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SEARCHLIGHT SYSTEM FOR VEHICLE POST

Abstract

A searchlight system for mounting to a vehicle, for example on the A-pillar, without requiring modification to structural frame components. The system comprises a mounting assembly which is installed on the vehicle and a searchlight assembly which is mounted to the mounting assembly. Searchlight assemblies with different optical devices can be modularly exchanged with respect to the same mounting assembly installed on the vehicle. Also disclosed is a method for installing such systems. Other aspects are directed to heat dissipation and ingress protection for the searchlight assembly, as well as a pan-tilt mechanism with symmetrical drivetrains.

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Background/Summary

RELATED APPLICATIONS [0001] This application claims the benefit of application Ser. No. 17/099,147 filed Nov. 16, 2020 and application No. 62/935,734 filed Nov. 15, 2019, which are incorporated-by-reference herein.

BACKGROUND
[0002] It can be desirable to mount a spotlight or searchlight to the post or pillar of a vehicle frame. For example, searchlights mounted to the A-pillar of an automobile are commonly used in law enforcement. However, many pillar-mounted searchlight systems are invasive, with installation requiring holes be drilled into and through the pillar of the vehicle body. For example, steering rods of handle-operated spotlights may extend from the interior passenger cabin through the vehicle frame post to the exteriorly-mounted spotlight. Such invasive configurations can potentially weaken the structural integrity of the pillar, which may negatively affect the pillar's crush performance in an impact event such as a rollover and thus present a safety risk. Such structural pillar modifications will also remain in the event that the searchlight system is to be uninstalled and no longer desired, thereby requiring repair in order to restore its pre-modification condition. Additionally, some searchlight mounting systems can involve a tedious process for dismounting and remounting the searchlight, for example during repair or replacement, and may not be readily compatible for use with other types of optical or sensor devices which can be advantageous depending on the user's circumstances.
[0003] The foregoing examples of the related art and limitations therewith are intended to be illustrative and not exclusive. Other limitations of the related art will become apparent to those of skill in the art upon a reading of the specification and a study of the drawings.
SUMMARY
[0004] The following embodiments and aspects thereof are described and illustrated in conjunction with systems, tools and methods which are meant to be exemplary and illustrative, not limiting in scope. In various embodiments, one or more of the above described problems have been reduced or eliminated, while other embodiments are directed to other improvements.
[0005] The present disclosure relates to a searchlight mounting system, including a mounting assembly and a searchlight assembly, and various aspects thereof, including a method for installing such a system to a vehicle. One aspect provides for the modular exchange of searchlights with respect to a mounting assembly installed on a vehicle. Another aspect provides for a mounting assembly to mount a searchlight to a vehicle with minimal or no structural modification to the A-pillar. Another aspect provides for a searchlight assembly with improved heat dissipation functionality. Another aspect is directed to ingress protection for a searchlight assembly having a head that is mounted to and rotatable relative to a pivot post. Another aspect relates to the design of the pan-tilt mechanism of the searchlight assembly.
[0006] In one embodiment for the modular exchange of searchlights, a searchlight mounting system comprises a mounting assembly and a searchlight assembly. The mounting assembly includes at least one bracket and an adapter, with the at least one bracket having an interior surface and an exterior surface opposite the interior surface, and the adapter projecting out from the exterior surface of the at least one bracket. The searchlight assembly includes a support arm/base

portion and a head portion rotatably mounted with respect to the support arm, with the head carrying an optical or sensor device, and the support arm configured to attach to the adapter. The adapter comprises a first projection and a second projection which are arranged opposite the exterior surface, with a cross-sectional geometry of the first projection becoming wider as the first projection extends away from the adapter. The support arm comprises two corresponding projections at one end. The two projections of the support arm are spaced apart from each other to form a channel therebetween which is shaped to receive the first projection of the adapter. A cross-sectional geometry of this channel becomes narrower as the two projections extend away from the support arm. For example, the cross-sectional geometry of the first projection of the adapter may be trapezoidal in shape, with facing walls of the two projections of the support arm angled inward toward each other in extending away from the support arm to correspond to the trapezoidal shape of the first projection of the adapter. In this way, the first projection of the adapter and the two projections of the support arm may interface to form a dovetail joint. The second projection of the adapter may further comprise two bores configured to receive fasteners, with each bore of the second projection configured to align with a respective fastener mating bore formed in each of the two projections of the support arm. For wired embodiments, the support arm may comprise an internal conduit which aligns with an internal conduit of the adapter, when the support arm is mounted on the adapter, for running wiring from the searchlight assembly through the adapter. The first projection of the adapter may be positioned vertically higher than the second projection of the adapter when the mounting assembly is mounted to a vehicle, such that the searchlight assembly is downwardly slidable onto adapter of the mounting assembly.

