US 20180195578A1

(19) United States
(12) Patent Application Publication
(10) Pub. No.: US 2018/0195578 A1
Stuart
(43) Pub. Date: Jul. 12, 2018

(54) **SHAFT ASSEMBLY WITH INTERNAL UV-CURED BALANCE WEIGHT**

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(21) Appl. No.: **15/402,555**

(22) Filed: **Jan. 10, 2017**

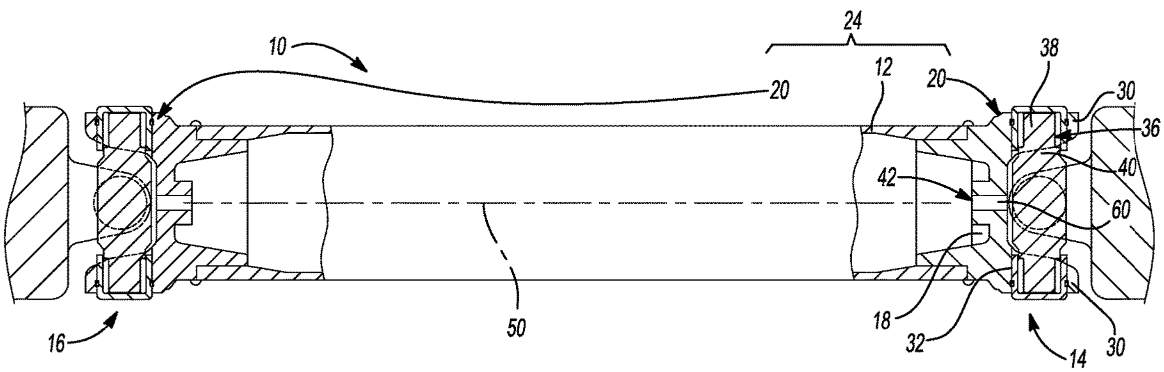
Publication Classification

(51) **Int. Cl.**
F16F 15/32 (2006.01)
F16C 3/02 (2006.01)
G01M 1/36 (2006.01)

(52) **U.S. Cl.**
CPC *F16F 15/322* (2013.01); *G01M 1/36* (2013.01); *F16C 3/02* (2013.01)

(57) **ABSTRACT**

A method for forming a shaft assembly includes: providing a shaft structure, the shaft structure comprising a shaft and a universal joint member that is coupled to an end of the shaft; inserting a weight member to the shaft structure to form an intermediate assembly, the weight member being formed at least partly from a liquid resin, the intermediate assembly having an initial rotational unbalance; rotating the intermediate assembly about a longitudinal axis of the shaft structure to re-distribute a least a portion of the weight member circumferentially about the shaft structure to at least partly attenuate the initial rotational unbalance; and curing the liquid resin while rotating the intermediate assembly to fix the re-distributed portion of the weight member to the shaft structure to thereby form a balance weight that at least partly attenuates the initial rotational unbalance. A shaft assembly is also provided.



