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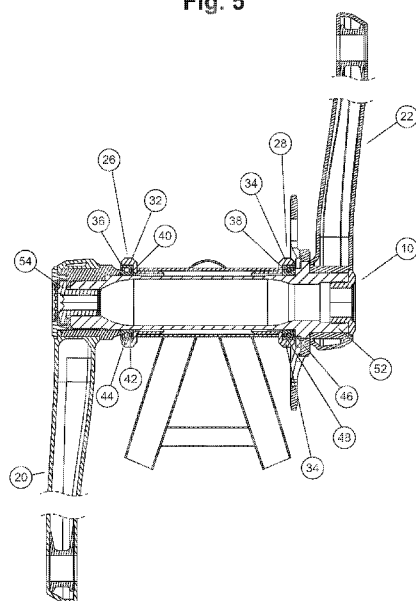
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[Continued on next page]

(54) Title: BICYCLE CRANK WITH SPINDLE ATTACHMENT STRUCTURE

Fig. 5



(57) Abstract: A composite bicycle crank with an integral spindle attachment structure provides a unique method for attaching a bicycle crank arm to a bicycle crank spindle, and also for attaching a bicycle crank arm to a crank arm insert. A light-weight crank arm is able to be manufactured separately from the crank spindle or insert, and then securely attached after both pieces have been made. This allows for the pieces of the crank assembly to be manufactured from one or more different materials, and securely connected after manufacturing, to create a lower weight assembly than would be possible otherwise.

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BICYCLE CRANK WITH SPINDLE ATTACHMENT STRUCTURERELATED APPLICATIONS

This Patent Application claims priority under 35 U.S.C. 119(e) of the co-pending U.S. provisional patent application, Application No. 62/313,024, filed on March 24, 2016, and entitled "**BICYCLE CRANK WITH SPINDLE ATTACHMENT STRUCTURE**," which is also hereby incorporated by reference in its entirety.

FIELD OF THE INVENTION:

The present invention is generally directed to bicycle cranks and crank arms. More specifically, the present invention is directed to a composite bicycle crank with an integral spindle attachment structure.

BACKGROUND OF THE INVENTION:

For an efficient transfer of power to a bicycle it is important that the crank set and crank arms are manufactured from strong materials while at the same time minimizing the weight of the crank set and the crank arms. Typically, a left side crank arm and a right side crank arm are shaped differently and must be manufactured in separate processes or using different molds. This adds time and cost to the manufacturing process and also requires that the left side crank arm and the right side crank arm are attached using different methods.

SUMMARY OF THE INVENTION:

A composite bicycle crank with an integral spindle attachment structure provides a unique method for attaching a bicycle crank arm to a bicycle crank spindle, and also for attaching a bicycle crank arm to a crank arm insert. A light-weight crank arm is able to be manufactured separately from the crank spindle or insert, and then securely attached after both pieces have been made. This allows for the pieces of the crank assembly to be manufactured from one or more different materials, and securely connected after manufacturing, to create a lower weight assembly than would be possible otherwise.

In one aspect, a bicycle crank set comprises a crank spindle, a left side crank arm configured to couple to the crank spindle through an integral spindle attachment structure and a right side crank arm configured to couple to the crank spindle through the integral spindle attachment structure. In some embodiments, the integral spindle attachment structure of the left side crank arm and the right side crank arm comprises a round lobed spline interface. In further embodiments, the integral spindle attachment structure of the left side crank arm and the right side crank arm comprises one of a circular interface, a square interface, a triangular interface, a square toothed spline, an involute spline, a tri-lobe polygon shape, a four-lobe polygon shape, and a geometric shape. In some embodiments, the left side crank arm couples to the crank spindle through a spindle insert. In some embodiments, the right side crank arm couples to the crank spindle through a spindle insert. In further embodiments, the left side

crank arm couples to the crank spindle through one of a splined interface, a tapered square interface, and a torque transmitting coupling. In some embodiments, the left side crank arm is manufactured from a first material and the insert is manufactured from a second material different than the first material. In some embodiments, the right side crank arm couples to the crank spindle through one of a splined interface, a tapered square interface, and a torque transmitting coupling. In further embodiments, right side crank arm is manufactured from a first material and the insert is manufactured from a second material different than the first material. In some embodiments, the integral spindle attachment structure of the left side crank arm and the right side crank arm comprises a tapered interface. In some embodiments, the left side crank arm and the right side crank arm comprise a hollow structure. In some embodiments, the bicycle crank set comprises one or more chain rings. In some embodiments, the bicycle crank set comprises one or more spacers for adjusting a chainline of the one or more chain rings.

In another aspect, a bicycle crank arm comprises an integral spindle attachment structure comprising a round lobed spline interface for coupling with a crank spindle of a bicycle. In some embodiments, the crank arm comprises a right side crank arm. In some embodiments, the crank arm comprise a left side crank arm. In some embodiments, the crank arm couples to the crank spindle through a spindle insert. In further embodiments, the crank arm is manufactured from a first material and the insert is manufactured from a second material different than the first material. In some embodiments, the crank arm comprise a hollow structure.

In a further aspect, a method of installing a crank arm on a crank spindle comprises cleaning one or more bonding surfaces of an insert and a crank arm, applying an adhesive to the one or more bonding surfaces of the insert and the crank arm, sliding on the insert into a receiving shape of the crank arm, installing a fastener through a hole in the crank arm, applying torque to the fastener, and curing the adhesive. In some embodiments, the crank arm comprises a left side crank arm. In some embodiments, the crank arm comprises a right side crank arm. In further embodiments, the crank arm is manufactured from a first material and the insert is manufactured from a second material different than the first material. In some embodiments, the crank arm comprise a hollow structure.

In still a further aspect, method of installing a crank arm on a crank spindle comprises cleaning one or more bonding surfaces of a crank arm, applying an adhesive to the one or more bonding surfaces of the crank arm, installing a fastener through a hole in the crank arm, applying torque to the fastener, and curing the adhesive. In some embodiments, the crank arm comprises a left side crank arm. In some embodiments, crank arm comprises a right side crank arm. In some embodiments, the crank arm comprise a hollow structure.

BRIEF DESCRIPTION OF THE DRAWINGS:

Several example embodiments are described with reference to the drawings, wherein like components are provided with like reference numerals. The example embodiments are

intended to illustrate, but not to limit, the invention. The drawings include the following figures:

Figure 1 illustrates an isometric top front right view of a crank set assembled to a bicycle frame in accordance with some embodiments.

Figure 2 illustrates a top view of a crank set assembled to a bicycle frame in accordance with some embodiments.

Figure 3 illustrates a right side view of a crank set assembled to a bicycle frame in accordance with some embodiments.

Figure 4 illustrates a rear view of a crank set assembled to a bicycle frame in accordance with some embodiments.

Figure 5 illustrates a top section view derived from Figure 4 of a crank set with a bottom bracket installed on a bicycle in accordance with some embodiments.

Figure 6 illustrates a top section view derived from Figure 4 of a crank set with a bottom bracket installed on a bicycle in accordance with some embodiments.

Figure 7 illustrates a detail section view from Figure 6 of a crank set with a bottom bracket installed on a bicycle in accordance with some embodiments.

Figure 8 illustrates an isometric top rear right exploded view of a right crank arm assembly in accordance with some embodiments.

Figure 9 illustrates a front exploded view of a right crank arm assembly in accordance with some embodiments.

Figure 10 illustrates a top exploded section view of a right crank arm assembly in accordance with some embodiments.

Figure 11 illustrates a left side view of a right crank arm assembly in accordance with some embodiments.

Figure 12 illustrates a top section view derived from Figure 11 of a right crank arm assembly in accordance with some embodiments.

Figure 13 illustrates an isometric top rear left exploded view of a left crank arm assembly in accordance with some embodiments.

Figure 14 illustrates a front exploded view of a left crank arm assembly in accordance with some embodiments.

Figure 15 illustrates a top exploded section view of a left crank arm assembly in accordance with some embodiments.

Figure 16 illustrates a left side view of a left crank arm assembly in accordance with some embodiments.

Figure 17 illustrates a top section view of a left crank arm assembly in accordance with some embodiments.

Figure 18 illustrates a top section view derived from Figure 4 showing detail for Figure 19 of a crank set with a bottom bracket installed on a bicycle in accordance with some embodiments.

Figure 19 illustrates a left arm section hub detail view derived from Fig. 18 of a crank set with bottom bracket installed on a bicycle in accordance with some embodiments.

Figure 20 illustrates a method of installing a crank arm on a crank spindle in accordance with some embodiments.

5 Figure 21A illustrates a top section view of a right crank arm assembly in accordance with some embodiments.

Figure 21B illustrates a front view of a right crank arm assembly in accordance with some embodiments.

10 Figure 22A illustrates a top section view of a right crank arm assembly in accordance with some embodiments.

Figure 22B illustrates a front view of a right crank arm assembly in accordance with some embodiments.

DETAILED DESCRIPTION OF THE EMBODIMENTS:

15 Embodiments of the invention are directed to a composite bicycle crank with an integral spindle attachment structure provides a unique method for attaching a bicycle crank arm to a bicycle crank spindle, and also for attaching a bicycle crank arm to a crank arm insert. A light-weight crank arm is able to be manufactured separately from the crank spindle or insert, and then securely attached after both pieces have been made. This allows for the
20 pieces of the crank assembly to be manufactured from one or more different materials, and securely connected after manufacturing, to create a lower weight assembly than would be possible otherwise.

Reference will now be made in detail to implementations of a bicycle crank with spindle attachment structure. The same reference indicators will be used throughout the
25 drawings and the following detailed description to refer to the same or like parts. In the interest of clarity, not all of the routine features of the implementations described herein are shown and described. It will be appreciated that in the development of any such actual implementation, numerous implementation-specific decisions can be made in order to achieve the developer's specific goals, such as compliance with application and business related
30 constraints, and that these specific goals will vary from one implementation to another and from one developer to another. Moreover, it will be appreciated that such a development effort might be complex and time-consuming, but would nevertheless be a routine undertaking of engineering for those of ordinary skill in the art having the benefit of this disclosure.

35 Referring now to Figure 1, a bicycle crank set and bottom bracket assembly 10 is installed in a bicycle frame bottom bracket assembly 12. The bicycle crank set and bottom bracket assembly 10 are shown cut away from a complete bicycle frame.

As shown within Figure 2 and Figure 3, the bicycle frame bottom bracket assembly 12 comprising a bottom bracket shell 14 that comprises a left end 16 and a right end 18. The
40 crank set and bottom bracket assembly 10 comprises a left crank arm assembly 20, a right

crank arm assembly 22, and one or more chain rings 24. The crank set and bottom bracket assembly 10 also comprises a left bottom bracket cup assembly 26 and a right bottom bracket cup assembly 28.