[0007] In one embodiment for mounting a searchlight to a vehicle with minimal or no structural modification to the A-pillar, a mounting assembly comprises at least one bracket and an adapter. The bracket has an interior surface opposite an exterior surface, with the interior surface configured to face toward the vehicle when installed. The adapter projects out from the exterior surface of the bracket and is configured to attach to the searchlight. The bracket comprises fastener openings that extend between the exterior surface and the interior surface. Preferably, the fastener openings are counterbores or countersinks, with a first bore on the exterior surface side being larger in diameter than a second bore on the interior surface side. According to some embodiments, the bracket comprises projections which extend out from the interior surface, with the first bore formed into each projection from the exterior surface. Each projection has an end wall opposite the interior surface with the second bore formed through the end wall. Fasteners having a head and a shank insert into the fastener openings. The head is larger in diameter than the second bore, while the shank is smaller in diameter than the second bore. Openings are formed in a trim cover, or vehicle surface of the outermost component of the A-pillar structure, of the vehicle. Otherwise, no structural modification of the strong underlying A-pillar frame of the vehicle is necessary such that crash performance requirements are not compromised. The bracket projections may or may not extend through the openings formed in the vehicle surface depending on the embodiment. During installation of the mounting assembly onto the A-pillar, fasteners are inserted into the first bore at the exterior surface of the at least one bracket and through the second bore. The fasteners are anchored into either existing fastener mating holes of the A-pillar or into nuts, such as clip nuts or rivet nuts, whereby the fasteners are then tightened to secure the bracket to the vehicle surface. In particular, the fastener head is tightened against a contact surface which faces away from the vehicle surface and surrounds the second bore, such as the contact surface provided by the end walls of the projections for example. The clip nuts, as part of the mounting assembly, are positioned underneath the vehicle surface and receive the shanks of the fasteners. For example, the clips nuts may be mounted onto a metal base piece of the vehicle between the pillar and trim piece, such as in vehicles having such a base piece welded onto the A-pillar for attachment of the trim piece thereon. The rivet nuts, as part of the mounting assembly, are placed in the openings formed in the vehicle surface and fixed thereon using an installation tool. For example, the installation tool

may collapse the threaded nut body against the blind side of the vehicle surface to create a material bulge securing the rivet nut to the vehicle surface. The at least one bracket may comprise a shell construction with the interior surface defining a cavity for running wiring from the searchlight to the vehicle. For example, the adapter may have an internal conduit for running wiring from the searchlight to the cavity defined by the interior surface of the at least one bracket. The at least one bracket may extend along the A-pillar down to a windshield cowling area of the vehicle. In some embodiments, the adapter is a separate component secured to the bracket. For example, the interior surface of the bracket may comprise an interface surface adjacent a bracket opening therethrough, with the adapter having a mounting collar with a wider geometry than the rest of the adapter and bracket opening, such that the adapter extends through the bracket opening in projecting out from the exterior bracket surface, and the mounting collar of the adapter is coupled to the interface bracket surface. In which case, the mounting collar and/or the interface surface may include a collar conduit for running wiring across the mounting collar. In some embodiments, the at least one bracket comprises an upper bracket and a lower bracket, and the adapter projects out from the exterior surface of the upper bracket. In some embodiments, the at least one bracket and the adapter are formed together as a single component. Such a single-piece construction of the bracket and adapter may or may not have a separate lower bracket depending on the embodiment. Preferably, a gasket covers the bracket portions that contact the pillar surface.