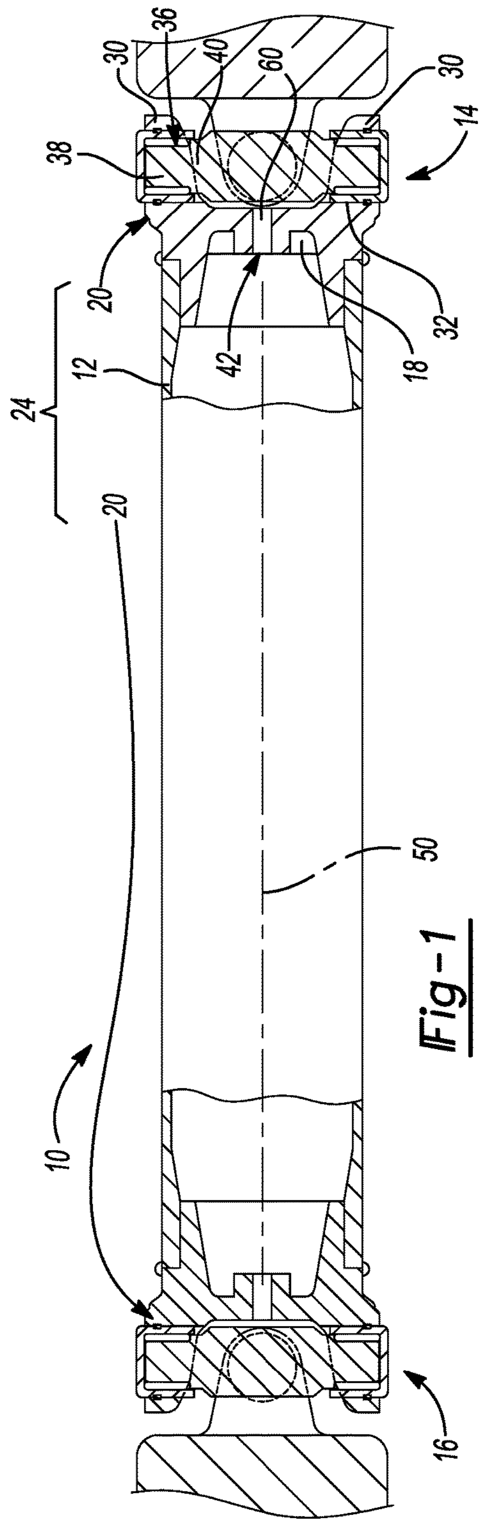


Fig-1

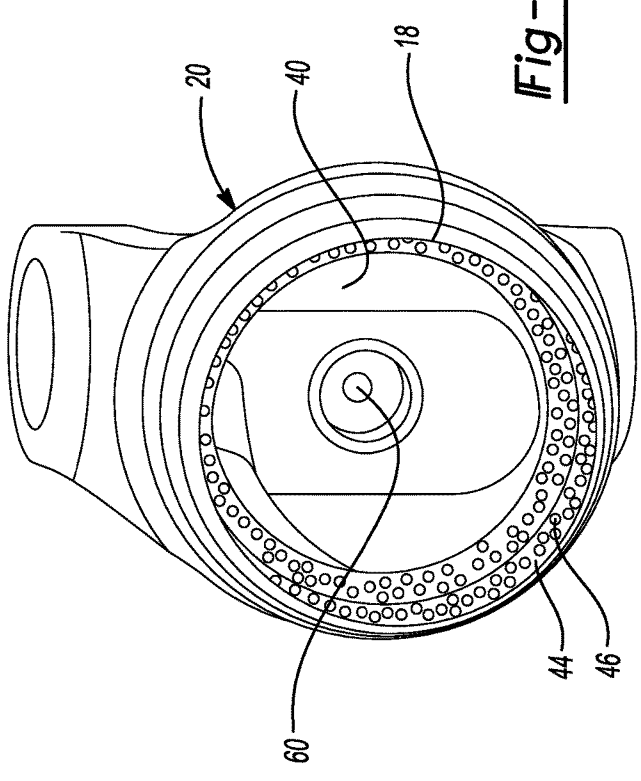


Fig-2

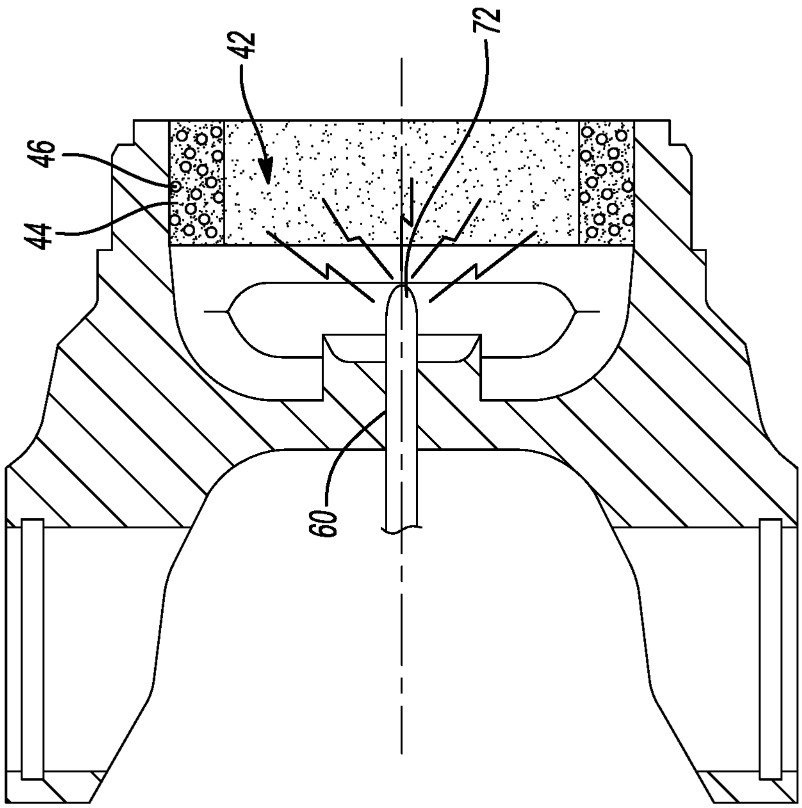


Fig-4

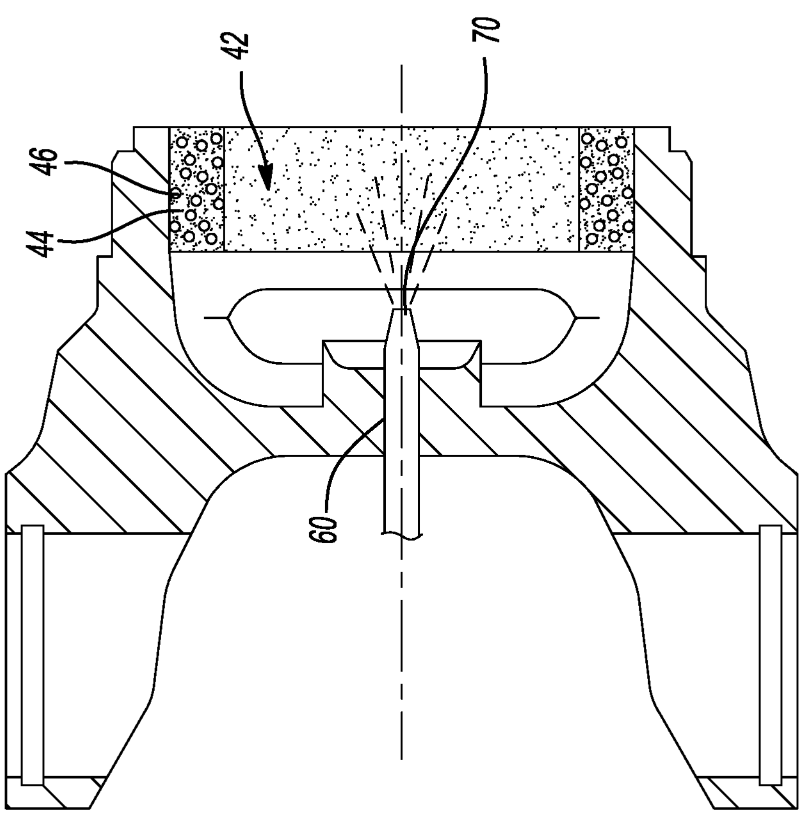


Fig-3

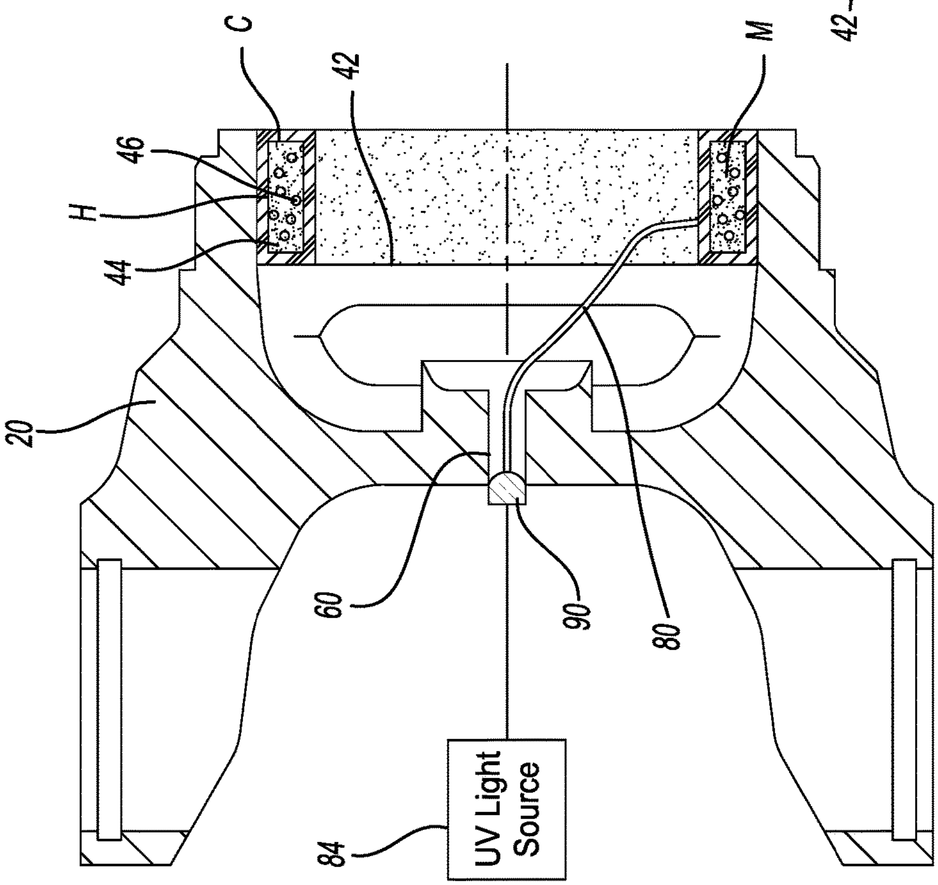


Fig-5

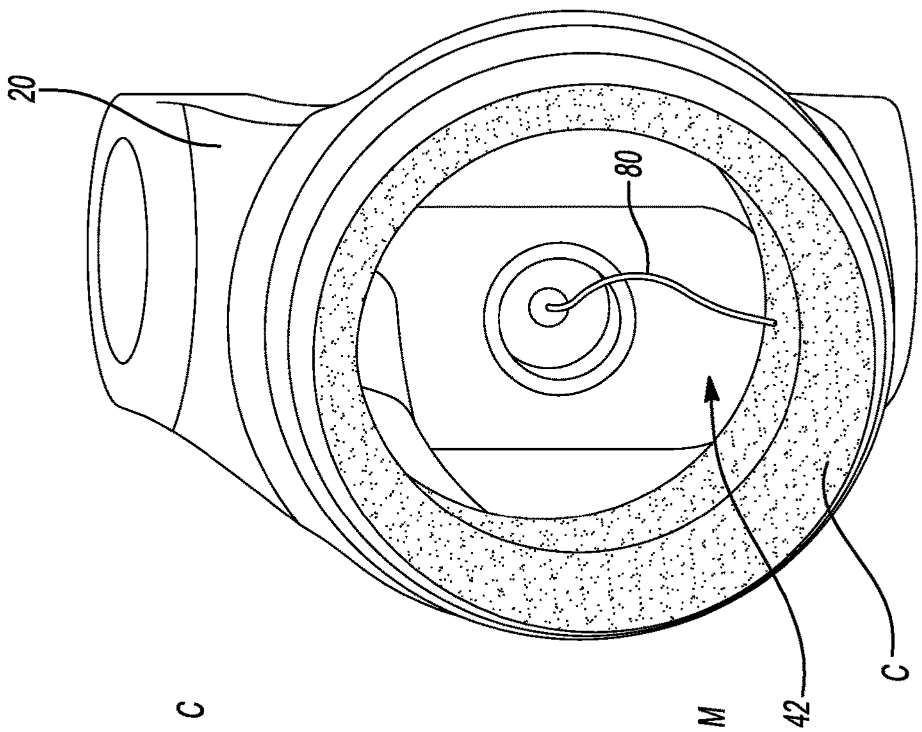


Fig-6

SHAFT ASSEMBLY WITH INTERNAL UV-CURED BALANCE WEIGHT

FIELD

[0001] The present disclosure relates to shaft assembly with an internal balance weight and a related method for forming the shaft assembly.

BACKGROUND

[0002] This section provides background information related to the present disclosure which is not necessarily prior art.

[0003] Various shafts assemblies, such as propshafts used in the automotive industry to transmit rotary power from a powertrain to an axle or transfer case, must be rotationally balanced so that undesired vibration is not generated during the use of the shaft assembly. In the production of modern automotive propshafts, it is common practice to