As shown within Figure 4 and Figure 5, the left bottom bracket cup assembly 26 and the right bottom bracket cup assembly 28 comprise a left bottom bracket cup 32 and a right bottom bracket cup 34, a left bottom bracket ball bearing 36 and a right bottom bracket ball bearing 38. The left bottom bracket ball bearing 36 includes a left inner race 40, a left outer race 42 and a left bearing plurality of balls 44 between the races. The right bottom bracket ball bearing 38 includes a right inner race 46, a right outer race 48 and a right bearing plurality of balls 50 between the races. The bicycle crank set and bottom bracket assembly 10 comprises a crank spindle 52 which is attached to right arm assembly 22, and a left crank fastening bolt 54 which removably couples the left crank arm assembly 20 to the spindle 52.

As shown in a detail cross section view of Figure 7, the chain ring 24 is sandwiched between a right molded crank arm 82 and the chainring lock ring 25.

As shown in the exploded view of Figure 8, a right crank arm assembly 22 comprises a crank spindle 52, a right crank arm 60, and a right crank arm attachment screw 62. The crank spindle 52 includes a left spindle end 64, a right spindle end 66, a left bearing race surface 68, a right bearing race surface 70, a left crank arm spindle torque coupling feature 72, a right crank arm spindle torque coupling feature 74, a torque coupling feature stop face 75, a chainring attachment spline 76, a lockring attachment thread 78, and a right arm bolt threaded hole 80.

The right crank arm assembly 60 comprises a right molded crank arm 82. The molded crank arm 82 comprises a right pedal hole 84, a right arm spindle fastener counterbore 86, a right arm spindle fastener counterbore pressure face 87, and a right crank arm torque coupling feature 88. In some embodiments such as shown with Figure 8, the coupling feature comprise a spline.

The right crank arm attachment screw 62 comprises a right crank arm attachment screw driving feature 90, and a right crank arm attachment screw male thread 92.

Figure 10 shows an exploded section view of the right crank arm assembly 60. In addition to the features represented in Figure 8, Figure 10 also shows a left crank fastening bolt threaded hole 94, and a crank spindle hollow bore 96.

Figure 10 also shows a cross section view of a right molded crank arm 82. The right molded crank arm 82 includes a right in-molded pedal insert 98, which comprises a right pedal insert threaded hole 100. The right molded crank arm 82 also comprises a right crank arm molded void 102, and a right crank arm spindle end void 106.

As further shown within Figure 10, the right crank arm attachment screw 92 comprises of a right crank arm attachment screw flange 108, a right crank arm attachment screw flange pressure face 110, and the right crank arm attachment screw male thread 92. Figure 10 also shows a spindle insert insertion distance 192, and a right arm spindle pocket distance 194.

Figure 12 shows a cross section of the right crank arm assembly 60 with the crank spindle 52 and right crank arm attachment screw 62 in their assembled positions relative to the right molded crank arm 82. As shown within Figure 12, the right crank arm spindle bond surface 112 in its assembled and bonded position.

As shown in the exploded view of Figure 13, the left crank arm assembly 20 comprises a left crank arm 116, a left crank arm attachment screw 118, a left crank arm insert attachment screw 120 and a left crank arm spindle attachment insert 122. The left crank arm 116 comprises a left molded crank arm 124, a left pedal hole 126, a left arm spindle fastener counterbore 128, and a left crank arm torque coupling feature 130, in this case a spline is shown, and a left crank arm insert through hole 132. The left crank arm spindle attachment insert 122 is comprised of a left arm insert torque coupling feature 134, a left arm spindle attachment insert stop face 136, a left arm spindle attachment insert end face 138, a left arm spindle attachment insert internal thread 140, a left arm spindle attachment insert through hole 142, and a left arm spindle attachment insert screw press face 144.

Exploded section view of Figure 15 shows an alternate view of the left crank arm assembly 20, including a left molded crank arm 124 which is comprised of a left in-molded pedal insert 146, which includes a left pedal insert threaded hole 148. The left molded crank arm 124 also comprises a left crank arm molded void 150, a left crank arm pedal end void 152, a left crank arm spindle end void 154, a left crank arm torque coupling feature 156. The left molded crank arm 124 also includes a left arm torque coupling feature end face 158, a left coupling feature through hole 160, and a left arm outside counterbore pressure face 162.

Figure 15 also shows a cross section of a left arm spindle attachment insert 122, also comprising a left arm spindle insert torque coupling feature 164, and a left arm spindle insert bearing stop face 166.

As further shown within Figure 15, a left crank arm attachment screw 118 comprises a left arm attachment screw thread 168, a left arm attachment screw pressure face 170, a left arm attachment screw flange 172, a left arm attachment screw extraction face 174, and a left arm attachment screw torque driving feature 176.

Figure 15 also shows a cross section of a left crank arm insert attachment screw 120, which comprises a left insert attachment screw thread 178, a left insert attachment screw compression face 180, a left insert attachment screw internal driving feature 182, a left insert attachment screw through hole 184, and a left insert attachment screw extraction pressure face 186, and a left insert attachment screw flange 188. Figure 15 further shows a left arm insert stop face 161, a left arm insert insertion distance 196, and a left arm spindle pocket distance 198.

Figure 17 shows an alternate cross section view of a left crank arm assembly 20 in its assembled configuration.

Figure 19 shows a cross section detail view of a left crank arm assembly 20 attached to a crank spindle 52 in its operable configuration mounted to a bicycle bottom bracket assembly 14.

Figure 20 shows a method of assembling either the left crank arm assembly 20 or right crank arm assembly 60. The method begins in the step 2002. In the step 2004 one or more bonding surfaces of an insert and a crank arm are cleaned. In the step 2006 adhesive is applied to one or more bonding surfaces of the insert and the crank arm and in the step 2008 the insert is slid into a receiving shape of the crank arm. In the step 2010 a fastener is installed into the insert through a hole in a crank arm. In the step 2012 torque is applied to the fastener and in the step 2014 the adhesive is cured. The method ends in the step 2016.

Figure 21A–22B illustrate a right crank arm assembly in accordance with some embodiments. As shown within Figure 22A and 22B one or more spacers 200 are able to be used to adjust a chainline of a chain ring relative to the crank set. For example, in some embodiments, the one or more spacers 200 are able to comprise 1mm spacers for adjusting the chainline.

As described above, during assembly of a right crank arm assembly 60, first an adhesive is applied to the right crank arm spindle torque coupling feature 74, and also applied to the right crank arm torque coupling feature 88. The right crank arm spindle torque coupling feature 74 is then inserted into the right crank arm torque coupling feature 88. Next the right crank arm attachment screw 62 is threaded into the right arm bolt threaded hole 80, and the screw is tightened until the necessary assembly torque is achieved in the fastener.

In some embodiments, the spindle insert insertion distance 192 is shorter than the right arm spindle pocket distance 194, such that when the screw is tightened, a compressive force is created in the right arm between the torque coupling feature stop face 75 and the right crank arm attachment screw flange pressure face 110.

Similarly, such as described above, during assembly of the left crank arm assembly 20, first adhesive is applied to the left crank arm torque coupling feature 156, and also applied to the left arm insert torque coupling feature 134. The left arm insert torque coupling feature 134 is then inserted into the left crank arm torque coupling feature 156. Next the left crank arm insert attachment screw 120 is threaded into the left arm spindle attachment insert internal thread 140, and the screw is tightened until some designated assembly torque is achieved in the fastener.

In some embodiments, the left arm insert insertion distance 196 is shorter than the left arm spindle pocket distance 198, such that when the screw is tightened, a compressive force is created in the left arm between the left arm outside counterbore pressure face 162 and the left arm insert stop face 161.

To assemble the cranks to the bicycle, first the left bottom bracket cup assembly 26 and the right bottom bracket cup assembly 28 are installed on the bicycle frame. Typically, these bottom bracket cup assemblies are threaded into the frame, or pressed into place, etc. Alternately bearings may be fitted directly into the frame using appropriately sized pockets in the bottom bracket assembly or analogous bicycle frame area.

Before installation on the bicycle, a chain ring 24 is installed on the crank spindle 22, and a chainring lock ring 25 is used to retain the chain ring 24 on the chainring attachment spline

76. The spindle is passed through the bottom bracket bearings so that the left crank arm spindle torque coupling feature 72 is exposed on the left side of the left bottom bracket cup assembly 26, and the right crank arm assembly 22 presses against the right inner race 46 of the right bottom bracket cup assembly 28. As shown, the chainring lock ring 25 contacts the right inner race 46, and acts as a stop for the right crank arm assembly 22.

Next, the left crank arm assembly 20 is attached to the crank spindle 22 using the crank fixing bolt 54. As shown, the crank/spindle assembly is a net fit between the left inner race 40 and the right inner race 46. In some embodiments of the invention the tolerance in the spindle interface may be taken up by a bearing preload device such as a wave spring, or a threaded preload mechanism, a compliant washer, or some other method.

In some embodiments, the left crank arm assembly 20 is attached to the crank spindle 22 through an integral attachment structure and the right crank arm assembly 60 is attached to a spindle insert, where the chain ring 24 is attached to the right crank arm assembly 60 and the demountable spindle interface is on the same side of the bicycle as the chain ring.

The composite bicycle crank with an integral spindle and attachment structure as described above and shown in the illustrations uses a round lobed spline as the interface between the spindle and the right arm structure, and between the bonded insert and the left arm structure. As will be understood by someone of ordinary skill in the art, the spline is able to comprise any number of other shapes, including a circular square or triangular shaped profile, a square toothed spline, and involute spline, a tri-lobe or four lobed polygon type shape, or any other straight geometric shape.

In some embodiments, the connection between the left crank arm assembly and the spindle could be a splined interface, a tapered square interface, or some alternative torque transmitting coupling.

Alternatively, in some embodiments, the interface between the spindle or insert and arm structures is able to be created with a taper to the shape from one end of the profile to the other, or a partial straight profile with a tapered profile on the lead-in end.

In further embodiments, a similar structure as is used to connect the crank arms to the spindle and inserts could be used to connect a pedal inset to a crank arms. In this embodiment, a shaped sleeve area would be molded or formed into the pedal end of the crank arm piece, and an insert and threaded fastener would be used to hold the insert in place, while the insert is bonded to the arm with adhesive. This could form a light-weight and strong interface between, for instance, a metal pedal insert and a plastic composite crank arm.

In some embodiments, the molded crank arm is constructed using any number of material molding or forming technologies. For instance, the arm could be formed using molded carbon-fibers in an epoxy resin or thermoplastic resin, short carbon or glass fibers injection molded using any number of moldable resins. The arms could also be forged or cast from light metal alloys, such as magnesium, aluminum or titanium and their alloys.

