17. A method of manufacturing a firearm barrel, the method comprising:
 - providing a metal elongate core member having a central longitudinal bore; and
 - injection moulding a sheath of a composite material over at least a substantial length of an outer surface of said core member,wherein the sheath has a non-circular cross-section along at least a part of said length, the non-circular cross-section adapted to provide an optimal stiffness to the firearm barrel.

18. The method according to claim 17, wherein the non-circular cross-section of the sheath varies along the length.
19. The method according to claim 17 or 18, the non-circular cross-section of the sheath having a stiffness greater around a horizontal axis than around a vertical axis of the sheath.
20. The method according to anyone of claims 17 to 19, the non-circular cross-section of the sheath being shaped to optimise a stiffness ratio between the horizontal and vertical axes of the sheath.



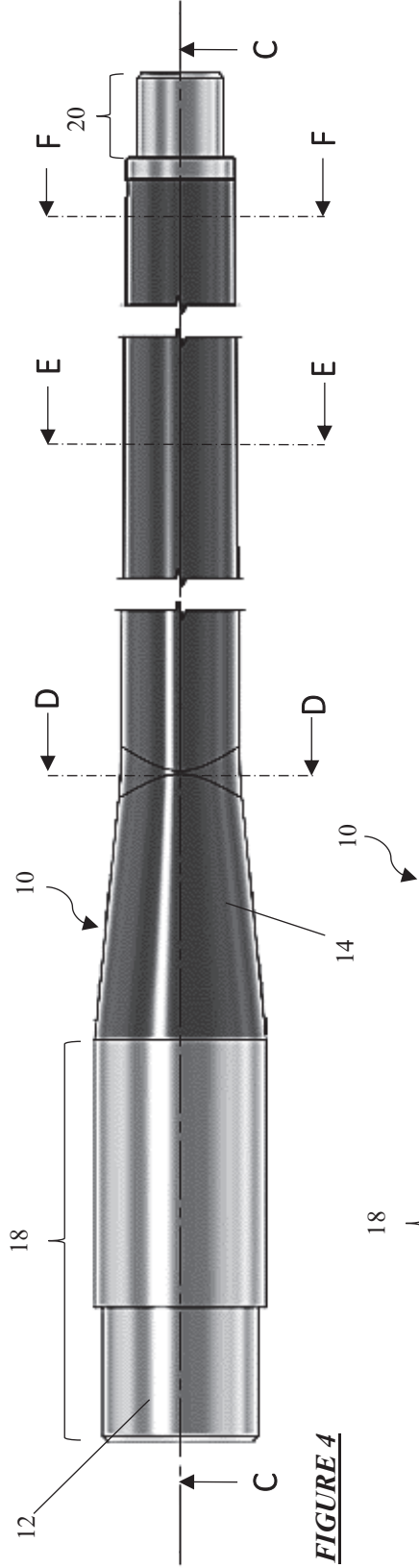


FIGURE 4

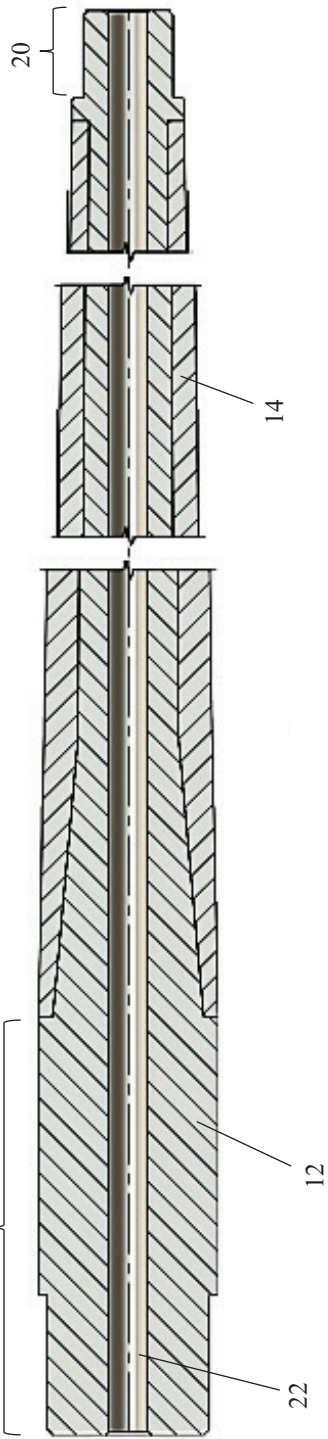


FIGURE 5
(C-C)