weld an appropriately sized balance weight to a portion of the propshaft to minimize unbalance. This solution, however, is known to suffer from several drawbacks.

[0004] For example, it is desirable to form automotive propshafts from increasingly thinner-walled tubing in an effort to reduce the cost and mass of the propshaft. The welding of balance weights to such thin-walled tubing, however, requires more precise control of the welding operation and moreover, may create stress-risers in the tubing.

[0005] Accordingly, there remains a need in the art for an improved rotationally balanced shaft assembly and for an improved method for forming a rotationally balanced shaft assembly.

SUMMARY

[0006] This section provides a general summary of the disclosure, and is not a comprehensive disclosure of its full scope or all of its features.

[0007] In one form, the present teachings provide a method for forming a shaft assembly. The method includes: providing a shaft structure, the shaft structure comprising a shaft and a universal joint member that is coupled to an end of the shaft; inserting a weight member to the shaft structure to form an intermediate assembly, the weight member being formed at least partly from a liquid resin, the intermediate assembly having an initial rotational unbalance; rotating the intermediate assembly about a longitudinal axis of the shaft structure to re-distribute a least a portion of the weight member circumferentially about the shaft structure to at least partly attenuate the initial rotational unbalance; and curing the liquid resin while rotating the intermediate assembly to fix the re-distributed portion of the weight member to the shaft structure to thereby form a balance weight that at least partly attenuates the initial rotational unbalance.

[0008] In another form, the present teachings provide a shaft assembly that includes a shaft structure and a balance weight. The shaft structure has a shaft and a universal joint member coupled to an end of the shaft and defines a hollow interior zone. The balance weight is received in the hollow interior zone and is fixedly coupled to the shaft structure. The balance weight is at least partly formed of a cured resin and is non-uniformly distributed in a circumferential direction about a longitudinal axis of the shaft structure. The balance weight is configured to reduce a rotational unbalance of the shaft structure about a longitudinal axis of the shaft structure.

[0009] Further areas of applicability will become apparent from the description provided herein. The description and specific examples in this summary are intended for purposes of illustration only and are not intended to limit the scope of the present disclosure.

DRAWINGS

[0010] The drawings described herein are for illustrative purposes only of selected embodiments and not all possible implementations, and are not intended to limit the scope of the present disclosure.