Alternatively in some embodiments, the crank arms could be made from a solid, low cost piece of reinforced plastic in order to make a low-cost crank assembly. In this embodiment a metal spindle or insert could be used to provide necessary strength where needed to the assembly.

5 In some embodiments, the hollow crank arms could be formed from two pieces of sheet metal, which would then be seam welded together to form a hollow structure, or bonded together. Alternatively a hollow arm structure could be composed of two pieces of dissimilar material and then bonded together to form a light hollow structure, which would then be bonded to the spindle and insert structures as described.

10 In further embodiments, two half-spindles are able to be substituted for the single full-length spindle in the preferred embodiment, with a torque transmitting connection included where the two half spindles meet near the centerline of the bicycle. In this embodiment the two spindle stubs would connect to the crank arms with the same structure described in the preferred embodiment.

15 In some embodiments, the crank assembly such as described above is used with a crank set comprising a toothed pulley for use with a belt drive. Alternatively, in the crank assembly such as described above is used with a gear or gear coupling for use with a gearbox drive to propel the bicycle.

20 In operation, the attachment method for the crank spindle to the drive side crank arm may be used for mounting either a spindle of the drive side crank spindle attachment, or to attach a de-mountable interface, as shown on the non-drive-side crank arm. Thus it is possible to make a single molded plastic composite arm for use on both the drive and non-drive side crank arms, rather than differently shaped arms for each side of the assembly. Consequently, a single mold is able to be used to form both arms, saving time and cost.

25 Another advantage of the novel composite bicycle crank with an integral spindle attachment structure is that it allows a hollow crank arm to be manufactured separately from the crank spindle, using different materials for each, and attaching them together after manufacture to create a structure that is lightweight and strong.

30 A further advantage of the novel composite bicycle crank with an integral spindle attachment structure is that it allows for hollow areas to be designed into a composite crank arm surrounding the attachment point for the spindle, resulting in a lighter and stronger finished product. Additionally, the composite bicycle crank with an integral spindle attachment structure separates the attachment point for a chainring or chainring spider from the crank arm structure, so that splined features and threads may be included on a spindle
35 made of a suitable metal alloy, as threads and narrow splines are not easy to manufacture in plastic composite materials, but are easy to manufacture using suitable metal alloys. Moreover, in the case where the crank arm is manufactured from a plastic composite material, the area surrounding the spindle attachment may be formed without a metal insert, allowing the structure to be stronger and lighter than if an insert is molded into the structure during
40 fabrication of the arm. As such, the composite bicycle crank with an integral spindle

attachment structure as described herein has many advantages.

The present invention has been described in terms of specific embodiments incorporating details to facilitate the understanding of the principles of construction and operation of the invention. Such references, herein, to specific embodiments and details thereof are not
5 intended to limit the scope of the claims appended hereto. It will be apparent to those skilled in the art that modifications can be made in the embodiments chosen for illustration without departing from the spirit and scope of the invention.

C L A I M S

What is claimed is:

1. A bicycle crank set comprising:
 - a. a crank spindle;
 - b. a left side crank arm configured to couple to the crank spindle through an integral spindle attachment structure; and
 - c. a right side crank arm configured to couple to the crank spindle through the integral spindle attachment structure.
2. The bicycle crank set of Claim 1, wherein the integral spindle attachment structure of the left side crank arm and the right side crank arm comprises a round lobed spline interface.
3. The bicycle crank set of Claim 1, wherein the integral spindle attachment structure of the left side crank arm and the right side crank arm comprises one of a circular interface, a square interface, a triangular interface, a square toothed spline, an involute spline, a tri-lobe polygon shape, a four-lobe polygon shape, and a geometric shape.
4. The bicycle crank set of Claim 1, wherein the left side crank arm couples to the crank spindle through a spindle insert.
5. The bicycle crank set of Claim 1, wherein the right side crank arm couples to the crank spindle through a spindle insert.
6. The bicycle crank set of Claim 4, wherein the left side crank arm couples to the crank spindle through one of a splined interface, a tapered square interface, and a torque transmitting coupling.
7. The bicycle crank set of Claim 4, wherein the left side crank arm is manufactured from a first material and the insert is manufactured from a second material different than the first material.
8. The bicycle crank set of Claim 5, wherein the right side crank arm couples to the crank spindle through one of a splined interface, a tapered square interface, and a torque transmitting coupling.
9. The bicycle crank set of Claim 5, wherein the right side crank arm is manufactured from a first material and the insert is manufactured from a second material different than the first material.

10. The bicycle crank set of Claim 1, wherein the integral spindle attachment structure of the left side crank arm and the right side crank arm comprises a tapered interface.
11. The bicycle crank set of Claim 1, wherein the left side crank arm and the right side crank arm comprise a hollow structure.
12. The bicycle crank set of Claim 1, further comprising one or more chain rings.
13. The bicycle crank set of Claim 12, comprising one or more spacers for adjusting a chainline of the one or more chain rings.
14. A bicycle crank arm comprising an integral spindle attachment structure comprising a round lobed spline interface for coupling with a crank spindle of a bicycle.
15. The bicycle crank arm of Claim 14, wherein the crank arm comprises a right side crank arm.
16. The bicycle crank arm of Claim 14, wherein the crank arm comprise a left side crank arm.
17. The bicycle crank arm of Claim 14, wherein the crank arm couples to the crank spindle through a spindle insert.
18. The bicycle crank arm of Claim 17, wherein the crank arm is manufactured from a first material and the insert is manufactured from a second material different than the first material.
19. The bicycle crank arm of Claim 14, wherein the crank arm comprise a hollow structure.
20. A method of installing a crank arm on a crank spindle comprising:
 - a. cleaning one or more bonding surfaces of an insert and a crank arm;
 - b. applying an adhesive to the one or more bonding surfaces of the insert and the crank arm;
 - c. sliding on the insert into a receiving shape of the crank arm;
 - d. installing a fastener through a hole in the crank arm;
 - e. applying torque to the fastener; and
 - f. curing the adhesive.
21. The method of Claim 20, wherein the crank arm comprises a left side crank arm.

22. The method of Claim 20, wherein the crank arm comprises a right side crank arm.
23. The method of Claim 20, wherein the crank arm is manufactured from a first material and the insert is manufactured from a second material different than the first material.
24. The method of Claim 20, wherein the crank arm comprise a hollow structure.
25. A method of installing a crank arm on a crank spindle comprising:
- a. cleaning one or more bonding surfaces of a crank arm;
 - b. applying an adhesive to the one or more bonding surfaces of the crank arm;
 - c. installing a fastener through a hole in the crank arm;
 - d. applying torque to the fastener; and
 - e. curing the adhesive.
26. The method of Claim 25, wherein the crank arm comprises a left side crank arm.
27. The method of Claim 25, wherein the crank arm comprises a right side crank arm.
28. The method of Claim 25, wherein the crank arm comprise a hollow structure.