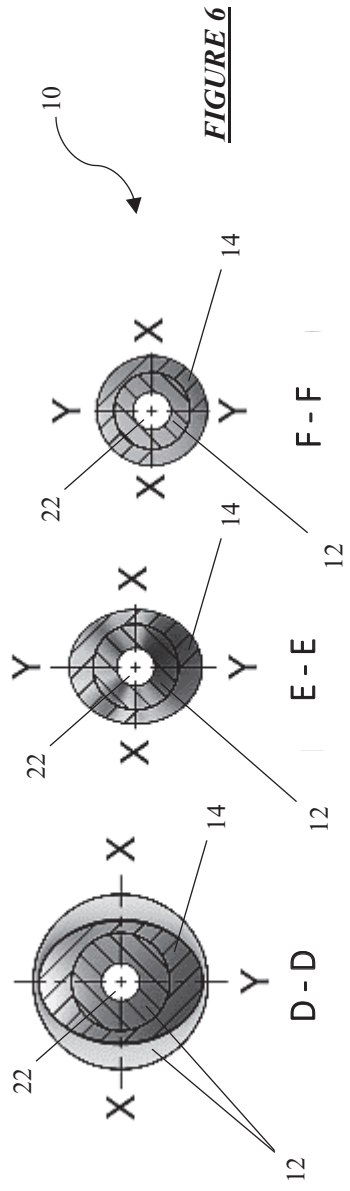
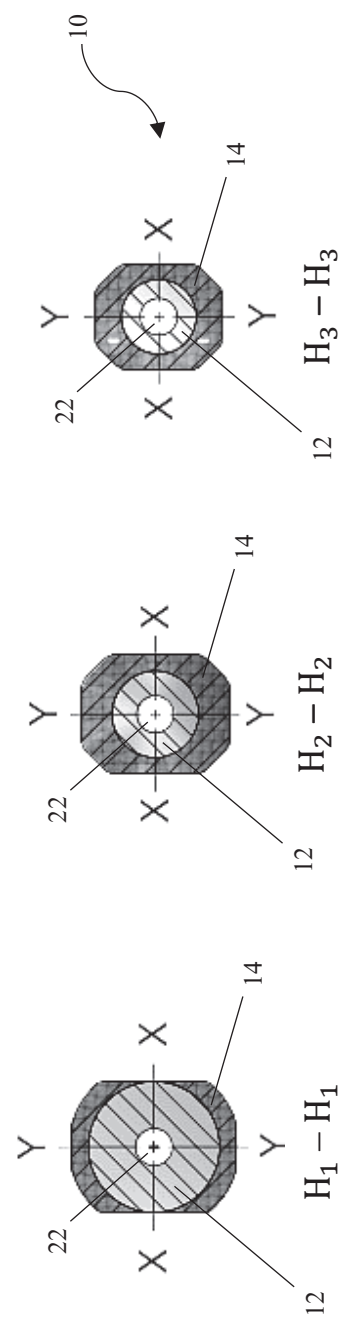
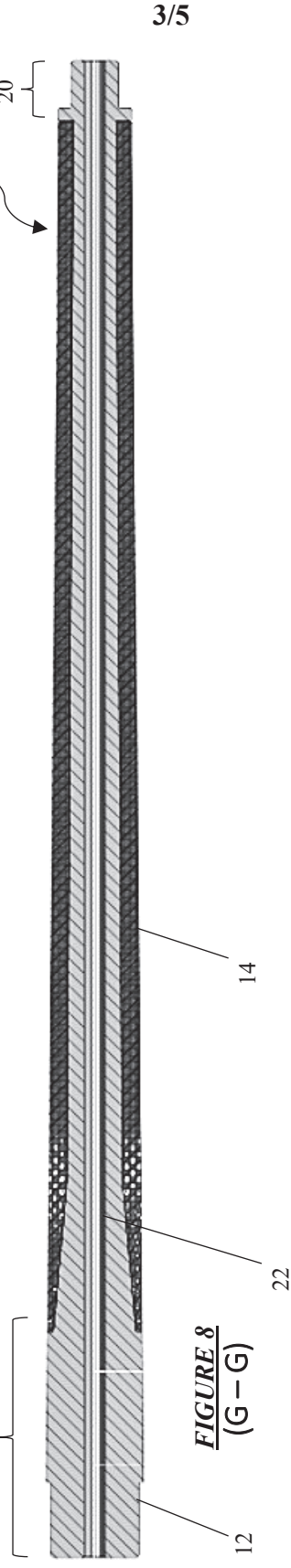
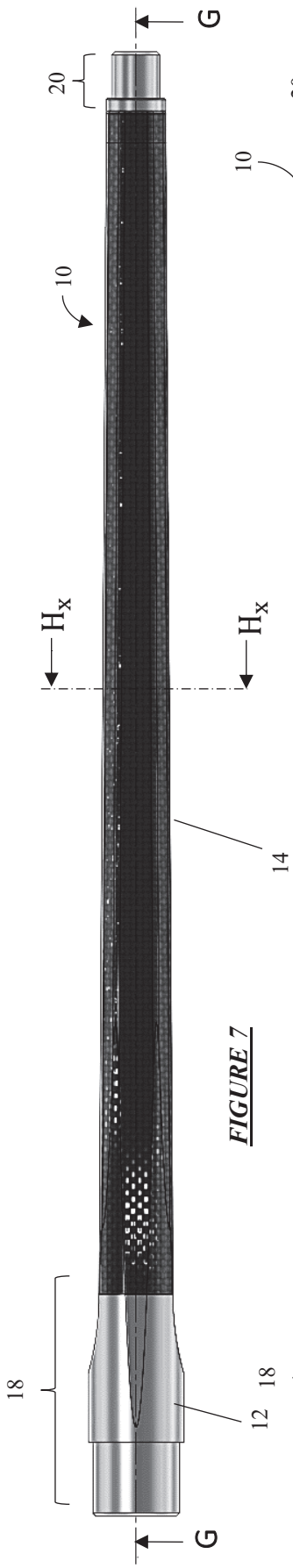