[0011] FIG. **1** is a side elevation view in partial section of an exemplary shaft assembly constructed in accordance with the teachings of the present disclosure;

[0012] FIG. **2** is perspective view of a portion of the shaft assembly of FIG. **1** illustrating a balance weight mounted in a universal joint member;

[0013] FIG. **3** is a longitudinal section view of a portion of a shaft assembly depicting a nozzle for injecting a liquid resin material into a shaft structure;

[0014] FIG. **4** is a view similar to that of FIG. **3** but depicting a light source received into the shaft structure to cure the liquid resin material;

[0015] FIG. **5** is a view similar to that of FIG. **3** but depicting an alternate embodiment in which a cartridge is assembled to the shaft structure, the cartridge including a housing that holds a liquid resin; and

[0016] FIG. **6** is a perspective view of a portion of the alternate embodiment of FIG. **5** illustrating a balance weight mounted in a universal joint member.

[0017] Corresponding reference numerals indicate corresponding parts throughout the several views of the drawings.

DETAILED DESCRIPTION

[0018] With reference to FIG. **1** of the drawings, an exemplary shaft assembly constructed in accordance with the teachings of the present disclosure is generally indicated by reference numeral **10**. The shaft assembly **10** can be any type of shaft assembly that is configured to transmit rotary power, but in the particular example provided, the shaft assembly **10** is a propshaft that is employed in a vehicle driveline to transmit propulsive rotary power.

[0019] The shaft assembly **10** can include a shaft member **12**, first and second universal joints **14** and **16**, respectively, and one or more balance weights **18**. Only one balance weight **18** is shown in the example provided, but it will be appreciated that one or more of the balance weights **18** can be employed where unbalance correction is desired, such as at the opposite ends of the shaft assembly **10**. Except as noted herein, the shaft member **12** and the first and second universal joints **14** and **16** can be constructed in a conventional manner and as such, a detailed discussion of these components is not needed herein. Briefly, the shaft member **12** can be a tubular structure that can be formed of an appropriate material, such as steel, aluminum, carbon fiber, etc. The first and second universal joints **14** and **16** can be configured to permit relative movement between the driveline components while transmitting rotary power. For example, the first and second universal joints **14** and **16** can be Cardan joints, or can be a type of constant velocity joint.

Each of the first and second universal joints **14** and **16** can include a universal joint member **20** that can be fixedly coupled to the shaft member **12** to form a shaft structure **24**.

[0020] In the particular example provided, each of the first and second universal joints **14** and **16** is a Cardan joint, and the universal joint members **20** are yokes that are fixedly coupled (e.g., via welding) to the shaft member **12** to form the shaft structure **24**. Each of the yokes can comprise a pair of arms **30** having a hole **32** formed there through. The holes **32** in the arms **30** are conventionally configured to receive bearing assemblies **36** therein that support the trunnions **38** of a cross-shaft **40**.

[0021] With reference to FIGS. **1** and **2**, the balance weight **18** can be received into a hollow interior zone **42** in the assembly **10** and can be fixedly coupled to the shaft structure **24** for rotation therewith. The hollow interior zone **42** could be disposed entirely within the hollow interior of the shaft member **12**, could be disposed entirely within an associated one of the universal joint members **20**, or could be disposed within both the shaft member **12** and one or both of the universal joint members **20**.

[0022] The balance weight **18** can be at least partially formed of a cured resin **44** and can optionally comprise particles **46** that are formed of a material having a density that is greater than a density of the cured resin **44**. In the example provided, the balance weight **18** includes steel particles **46** that are spherically shaped and have a density that is approximately 6 to 8 times that of the cured resin **44**. It will be appreciated, however, that the particles **46** could be formed of one or more different materials, and/or could be formed of two or more sizes, and/or could be formed of one or more shapes, and/or that one or more of the shape could be a non-spherical shape. The balance weight **18** can be non-uniformly distributed in a circumferential direction about a longitudinal axis **50** of the shaft structure **24** so as to reduce a rotational unbalance of the shaft structure **24** about its longitudinal axis **50**.