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Fig. 1

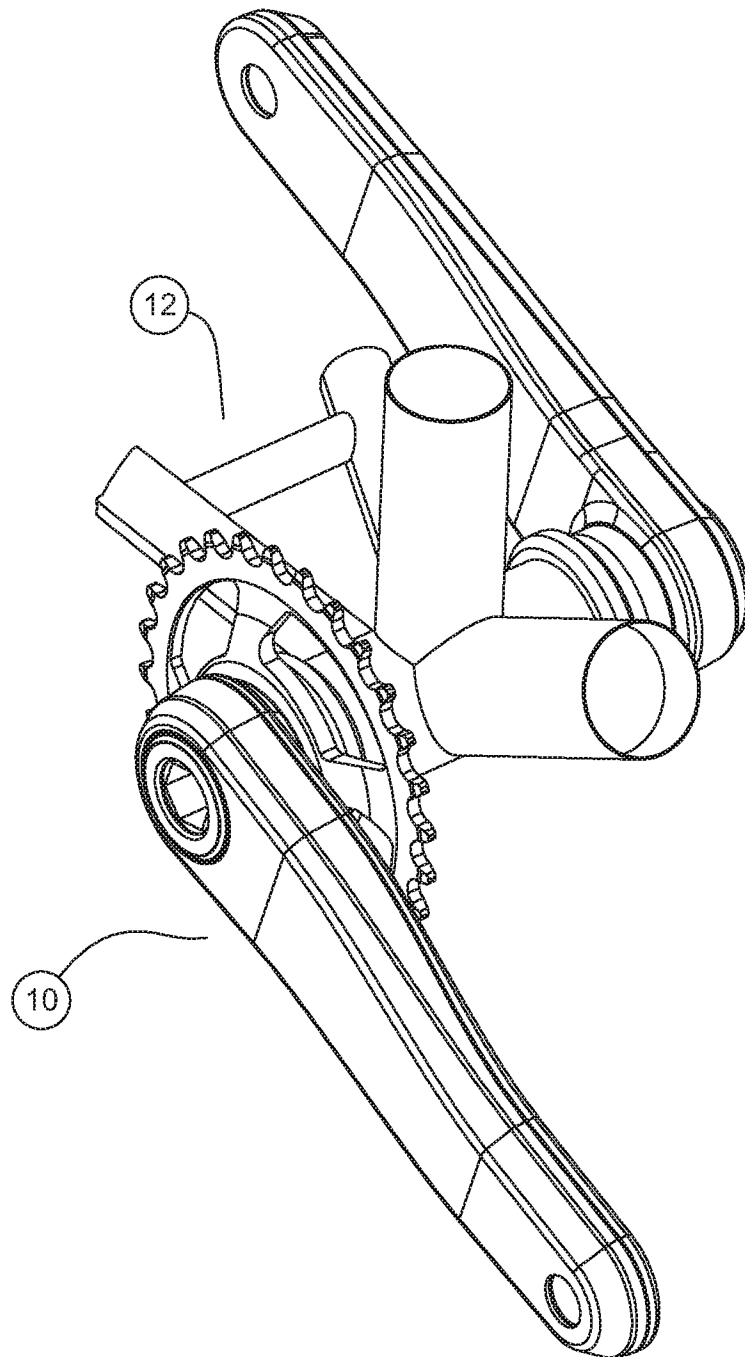


Fig. 2

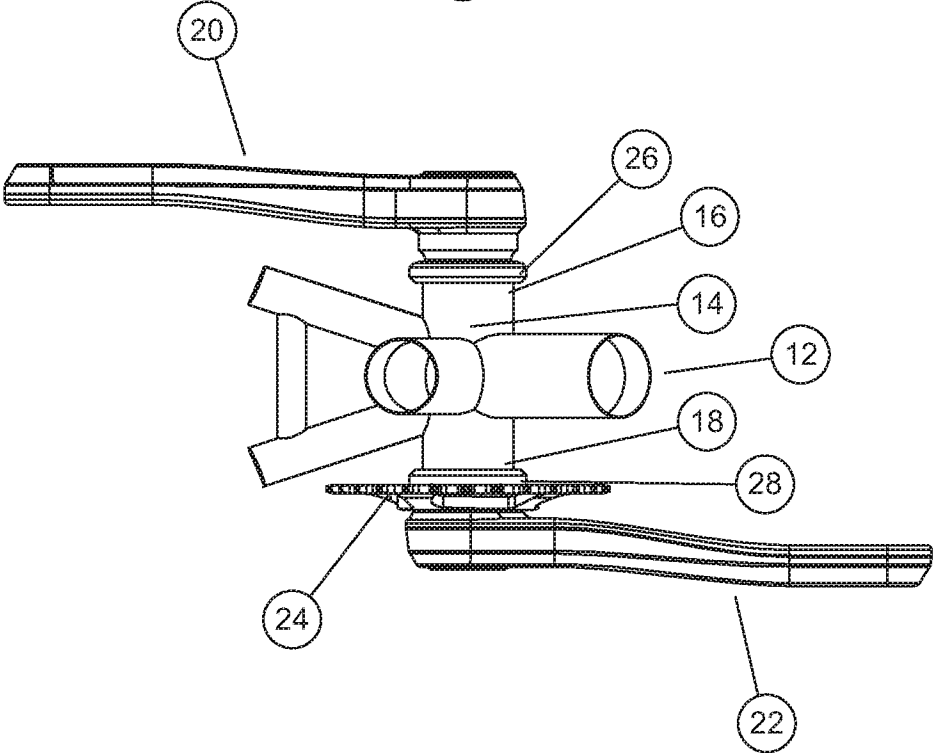
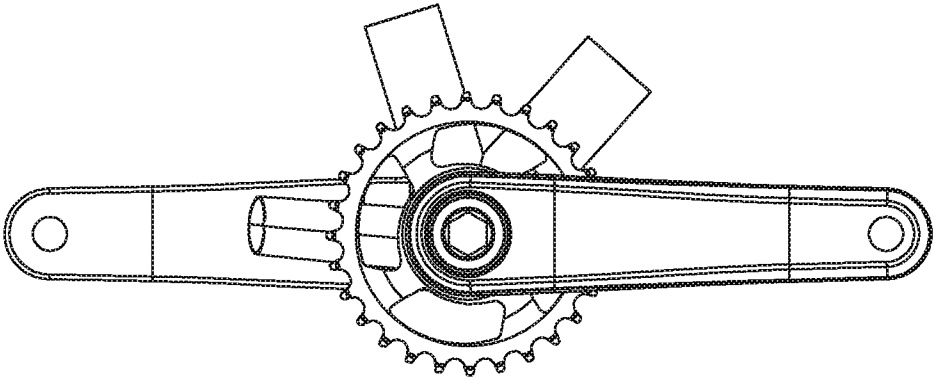
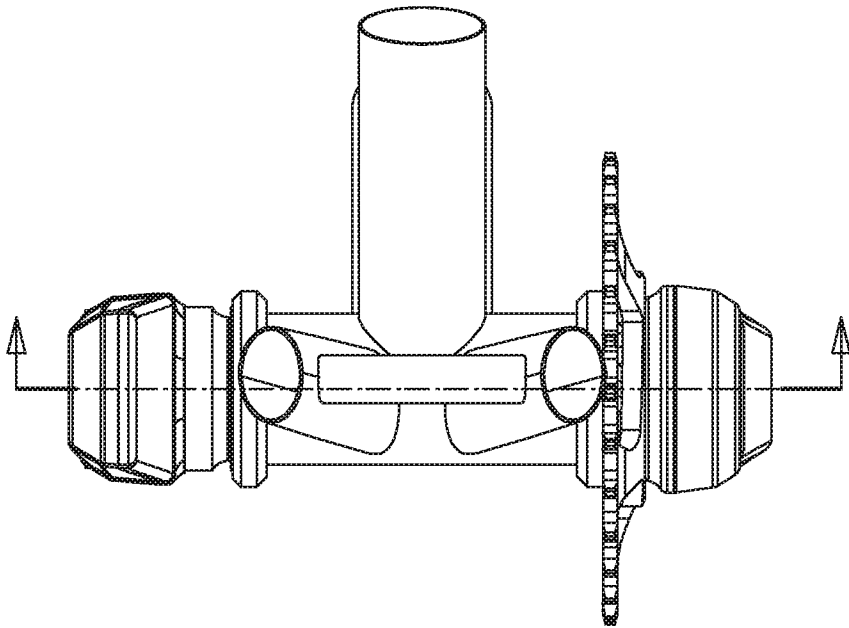


Fig. 3



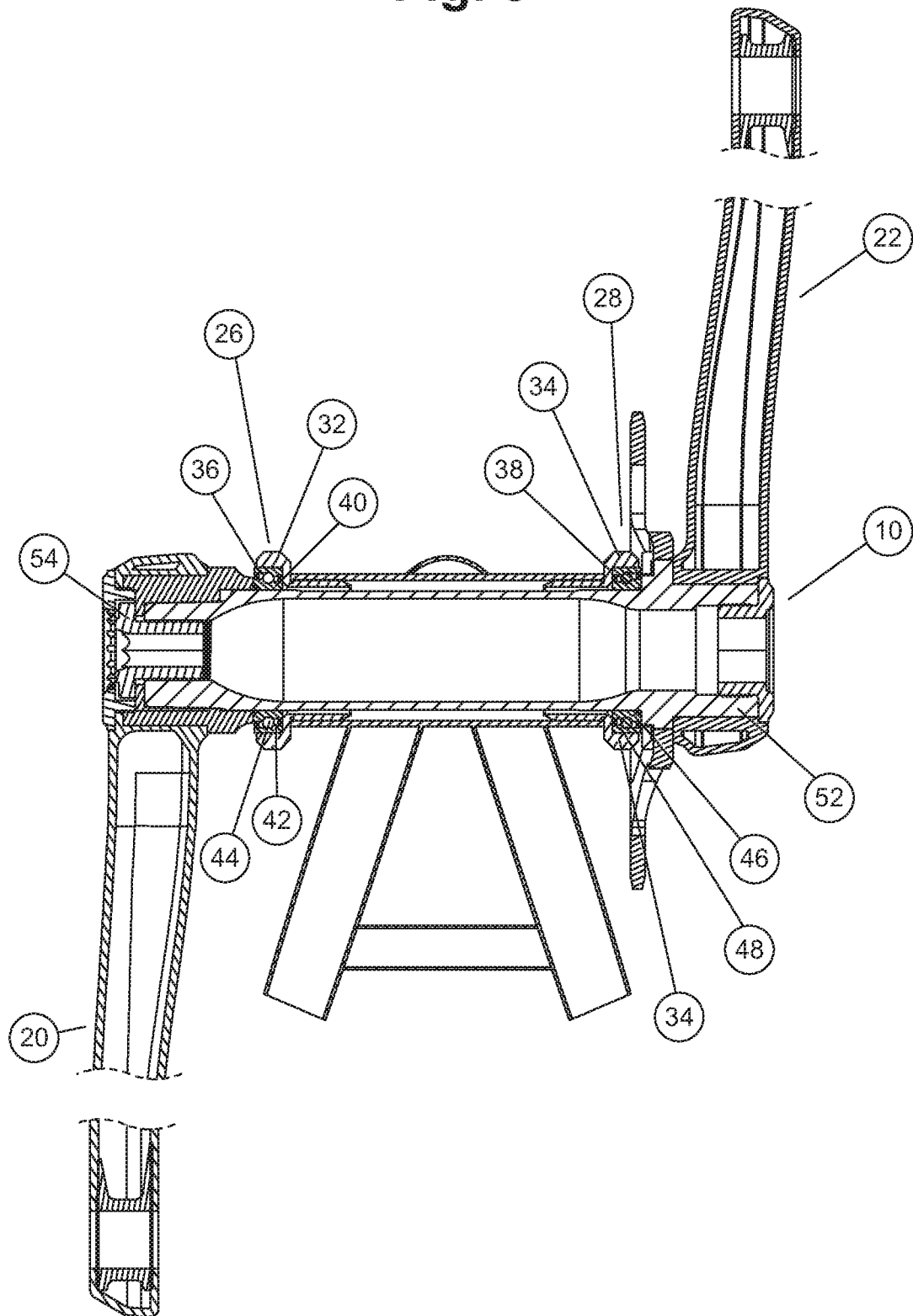
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Fig. 4