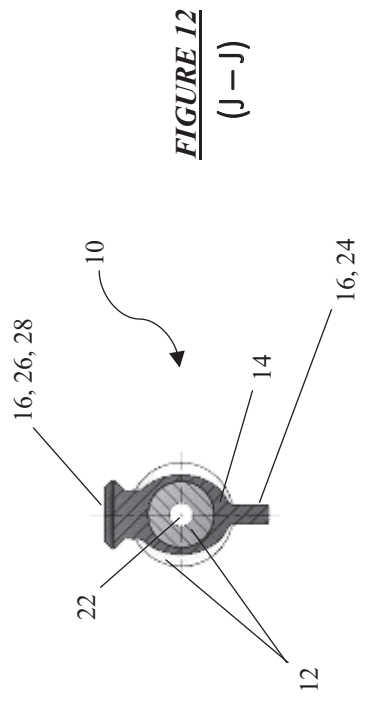
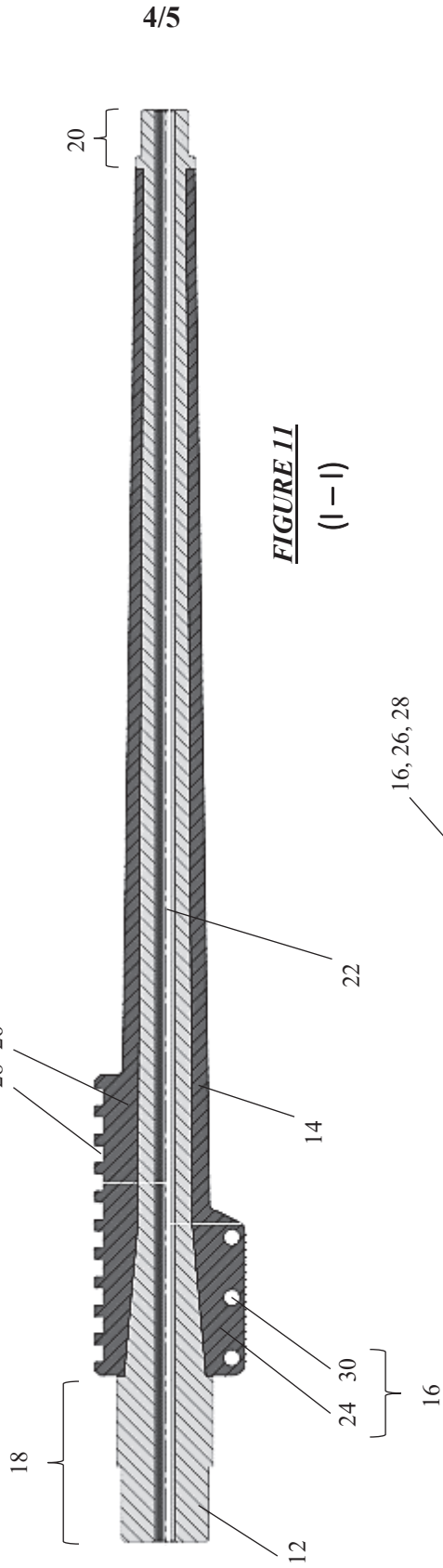
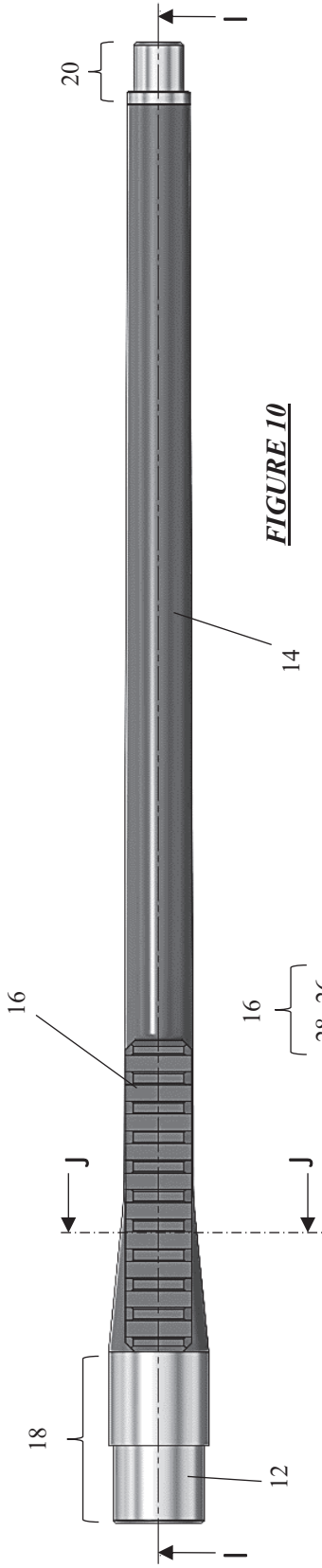