[0023] The material that forms the balance weight **18** can be installed to the hollow interior zone **42** prior to or after one or both of the universal joint members **20** have been fixedly coupled to the shaft member **12**. For example, material (i.e., a liquid comprising an uncured resin **44** with the optional higher-density particles **46** mixed therein) can be injected into the hollow interior zone **42**. The shaft structure **24**, with or without the entirety of the first universal joint **14** (FIG. **1**) and/or the second universal joint **16** (FIG. **1**), can be rotated about its longitudinal axis **50** at a speed that is within a predetermined rotational speed range to re-distribute the material, and the re-distributed material can be cured while the shaft structure **24** is being rotated to thereby form the balance weight **18**. It will be appreciated that rotation of the shaft structure **24** while the uncured resin is in a liquid state will permit portions of the material, including the higher density particles **46** if employed, to re-distribute in a circumferential direction in a manner that reduces the rotational unbalance of the shaft structure **24** about its longitudinal axis **50**. Accordingly, curing the liquid resin **44** after re-distribution of the material in the circumferential direction locks the material (i.e., the resin and if included, the higher density particles **46**) into an orientation relative to the shaft structure **24** that maintains the reduced rotational unbalance that was obtained prior to the curing of the liquid resin **44**.

[0024] To expedite curing of the liquid resin **44**, ultraviolet (UV) light may be employed. UV light could be introduced to the hollow interior zone through any convenient means, such as through a hole **60** formed through a universal joint member **20** that is disposed along the longitudinal axis **50** of the shaft structure **24**. The hole **60** could also be employed to introduce the material to the hollow interior zone **42**. With reference to FIG. **3**, a nozzle **70** can be inserted through the hole **60** and the material can be pumped through the nozzle **70** to introduce the material to the hollow interior zone **42**. Thereafter, and once the material has been re-distributed, a UV light source **72** (FIG. **4**) can be translated through the hole **60** into the hollow interior zone **42** so that UV light from the UV light source **72** (FIG. **4**) can expedite the curing of the liquid resin **44** in the material.

[0025] With reference to FIGS. **5** and **6**, a filament **80** that is formed of a material that is capable of transmitting UV light there through, such as a fiber-optic material, can be employed to facilitate the transmission of UV light into the hollow interior zone **42**. The filament **80** can have a relatively small diameter, thread-like structure that can receive UV light from a UV light source **84** that is located outside the shaft structure **24** and transmit the UV light to the liquid resin **44** in the hollow interior zone **42** to facilitate expedited curing of the liquid resin **44**. Optionally, a lens **90** can be coupled to the universal joint member **20** and can collect the UV light and transmit the UV light to the filament **80**. In the example provided, the lens **90** is received in the hole **60** and is fixedly coupled to both the universal joint member **20** and the filament **80**.

[0026] If desired, the material M (i.e., the liquid resin **44** and the higher density particles **46**, if any) can be disposed in a cartridge C that can be assembled to the universal joint member **20** or the shaft member **12** (FIG. **1**) prior to the coupling of the universal joint member **20** to the shaft member **12** (FIG. **1**). For example, the cartridge C can include a housing H, which can be shaped as a hollow ring torus or an annular or cylindrical plinth, and the material M (i.e., the liquid resin **44** with the heavier density particles **46** if included), can be received into the housing H. The housing H can be formed of a material that permits UV light to be transmitted there through, such as a transparent plastic material, and can be secured to the shaft member **12** and/or the universal joint member **20** in any desired manner, such as via a press-fitting and/or adhesive bonding. If a filament **80** is to be employed, the filament **80** could be optionally fixedly coupled to the housing H.

[0027] The above method and balance weight permit the shaft assembly **10** to be rotationally balanced without affecting the exterior surface of the shaft assembly **10**. Accordingly, it would be possible to rotationally balance the shaft assembly **10** after the shaft assembly **10** has been coated with a substance, such as paint, that would otherwise interfere with the welding of a balance weight to an exterior surface of the shaft assembly **10**. Moreover, in the event that the above method is not successful in entirely reducing the rotational unbalance of the shaft structure within predetermined limits, another rotational balancing method, such as the welding of balance weights to an exterior surface of the shaft structure **24**, could be employed.