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Fig. 5



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Fig. 6

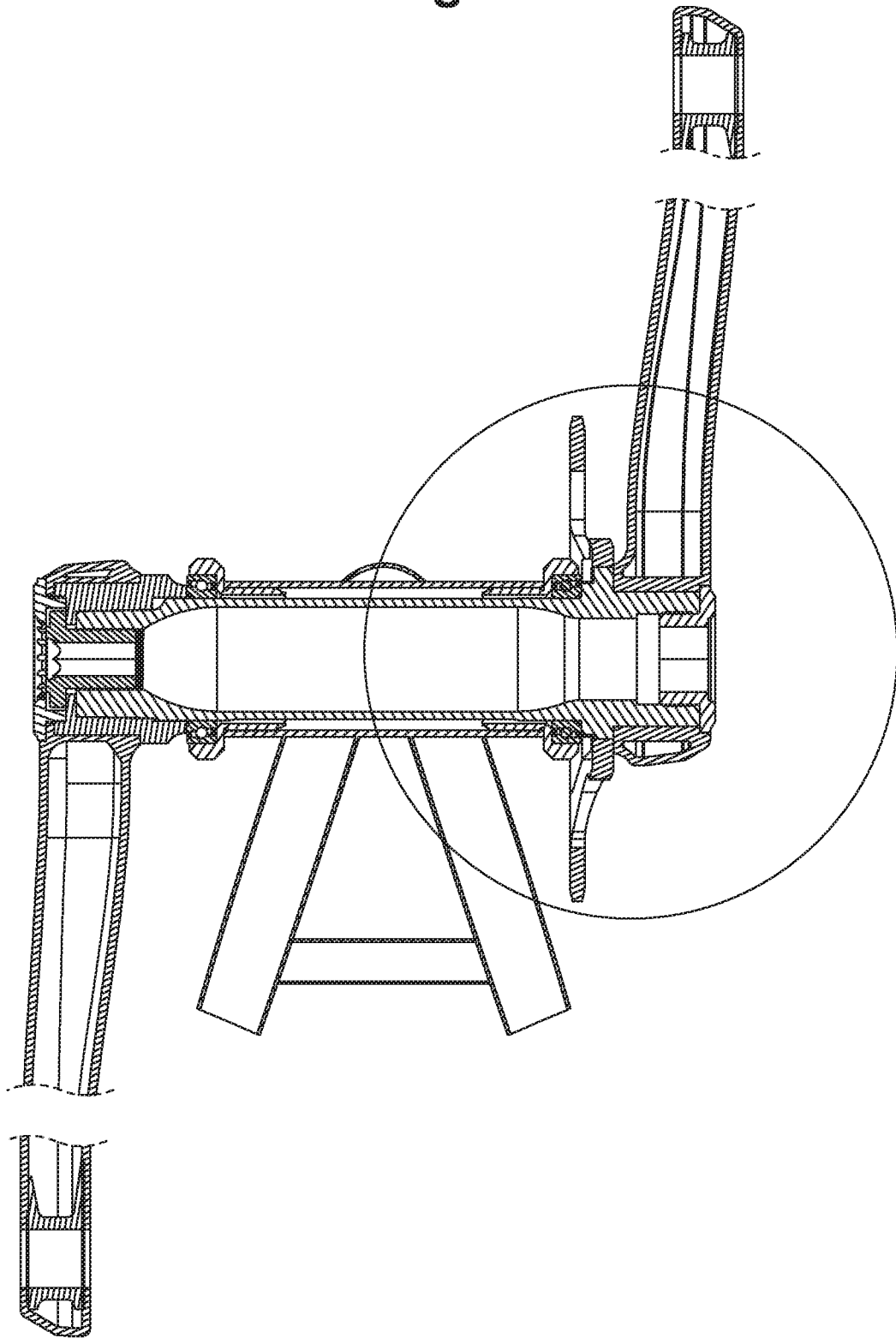
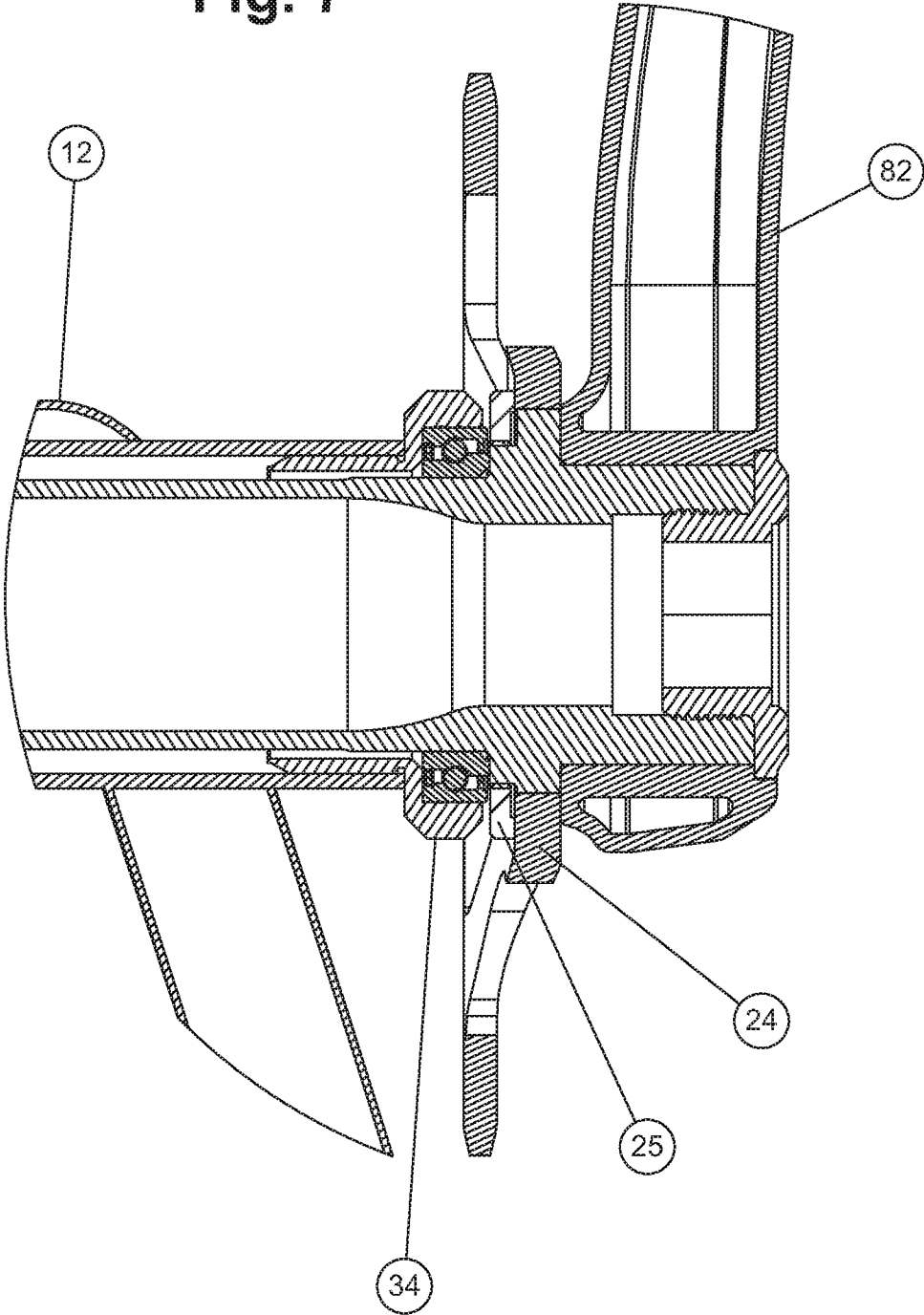
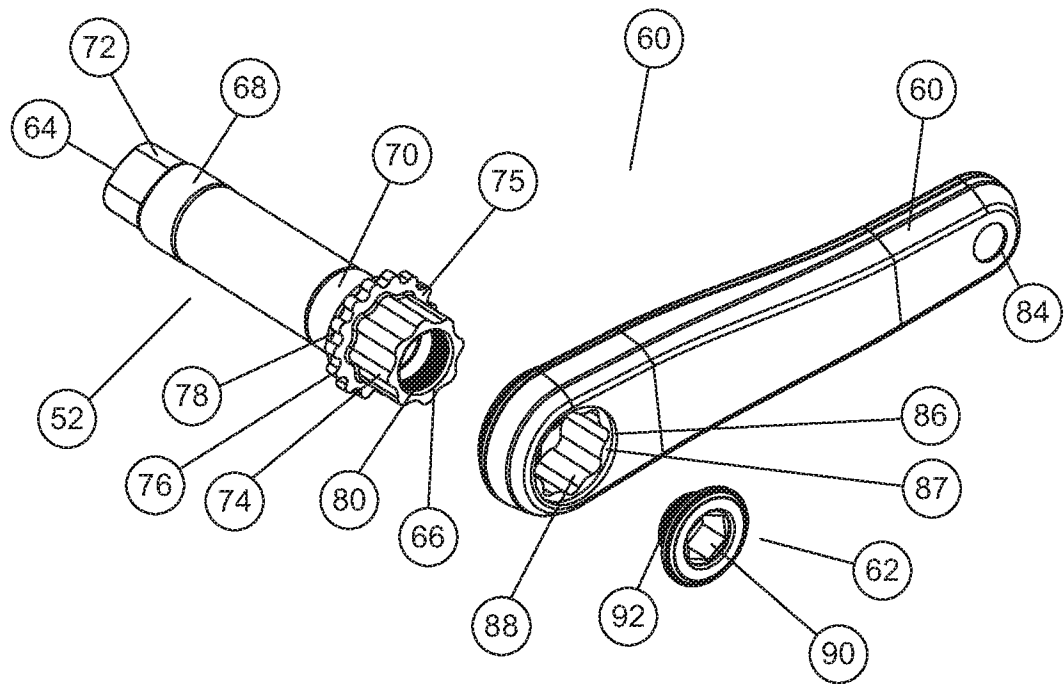


Fig. 7



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Fig. 8



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Fig. 9

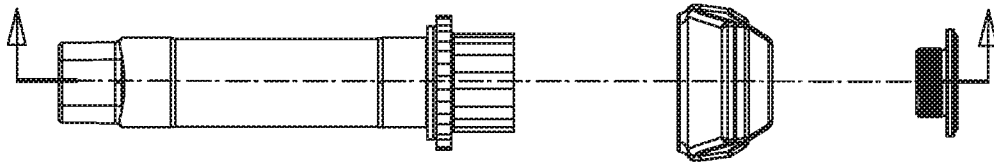


Fig. 10

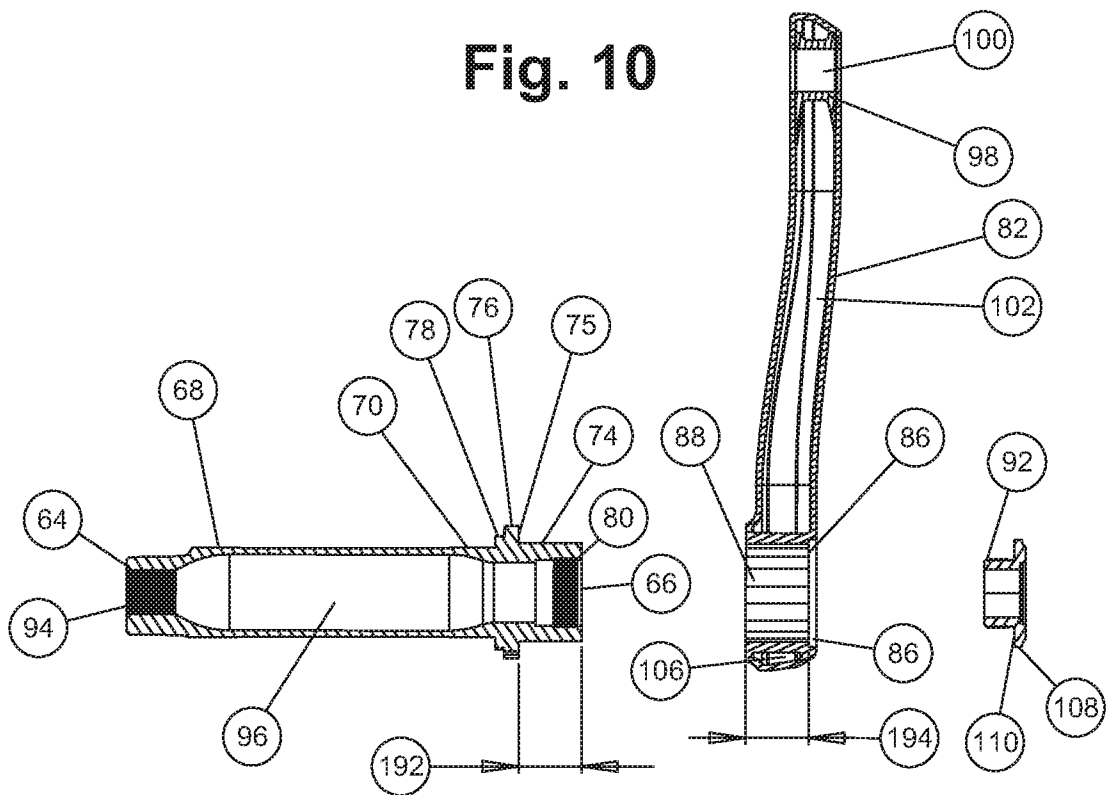
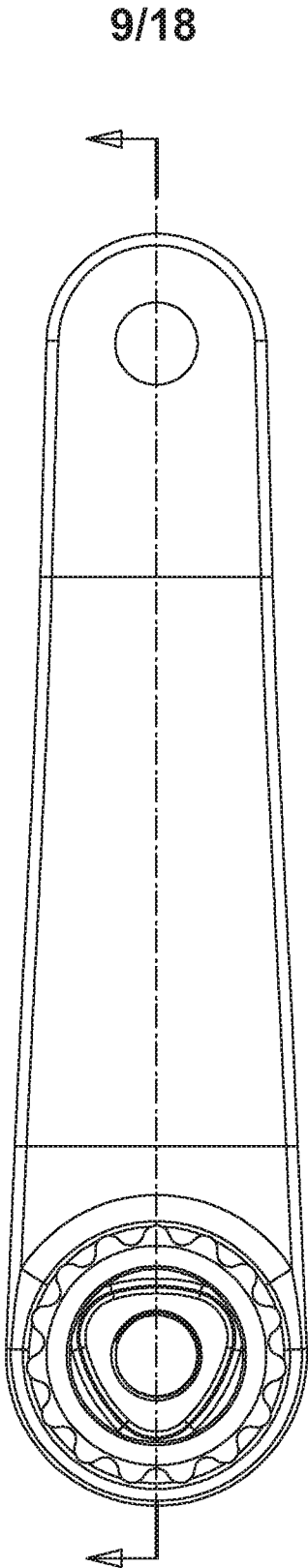