[0008] In one embodiment directed to heat exchange, a searchlight assembly comprises a head portion including at least one housing shell, a heat sink, a heat sink ring gasket, and an optical device. The at least one housing shell houses one or more internal components of the head, and the heat sink is coupled to the at least one housing shell. The heat sink comprises a heat sink ring having a first mating surface, a second mating surface opposite the first mating surface, and an exterior surface extending between the two mating surfaces. The heat sink ring gasket is positioned between the first mating surface and the at least one housing shell to provide a water-resistant seal therebetween. An outer surface of the head is formed, at least in part, by the exterior surface of the heat sink ring and the at least one housing shell. The outer surface of the head is exposed to an outside environment, whereby the heat sink ring is in direct thermal communication with the outside environment. It is preferable that the heat sink be made of a material with high thermal conductivity. For example, the heat sink may be made of aluminum. The at least one housing shell may generally be made of a molded material, such as plastic or aluminum. The heat sink may further comprise a plurality of cooling fins facing the internal components of the head within the at least one shell. A bezel may be provided which abuts the second mating surface of the heat sink ring, and configured to outwardly secure an optical device within the head. The heat sink ring may be coupled to the at least one housing shell via fasteners which extend through the heat sink ring and mate into bosses of the at least one housing. In some embodiments, the fasteners couple the bezel to the second mating surface of the heat sink ring as well.

[0009] In another embodiment directed to ingress protection, the searchlight assembly comprises a head portion and a pivot post/yoke portion. The head includes an optical device, at least one housing shell, and at least one internal housing insert. The pivot post at least partially extends into the head. The head is mounted to the pivot post in a vertically pivotable manner whereby a lower edge of the at least one housing shell is spaced apart from the pivot post for clearance space. The at least one housing shell houses one or more internal components of the head. An internal housing surface of the housing shell comprises insert piece fittings which project from the internal housing surface. The insert piece fittings are shaped to receive and retain the internal housing insert. The internal housing insert is positioned within the insert piece fittings and interfaces with the internal housing surface, whereby the at least one internal housing insert completes a physical partition between the pivot post within the head and the one or more internal components of the head. Both the at least one housing shell and the at least one internal housing insert may be made of a molded material, such as plastic or aluminum. In some embodiments, sealant or adhesive is provided along

contact points between the housing shell(s) and the internal housing insert(s). One or more rubber or elastomer seals may also be provided along contact points between the housing shell(s) and the internal housing insert(s). In some embodiments, the head further comprises at least one cradle structure for mounting the one or more internal components of the head, and the at least one internal housing insert interfaces with the at least one cradle structure in completing the physical partition. In which case, sealant or adhesive may be provided along contact points between the cradle structure(s) and the internal housing insert(s) as well. One or more rubber or elastomer seals may also be provided along contact points between the cradle structure(s) and the internal housing insert(s). In some embodiments, the at least one internal housing insert comprises two internal housing inserts, and the two housing inserts interface with each other in completing the physical partition. Again, sealant or adhesive may be provided along contact points between the two housing inserts. Likewise, one or more rubber or elastomer seals may also be provided along contact points between the two housing inserts.

[0010] Accordingly, a method for installing a searchlight system to a vehicle may comprise the steps of: forming openings in an exterior vehicle surface of a pillar of the vehicle; arranging a mounting assembly of the searchlight system on the vehicle surface, the mounting assembly comprising a mounting bracket having fastener openings, preferably counterbores or countersinks, which extend between an exterior surface of the mounting bracket and an interior surface of the mounting bracket, wherein the interior surface faces the vehicle surface when the mounting bracket is arranged thereon; securing the mounting bracket to the vehicle surface by tightening fasteners inserted into the counterbores or countersinks from the exterior surface of the mounting bracket, whereby the fasteners are anchored with respect to the vehicle surface by threaded holes or nuts, such as fastener mating holes of the pillar, clip nuts underneath the vehicle surface, and/or rivet nuts installed in the openings of the vehicle surface; and mounting a searchlight assembly to the mounting bracket, wherein an adapter projects from the exterior surface of the mounting bracket, and the searchlight assembly is configured to removably couple to the adapter. The counterbores or countersinks may be formed through projections which project from the interior surface of the mounting bracket. According to some embodiments, the projections are inserted through the openings of the vehicle surface when the mounting bracket is arranged thereon. In some embodiments, the mounting bracket comprises a shell construction defining a cavity, and after the step of securing the mounting bracket to the vehicle surface, wiring is run from the searchlight assembly through the adapter of the mounting bracket and into the cavity which is formed between the vehicle surface and the interior surface of the mounting bracket. In which case, the wiring may then be run from the cavity between the vehicle surface and mounting bracket to a windshield cowling area of the vehicle and then through into the interior cabin of the vehicle. In some embodiments, the mounting bracket comprises an upper mounting bracket and a lower mounting bracket, with the upper mounting bracket carrying the adapter, and the upper mounting bracket being secured to the vehicle surface before the lower mounting bracket is secured to the vehicle surface. In which case, the lower mounting bracket may be arranged between the upper mounting bracket and the windshield cowling area of the vehicle, and wiring run from the searchlight assembly through the upper bracket and into the interior cabin of the vehicle before the lower mounting bracket is secured to the vehicle surface. In some embodiments, during the step of mounting the searchlight assembly to the mounting bracket, the adapter of the mounting bracket and the searchlight assembly interface to form a dovetail joint. The searchlight assembly may also be slid downward onto the adapter of the mounting bracket. In some embodiments, fasteners used to secure the mounting bracket to the vehicle surface may be the original pillar fasteners that came with the vehicle. Where the fasteners are anchored into clip nuts, the clip nuts may be mounted onto a metal piece of the vehicle between the pillar and trim cover, for example, such as in vehicles having such a base piece welded onto the A-pillar for attachment of the trim cover thereon. Where the fasteners are anchored into rivet nuts, the rivet nuts may be fixed in the openings formed into