[0028] While the method for forming the shaft assembly **10** has been described as employing physical forces attendant to the rotation of the shaft structure **24** about its longitudinal axis **50**, it will be appreciated that a magnetic field or other means could be employed to move the higher density particles about the circumference of the shaft structure **24** to attenuate the initial rotational unbalance of the shaft structure **24**. If a magnetic field is employed in addition to the physical forces attendant to the rotation of the shaft structure **24**, the magnetic field would need to be tailored to the unbalance in its shape, magnitude and orientation relative to the shaft structure **24**.

[0029] Moreover, while the above method and balance weight **18** have been described as being received into a hollow interior zone of the shaft assembly **10**, it will be appreciated that the balance weight **18** (and more particularly the embodiment of the balance weight **18** that includes the housing—) can be fixedly mounted to an exterior surface of the shaft structure **24** so that it is not necessary to transmit UV light into the interior of the shaft structure **24**.

[0030] The foregoing description of the embodiments has been provided for purposes of illustration and description. It is not intended to be exhaustive or to limit the disclosure. Individual elements or features of a particular embodiment are generally not limited to that particular embodiment, but, where applicable, are interchangeable and can be used in a selected embodiment, even if not specifically shown or described. The same may also be varied in many ways. Such variations are not to be regarded as a departure from the disclosure, and all such modifications are intended to be included within the scope of the disclosure.

What is claimed is:

1. A shaft assembly having a hollow interior zone, the shaft assembly comprising:

a shaft structure having a shaft and a universal joint member coupled to an end of the shaft; and

a balance weight received in the hollow interior zone and fixedly coupled to the shaft structure, the balance weight being at least partly formed of a cured resin, the balance weight being non-uniformly distributed in a circumferential direction about a longitudinal axis of the shaft structure, the balance weight being configured to reduce a rotational unbalance of the shaft structure about a longitudinal axis of the shaft structure.

2. The shaft assembly of claim **1**, wherein the balance weight comprises particles formed of a material having a density that is greater than a density of the cured resin.

3. The shaft assembly of claim **2**, wherein the particles are formed of steel.

4. The shaft assembly of claim **1**, wherein the balance weight comprises a filament that is received in the hollow interior zone in the shaft assembly, the filament being formed of a material that is configured to transmit UV light there through.

5. The shaft assembly of claim **4**, wherein the filament extends into a hole that is formed through the universal joint member.

6. The shaft assembly of claim **5**, wherein the hole is formed along the longitudinal axis.

7. The shaft assembly of claim **1**, wherein the universal joint member comprises a pair of arms, each of the arms having a hole formed there through.

8. A method for forming a shaft assembly, the method comprising:

providing a shaft structure, the shaft structure comprising a shaft and a universal joint member that is coupled to an end of the shaft;

inserting a weight member to the shaft structure to form an intermediate assembly, the weight member being formed at least partly from a liquid resin, the intermediate assembly having an initial rotational unbalance;

rotating the intermediate assembly about a longitudinal axis of the shaft structure to re-distribute a least a portion of the weight member circumferentially about the shaft structure to at least partly attenuate the initial rotational unbalance; and

curing the liquid resin while rotating the intermediate assembly to fix the re-distributed portion of the weight member to the shaft structure to thereby form a balance weight that at least partly attenuates the initial rotational unbalance.

9. The method of claim **8**, wherein curing the re-distributed portion of the weight member comprises transmitting ultra-violet light into the shaft structure.

10. The method of claim **9**, wherein a filament is received through the shaft structure and wherein the ultra-violet light is transmitted into the shaft structure through the filament.

11. The method of claim **10**, wherein the filament is disposed axially along the longitudinal axis of the shaft structure and through the universal joint member.

12. The method of claim **8**, wherein the weight member comprises particles formed of a material having a density that is greater than a density of the liquid resin.

13. The method of claim **12**, wherein the particles are formed of steel.

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