Fig. 11



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Fig. 12

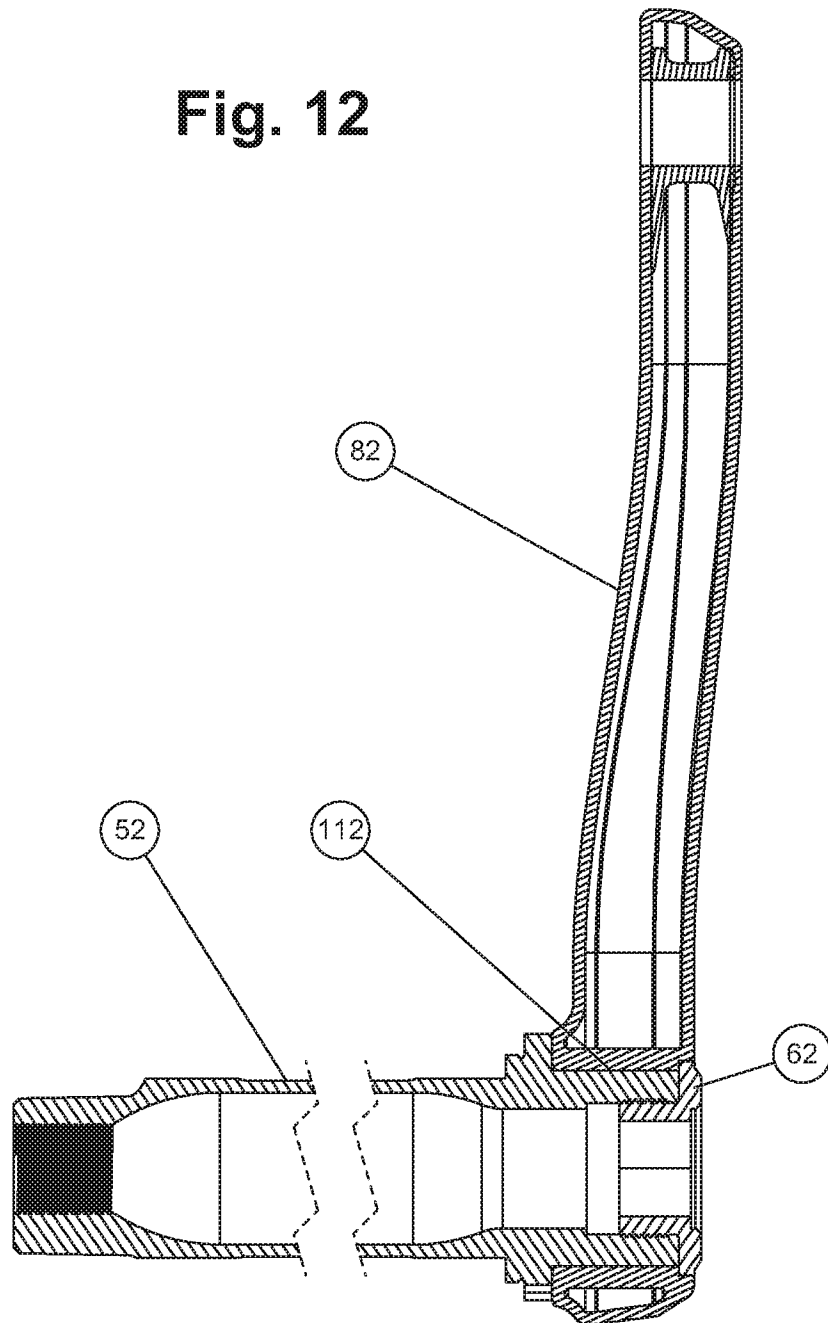
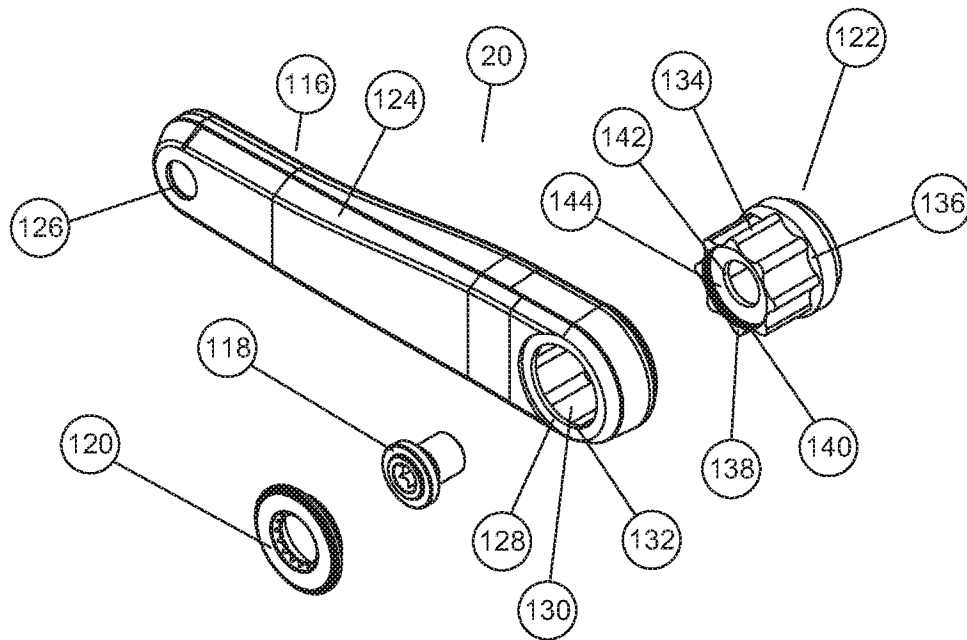


Fig. 13



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Fig. 14

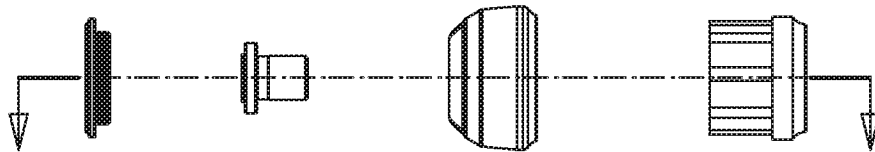
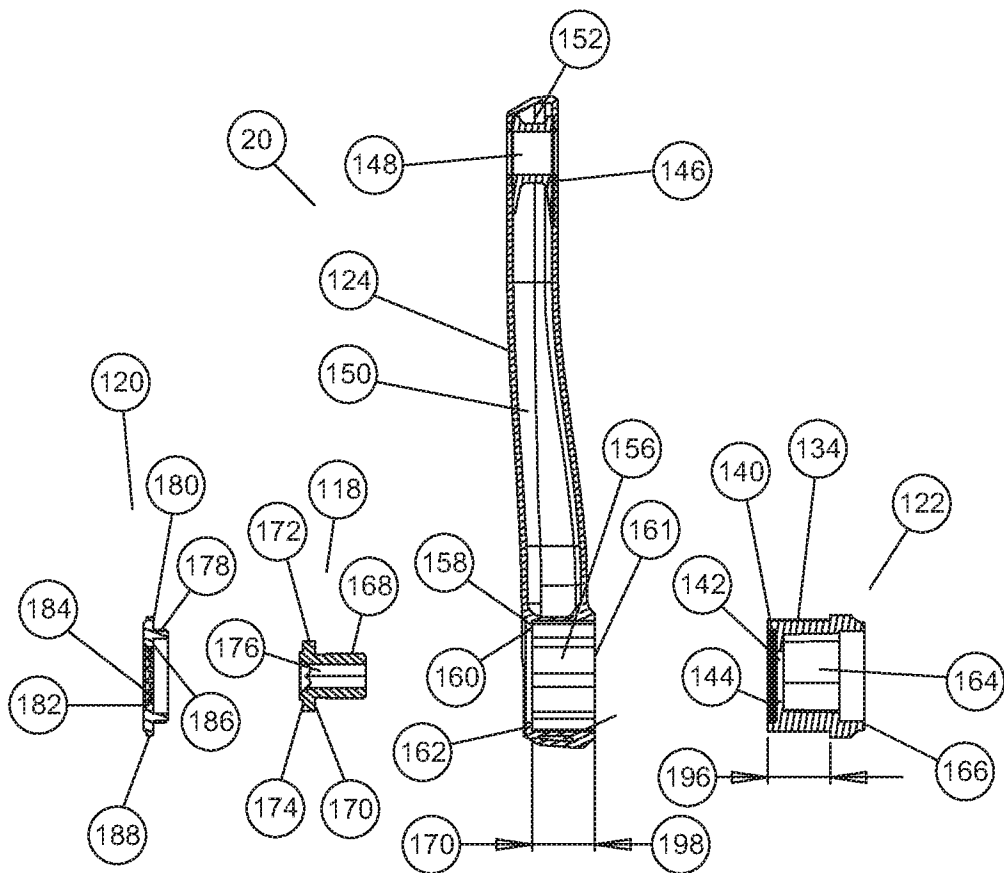