the vehicle surface.
[0011] In another embodiment directed to the design of the pan-tilt mechanism, the searchlight assembly comprises a base portion, a post portion rotatably mounted to the base portion, a head portion pivotably mounted to the post portion opposite the base portion, and a pan/tilt mechanism. The post portion has a hollow interior with a transverse conduit extending therethrough. The post portion may have a T shape formed by a neck structure and a body structure. Preferably, the post portion comprises a vertical conduit extending therethrough with the stationary bevel gear also having a vertical conduit extending therethrough for wiring. The pan/tilt mechanism comprises a plurality of components including two reversible motors, two belts, two rotatable lower gears, two rotatable bevel gears, and a stationary bevel gear. The plurality of components form two symmetrical drivetrains of the pan/tilt mechanism. In each drivetrain of the two symmetrical drivetrains, a respective reversible motor is drivingly connected to a respective belt, the belt is drivingly connected to a respective lower gear, the lower gear is drivingly connected to and positionally fixed relative to a respective rotatable bevel gear, and the rotatable bevel gear is drivingly connected to the stationary bevel gear. The respective lower gear and rotatable bevel gear are positionally fixed relative to one another and preferably axially aligned. The reversible motors are fixedly mounted to the head portion. The lower gears, and thus also the rotatable bevel gears, are rotatably mounted relative to the head portion. The stationary bevel gear is located in the hollow interior of the post portion and positionally fixed relative to the base portion. The rotatable bevel gears engage the stationary bevel gear via the transverse conduit of the post portion. For pan motion, the rotatable bevel gears are driven in the same rotational direction around the stationary bevel gear, such that the post portion and head portion rotate relative to the base portion. For tilt motion, the rotatable bevel gears are held motionless on the stationary bevel gear due to counteracting torques applied to the rotatable bevel gears, such that the head portion pivots relative to the post portion and the base portion. According to some embodiments, the pan/tilt mechanism further comprises two intermediary gears, and in each drivetrain of the two symmetrical drivetrains, a respective intermediary gear is drivingly engaged between the belt and the lower gear. For example, the intermediary gears may be double gears which intermesh with the lower gears and with the belts provided as toothed belts. In other embodiments without the intermediary gears, the toothed belts intermesh directly with the lower gears. In either case, the toothed belts may intermesh with drive shaft gears of the reversible motors. Preferably, the rotatable bevel gears are axially aligned with an axis of rotation which is perpendicular to the center axis of the stationary bevel gear. In some embodiments, the head portion contains a motor cradle structure, the reversible motors are fixedly mounted to the motor cradle structure, and the lower gears and the rotatable bevel gears are rotatably mounted relative to the motor cradle structure. Preferably, the motor cradle structure is pivotably mounted to the post portion at either end of the transverse conduit, with the motor cradle structure positioned between the lower gears and the rotatable bevel gears. Of course, head portion's optical device may be an LED lamp, halogen lamp, HID lamp, camera, infrared sensor, or heat sensor, or any other suitable device. The base portion may be a support arm for mounting to a vehicle pillar, or the base portion for a different searchlight assembly application using the pan-tilt mechanism.
[0012] The foregoing embodiments and aspects thereof may be practiced independently or combined with any other embodiments and aspects thereof according to the present disclosure. In addition to the aspects and embodiments described above, further aspects and embodiments will become apparent by reference to the accompanying drawings forming a part of this specification.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] The following description is provided on the basis of example embodiments with reference to the appended figures, wherein:

[0014] FIG. **1**A shows a front perspective view of a vehicle's left A-pillar with trim cover;

[0015] FIG. **1**B shows the vehicle A-pillar of FIG. **1**A without the trim cover, with underlying components in exploded view;

[0016] FIG. **2** shows the trim cover of FIG. **1**A with openings formed therein;

[0017] FIG. **3** shows a front perspective view of a searchlight system mounted on the trim cover of FIG. **2**;

[0018] FIG. **4** shows a left side view of the searchlight system and trim cover of FIG. **3**;

[0019] FIG. **5** shows a right side view of the searchlight system and trim cover of FIG. **4**;

[0020] FIG. **6** shows a front side view of the searchlight system and trim cover of FIG. **3**;

[0021] FIG. **7** shows a back side view of the searchlight system and trim cover of FIG. **6**;

[0022] FIG. **8** shows a front perspective view of the mounting assembly of FIG. **3**;

[0023] FIG. **9** shows the mounting assembly of FIG. **8** without the adapter;

[0024] FIG. **10** shows a bottom perspective view of the mounting assembly of FIG. **8**;

[0025] FIG. **11** shows the mounting assembly of FIG. **10** without the adapter and fasteners;

[0026] FIG. **12** shows a top rear perspective view of the adapter of FIG. **8** without the brackets;

[0027] FIG. **13** shows a bottom front perspective view of the adapter of FIG. **12**;

[0028] FIG. **14** shows a bottom front perspective view of the searchlight assembly of FIG. **3**;

[0029] FIG. **15** shows a detail view of box **15** of FIG. **14**;

[0030] FIG. **16** shows a back side perspective view of the searchlight assembly of FIG. **14**;

[0031] FIG. **17** shows a detail view of box **17** of FIG. **16**;

[0032] FIG. **18** shows a back perspective view of the searchlight assembly of FIG. **14**;

[0033] FIG. **19** shows the searchlight assembly of FIG. **18** connected to the adapter of the mounting assembly;

[0034] FIG. **20**A shows a front perspective view of another vehicle's left A-pillar with trim cover;

[0035] FIG. **20**B shows the vehicle A-pillar of FIG. **20**A without the trim cover;

[0036] FIG. **21** shows the trim cover of FIG. **20**A with openings formed therein;

[0037] FIG. **22** shows a rear view of the trim cover of FIG. **21**;

[0038] FIG. **23** shows a detail view of box **23** of FIG. **22**;

[0039] FIG. **24** shows the trim cover of FIG. **21** with another embodiment of the mounting assembly;

[0040] FIG. **25** shows a front perspective view of the mounting assembly of FIG. **24**;

[0041] FIG. **26** shows a bottom perspective view of the mounting assembly of FIG. **25**;

[0042] FIG. **27** shows the mounting assembly of FIG. **26** with clip nuts;

[0043] FIG. **28** shows the detail view of FIG. **23** with the mounting assembly and clip nuts installed on the trim cover;

[0044] FIG. **29** shows a side view of a fastener and clip nut of the mounting assembly;

[0045] FIG. **30** shows a left side perspective view of the searchlight assembly of FIG. **3** with the left housing shell omitted;

[0046] FIG. **31** shows a right side perspective view of the searchlight assembly of FIG. **3** with the right housing shell omitted;

[0047] FIG. **32** shows a front perspective view of the pan/tilt drive mechanism components of the searchlight assembly of FIGS. **31**-**32** with the pivot post component moved to the right;

[0048] FIG. **33** shows a side perspective view of the support arm of the searchlight assembly of FIGS. **31**-**32**;

[0049] FIG. **34** shows a bottom perspective view of the pivot post component of FIG. **32**;

[0050] FIG. **35** shows a left side perspective view of the head of the searchlight assembly of FIG.