FIGURE 6





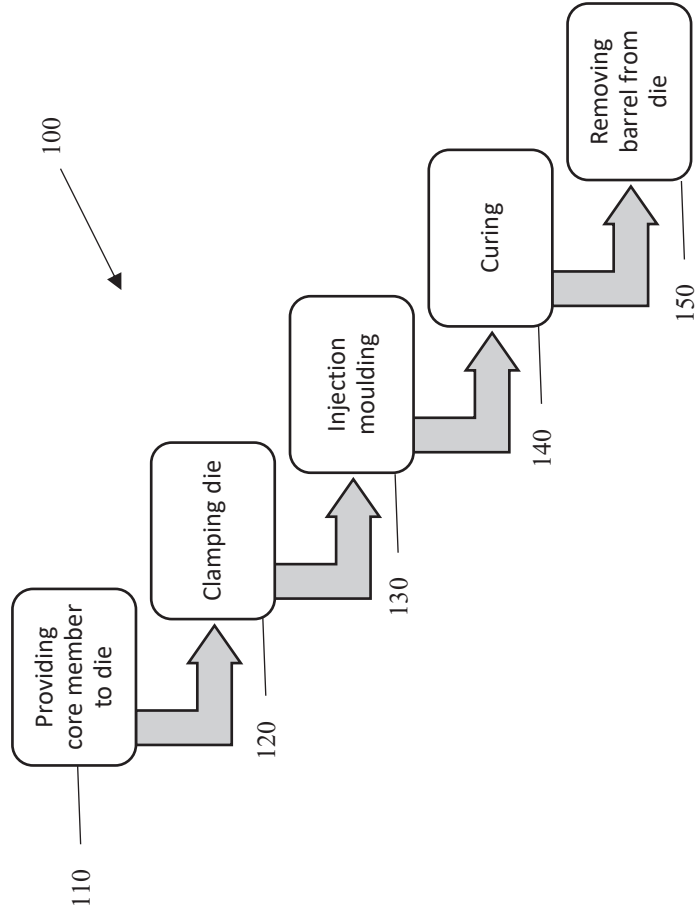


FIGURE 13