Fig. 15



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Fig. 16

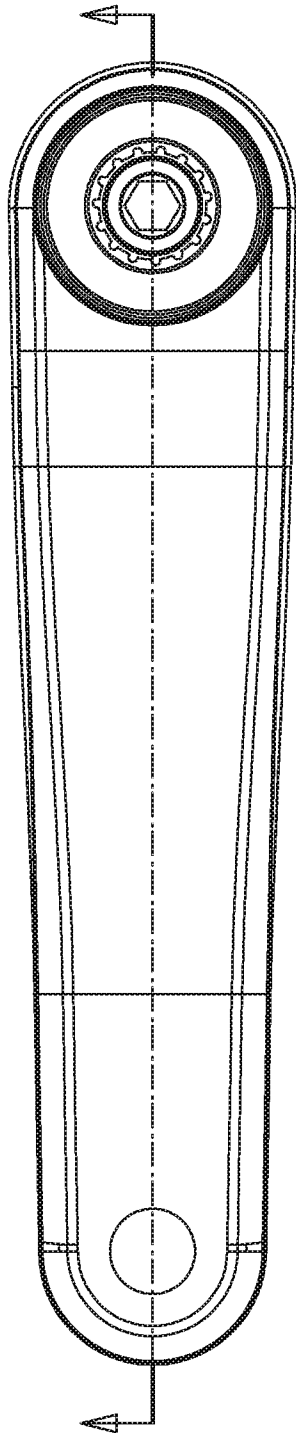
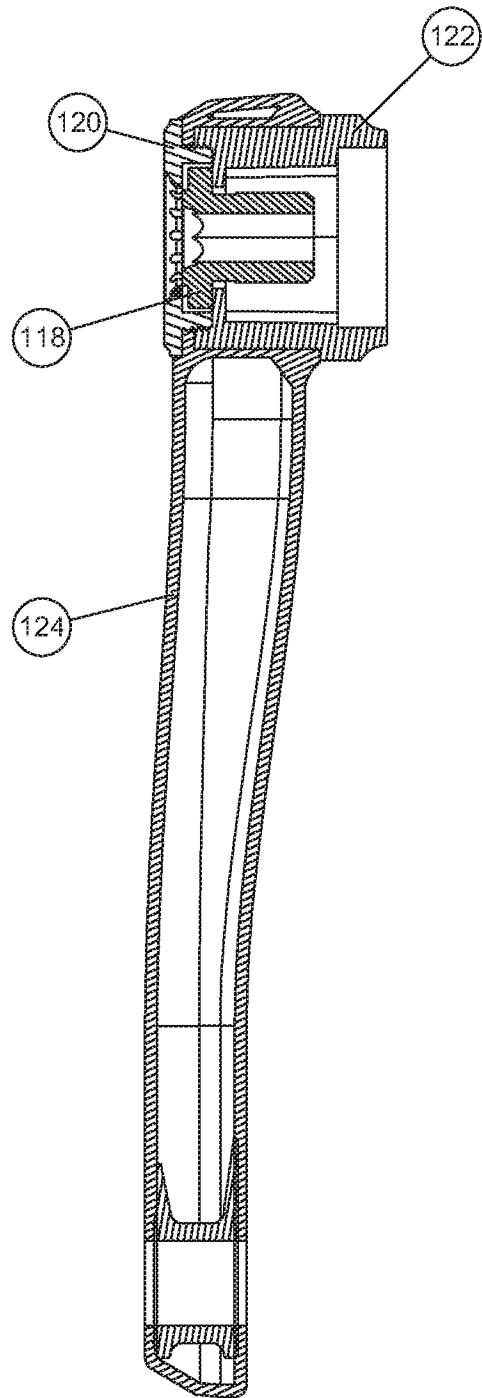


Fig. 17



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Fig. 18

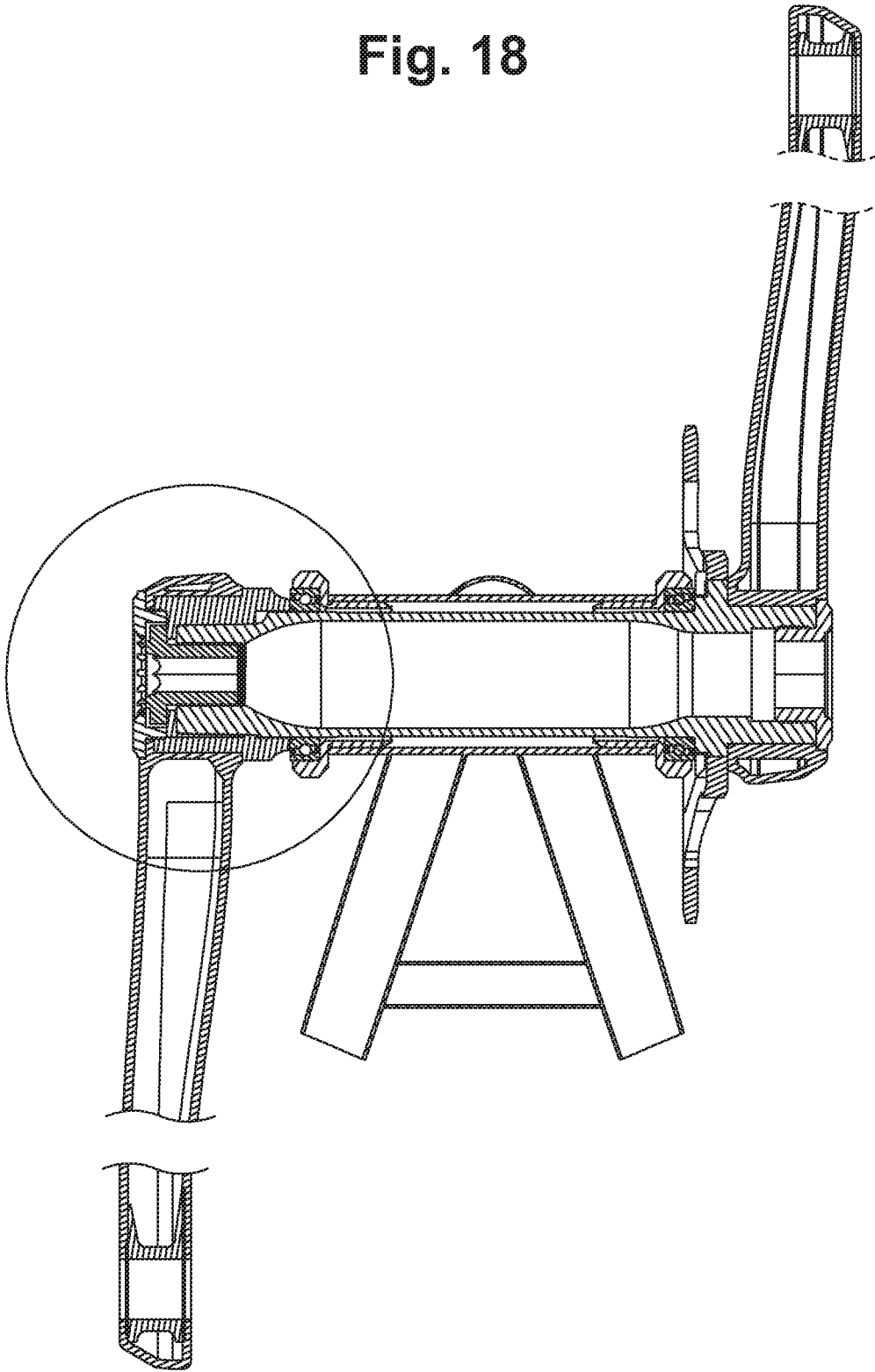
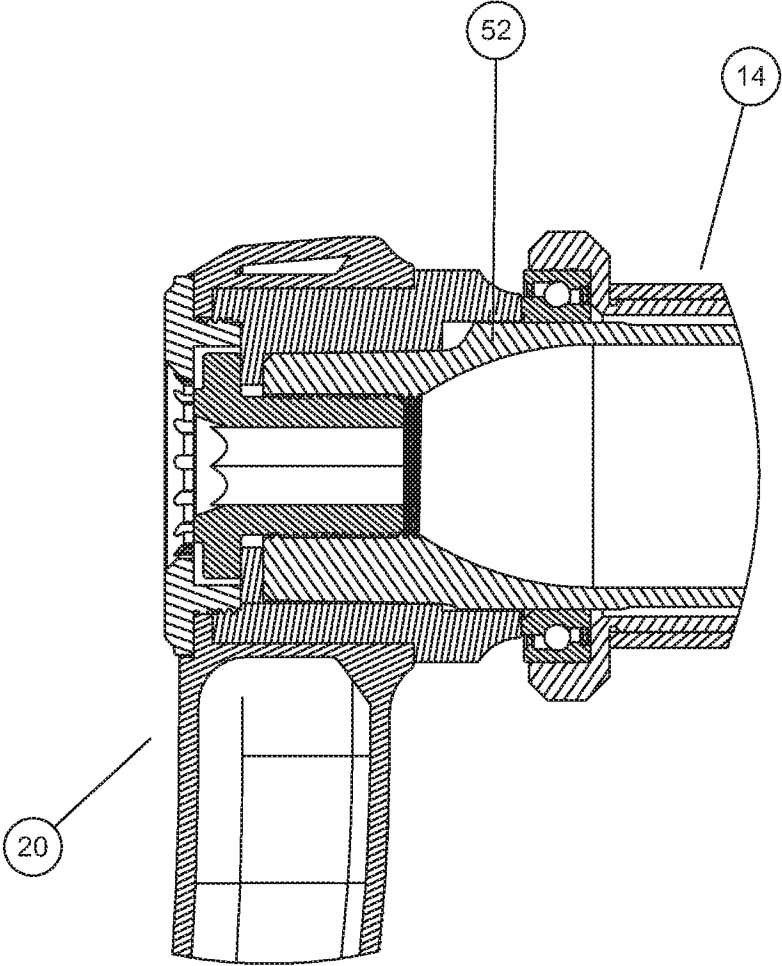
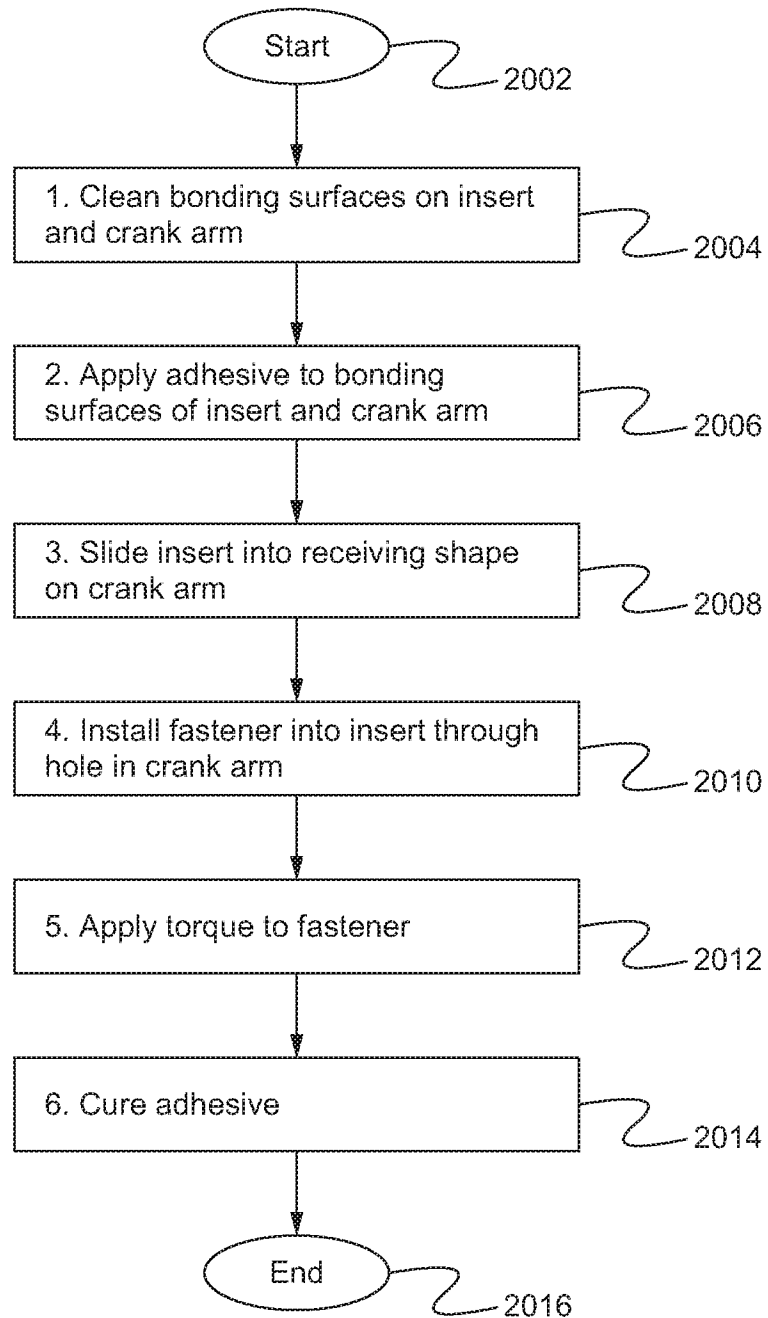