30 with the left housing shell and pan/tilt drive mechanism components omitted;
[0051] FIG. **36** shows a left side view of the head of FIG. **35**;
[0052] FIG. **37** shows an exploded view of the head of FIG. **36**;
[0053] FIG. **38** shows a front side view of the searchlight assembly of FIG. **3**;
[0054] FIG. **39** shows the searchlight assembly of FIG. **38** with the outer lens cover omitted;
[0055] FIG. **40** shows the searchlight assembly of FIG. **39** with the reflector omitted;
[0056] FIG. **41** shows the searchlight assembly of FIG. **40** with the LEDs and LED mounting bracket omitted;
[0057] FIG. **42** shows a front perspective view of the reflector of FIG. **39** and LED mounting bracket of FIG. **40**;
[0058] FIG. **43** shows a rear perspective view of the reflector and LED mounting bracket of FIG. **42** with LED circuit board and LEDs mounted to the mounting bracket;
[0059] FIG. **44** shows a bottom front perspective view of the reflector and LED mounting bracket of FIG. **43**;
[0060] FIG. **45** shows a left side perspective view of a right housing shell with insert piece installed;
[0061] FIG. **46** shows the right housing shell and insert piece of FIG. **45** with the insert piece moved off to the left;
[0062] FIG. **47** shows a front perspective view of another searchlight system;
[0063] FIG. **48** shows a front perspective view of an area of a vehicle pillar for mounting the searchlight system of FIG. **47**;
[0064] FIG. **49** shows a bottom perspective view of the mounting assembly of the searchlight system of FIG. **47**;
[0065] FIG. **50** shows a sectional view through a portion of the mounting assembly with a rivet nut fastened to the vehicle surface;
[0066] FIG. **51** shows a side rear view of another pan/tilt drive mechanism for the searchlight assembly;
[0067] FIG. **52**A shows the searchlight assembly of FIG. **51** with the pivot post omitted;
[0068] FIG. **52**B shows a top perspective view of the pivot post of FIG. **51**;
[0069] FIG. **52**C shows a top perspective view of one side of a motor cradle structure rotatably mounted on a support plate structure with interposed bearings;
[0070] FIG. **53** shows a side view of the searchlight assembly of FIG. **52**A;
[0071] FIGS. **54**A-**54**D show front perspective views of the searchlight assembly of FIG. **52**A, with righthand rule arrows indicating torque direction of the components of the gear train transmission for a pan left motion (FIG. **54**A), a pan right motion (FIG. **54**B), a tilt down motion (FIG. **54**C), and a tilt up motion (FIG. **54**D);
[0072] FIGS. **55**A-**55**D show top views of the miter gears of FIG. **52**A with directional arrows for the pan left motion (FIG. **55**A), the pan right motion (FIG. **55**B), the tilt down motion (FIG. **55**C), and the tilt up motion (FIG. **55**D);
[0073] FIG. **56** shows a front side perspective view of another searchlight assembly heatsink;
[0074] FIG. **57** shows a rear side perspective view of the heatsink of FIG. **56**;
[0075] FIG. **58** shows a top rear perspective view of the motor cradle structures and insert piece structures with seals;
[0076] FIG. **59** shows the view of FIG. **58** with the motor cradle structures omitted;
[0077] FIG. **60** shows the view of FIG. **59** with the insert piece structures omitted.
[0078] Before explaining the selected embodiments, it is to be understood that the present disclosure is not limited in application to the details of the particular arrangements shown and is capable of other embodiments. While certain embodiments are illustrated in reference to the figures, it is intended that the embodiments and figures disclosed herein are to be considered illustrative rather than limiting. Also, the terminology used herein is for the purpose of description

and not of limitation.

DETAILED DESCRIPTION

[0079] As used herein, the terms “front”, “forward” and the like refer generally to the normal direction of travel of an automobile having a searchlight system according to the present disclosure, while the terms “rear”, “back” and the like refer generally to the opposite or reverse direction.

[0080] FIG. **1**A shows the left A-pillar of an automobile with a trim cover **10**. These types of covers are also generally referred to as windshield, pillar or side trim pieces or moldings. The automobile in the depicted embodiment is a 2012-2019 Ford Explorer. The cover **10** snaps onto and covers a base trim piece **15** which is secured via fasteners **25** (e.g. bolts) to the A-pillar of the automobile frame (see FIG. **1**B). The A-pillar **5** in this type of construction includes threaded mating holes **30** for receiving the fasteners **25** which secure the base piece **15** thereto. When these components are assembled, the cover **10** gives a finished aesthetic appearance to the automobile exterior.

[0081] FIG. **2** shows the trim cover **10** of FIG. **1**A with openings **20** introduced for installing a searchlight system according to the present disclosure. As discussed in more detail below, the openings **20** in the cover **10** are aligned with the fastener holes **30** in the A-pillar **5**. It should be appreciated that the specific location and arrangement of the openings **20** may be different depending on the automobile model.

[0082] FIGS. **3-7** show a searchlight system **100** mounted on the trim cover **10**. The system **100** comprises a mounting assembly **200** and a searchlight assembly **300**. As discussed in more detail below, the searchlight assembly **300** comprises a support arm or base portion **310**, a pivot post or yoke portion **320**, and a head portion **330**.

[0083] Referring also now to FIGS. **8-13**, the mounting assembly **200** comprises one or more brackets **210**, **212** and an adapter **230**. Each bracket **210**, **212** has an interior surface **214**, which faces in the direction of the automobile frame when installed, and an exterior surface **216**, which faces away from the automobile when installed. Each bracket **210**, **212** has a shell construction which forms a cavity bounded by the interior surface **214**. This cavity provides clearance space between the brackets **210**, **212** and the cover **10** for running wiring (not shown).

[0084] The brackets **210**, **212** have projections **218** extending out from the interior surface **214**. The projections **218** are inserted into the openings **20** of the cover **10** during installation. A bore **220** is formed into each projection **218** from the exterior surface **216** of the brackets **210**, **212**. The diameter of the bore **220** is sized to allow passage of the head of the fastener **226**. Each projection **218** has an end wall **222** on its side opposite the interior surface **214**. The end wall **222** has a bore **224** sized to allow passage of the shank of the fastener **226**, but not the head of the faster **226**, and therefore provides a contact surface for tightening the fastener **226**. Therefore, bore **224** is smaller in diameter than bore **220** and together they form a counterbore (or countersink) within the projection **218**. In this way, the fastener **226** may be inserted into the bore **220** at the exterior surface **216**, then through the bore **224** of the end wall **222** of each projection **218**—which extend through the openings **20** of the trim piece **10**—into the fastener receiving hole **30** of the A-pillar **5**, and then tightened against the contact surface provided by the end wall **222** to securely couple the brackets **210**, **212** to the A-pillar **5** and trim pieces **10**, **15**.

[0085] It should be appreciated that the length of the projection **218** from the interior surface **214** (in conjunction with the depth of the cavity formed by the shell construction of the brackets **210**, **212**) determines how close the fastener contact surface of the end wall **222** is positioned relative to the fastener receiving hole **30** of the A-pillar **5**. In embodiments where the original A-pillar fasteners are to be reused in installing the mounting assembly **200** (i.e. fasteners **25** are fasteners **226**), the length of each projection **218** should permit a secure connection whereby the fastener **226** sufficiently extends into the fastener receiving hole of the A-pillar. In other embodiments, for example if longer replacement fasteners are to be used as fasteners **226** in installing the mounting assembly **200**, the length of the projections **218** may be reduced or the projections **218** omitted altogether (in which case the exterior surfaces **216** of the brackets may provide the fastener contact

surface and the size of the openings **220** reduced to allow passage of the fastener shank, but not the fastener head).

[0086] The depicted embodiment includes separate upper and lower brackets **210**, **212**. With this configuration, the upper bracket **210** may be mounted first, and any wiring of the searchlight assembly **300** may then be run before the lower bracket **212** is installed. The wiring can be run down into the windshield cowling area and through the firewall (which typically has apertures) separating the engine compartment from the passenger compartment. In this way, the searchlight assembly **300** may be controlled by a user within the passenger cabin. The lower bracket **212** largely serves a cosmetic/protective function in covering the wiring, rather than a structural function in supporting the searchlight assembly **300**. It should be appreciated that other embodiments may instead include only one bracket or more than two brackets, which additionally may differ in extent along the A-pillar.