Fig. 19



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Fig. 20

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Fig. 21A

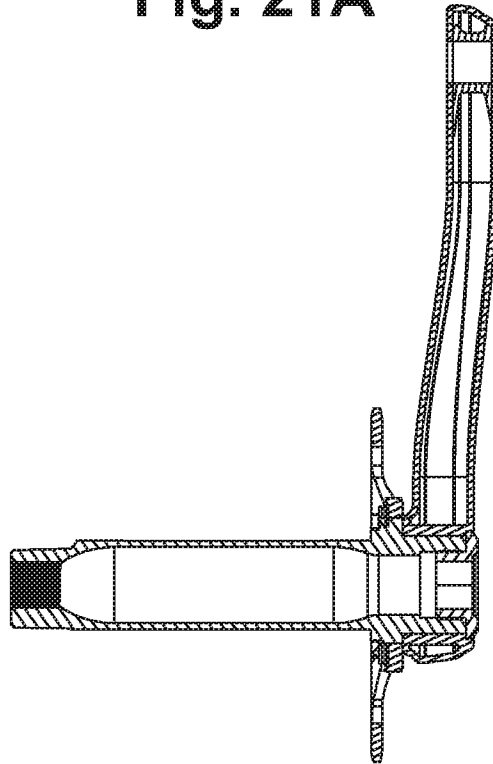
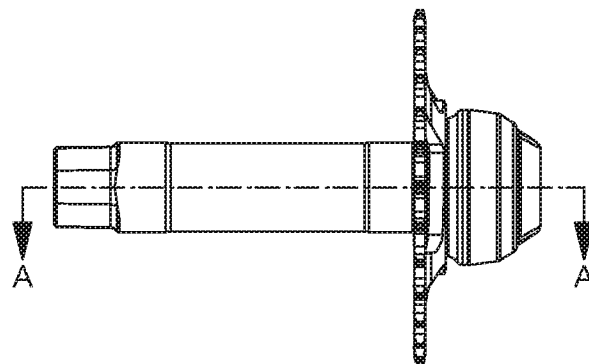


Fig. 21B



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Fig. 22A

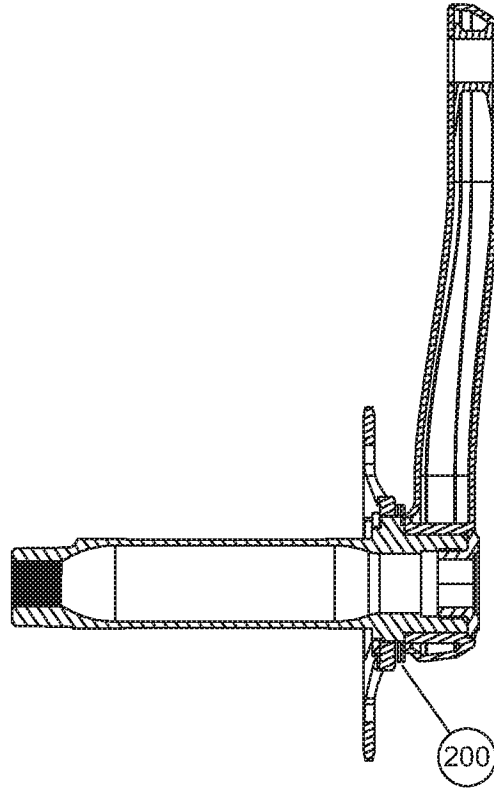
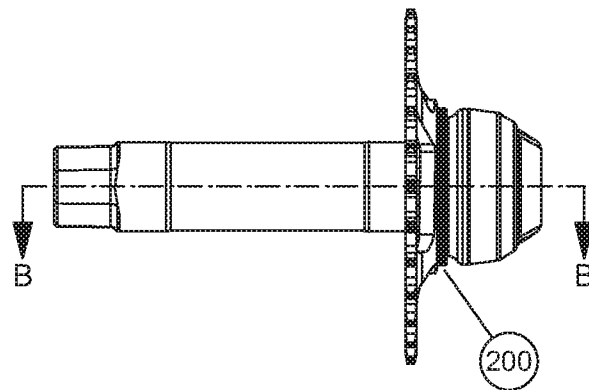


Fig. 22B



INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2017/023016

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

See extra sheet(s).

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. ☒ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
1-19
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☒ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2017/023016

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - B62M 3/00; B62M 1/30; B62M 1/36; B62M 3/08; G05G 1/30 (2017.01)

CPC - B62M 3/00; B62M 3/003; B62M 3/08; G05G 1/30 (2017.05)

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

See Search History document

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

USPC - 74/594.1; 74/594.2; 280/210; 280/259; 474/160 (keyword delimited)

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

See Search History document

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X ---	US 2006/0288819 A1 (DAL PRA' et al) 28 December 2006 (28.12.2006) entire document	1-3, 14-16
Y		17-19
X ---	US 2010/0275724 A1 (STAPLES et al) 04 November 2010 (04.11.2010) entire document	1, 3-9
Y		17, 18
X ---	US 2007/0182122 A1 (SMITH) 09 August 2007 (09.08.2007) entire document	1, 3-6, 8, 12
Y		13
X ---	US 2004/0200314 A1 (HERMANSEN et al) 14 October 2004 (14.10.2004) entire document	1, 3, 10-12
Y		19
Y	US 5,809,844 A (DURHAM) 22 September 1998 (22.09.1998) entire document	13
A	US 7,523,685 B2 (FRENCH) 28 April 2009 (28.04.2009) entire document	1-19

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

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

20 June 2017

Date of mailing of the international search report

07 JUL 2017

Name and mailing address of the ISA/US

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Facsimile No. 571-273-8300

Authorized officer

Blaine R. Copenheaver

PCT Helpdesk: 571-272-4300
PCT OSP: 571-272-7774

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2017/023016

Continued from Box No. III Observations where unity of invention is lacking

This application contains the following inventions or groups of inventions which are not so linked as to form a single general inventive concept under PCT Rule 13.1. In order for all inventions to be examined, the appropriate additional examination fees need to be paid.

Group I, claims 1-13 are drawn to a bicycle crank set.

Group II, claims 14-19 are drawn to a bicycle crank arm.

Group III, claims 20-28 are drawn to a method of installing.

The inventions listed in Groups I-III do not relate to a single general inventive concept under PCT Rule 13.1, because under PCT Rule 13.2 they lack the same or corresponding special technical features for the following reasons:

The special technical features of Group I, a bicycle crank set comprising a left side crank arm and a right side crank arm, are not present in Groups II, III; the special technical features of Group II, a bicycle crank arm comprising an integral spindle attachment structure comprising a round lobed spline interface, are not present in Groups I, III; and, the special technical features of Group III, a method of installing comprising cleaning one or more bonding surfaces of a crank arm, applying an adhesive to the one or more bonding surfaces, installing a fastener through a hole in the crank arm, applying torque to the fastener, and curing the adhesive, are not present in Groups I, II.

Groups I, II, and III share the technical features of a crank arm and a crank spindle.

However, these shared technical features do not represent a contribution over the prior art. Specifically, US 7,523,685 B2 to French teaches of a crank arm (crank arm 16, Fig. 1) and a crank spindle (spindle 14, Fig. 1).

Groups I, and II share the technical features of a bicycle crank arm comprising an integral spindle attachment structure.

However, these shared technical features do not represent a contribution over the prior art. Specifically, US 7,523,685 B2 to French teaches of a bicycle crank arm (crank arm 16, Fig. 1; Abstract regarding a bicycle sprocket crank assembly is comprised of first and second crank arms joined to a spindle) comprising an integral spindle attachment structure (first socket 46, Fig. 1; Col. 9, Lns. 22-25 regarding the axle end 45 of the second crank arm 16 thereby forms a first socket 46 with a hollow cavity 48 of cylindrical shape defined therein; Col. 9, Lns. 28-29 regarding the first coupling end 32 of the spindle 14 and the hollow cavity 48 of the first socket 46 are mating first joint elements).

Since none of the special technical features of the Groups I-III inventions are found in more than one of the inventions, unity is lacking.