[0087] In the depicted embodiment, the adapter **230** is provided as a separate component from the brackets **210**, **212**. The adapter **230** comprises a mounting collar **232** which has a wider geometry than the remainder of the adapter **230**. In this way the adapter **230** may be inserted through an opening **234** of the bracket **210**, whereby the mounting collar **232** contacts a corresponding interface surface **236** provided on the interior surface **214** of the bracket **210** and is coupled to the bracket **210** via fasteners **238**. This approach may be advantageous for fabrication purposes given the relatively complicated structure of the adapter **230** in the depicted embodiment. However, it should be appreciated that the adapter **230** and the bracket **210**, or brackets **210**, **212**, may instead be produced as a single-piece in other embodiments. Further, the specific design of the mounting collar **232** and interface surface **236**, including the number and position of fasteners **238**, may be modified and therefore different from the depicted configuration in other embodiments.

[0088] When coupled to bracket **210**, the adapter **230** projects outward from the exterior surface **216** of the bracket **210** and provides a structure for connecting the searchlight assembly **300** to the mounting assembly **200**. On its free side opposite the bracket **210**, the adapter **230** comprises a first projection **240** and a second projection **242**. In the depicted embodiment, the projection **240** has a trapezoidal shaped cross section, wherein the base of the projection **240** becomes wider as the projection **240** extends away from adapter **230**, although other geometries may also be used (e.g. a bulb shaped cross section). The second projection **242** includes two bores configured to receive fasteners **244** in the direction of the first projection **240**. The fasteners **244** are arranged on each side of an internal conduit **246** of the adapter **230**. The internal conduit **246** provides a passage for running wiring from the interior of the searchlight assembly **300** through to the internal-facing side of the mounting assembly **200**. The adapter mounting collar **232** and/or interface surface **236** may also include a conduit **248** for this purpose.

[0089] As seen in FIGS. **14-19**, the side of the support arm **310** of the searchlight assembly **300** which interfaces with the adapter **230** of the mounting assembly **200** comprises projections **312**. The projections **312** are spaced apart from one another. The space between the projections **312** is configured to receive the projection **240**. Thus, the space between the projections **312** forms a channel having a cross section corresponding to the shape of the adapter projection **240**, wherein the width of this channel becomes narrower as the projections **312** extend away from the support arm **310**. In the depicted embodiment, the facing walls of the projections **312** are angled inward to match the trapezoidal shape of the first adapter projection **240**. Each of the support arm projections **312** may further comprise a threaded fastener mating bore **314**. As seen here, the support arm **310** also has an internal conduit **316** which provides a passage for running wiring. When the searchlight assembly **300** is installed on the mounting assembly **200** (described below), the conduits **246**, **316** are aligned to form a single passage therebetween enclosed by the adapter/support arm projections **240**, **242**, **312**. In other embodiments, wiring from the searchlight assembly **300** may be run directly outside, such as through aperture **317** formed on the bottom side of the support arm **310** (see FIG. **14**), rather than internally through the mounting assembly **200**, preferably with a

protective covering to prevent damage to such exterior wiring extending between the searchlight assembly **300** and the vehicle ingress point.

[0090] In attaching the searchlight assembly **300** to the mounting assembly **200**, the searchlight assembly **300** is slid onto to the mounting assembly **200**, whereby the first projection **240** of the adapter **230** is moved into the space between the projections **312** of the support arm **310** until the second projection **242** of the adapter **230** abuts the projections **312**. In this way, a dovetail joint is formed between the adapter projection **240** and arm projections **312**. It is preferable if the first adapter projection **240** is arranged above the second adapter projection **242** when the mounting assembly **200** is installed on an automobile. In this case, the searchlight assembly **300** is slid downward onto the adapter **230** until the arm projections **312** are supported against gravity by the second adapter projection **242**, which provides a strong attachment in combination with the dovetail mating between the first adapter projection **240** and arm projections **312**. Once the supporting arm **310** is positioned on the adapter **230**, the fasteners **244** may be inserted through the second adapter projection **242** into the threaded fastener mating bores **314** of the arm projections **312**, and then tightened against the contact surface provided by the second adapter projection **242** to further secure the attachment between the searchlight assembly **300** and the mounting assembly **200**. Wiring for the searchlight assembly **300** may be run through the mounting assembly **200** before mounting, and pulled taut as the support arm **310** is slid onto the adapter **230** to avoid wire damage during installation.

[0091] With this attachment, the searchlight assembly **300** may be readily exchanged with respect to the mounting assembly **200** in a modular manner. For example, it may be desirable to uninstall a particular searchlight assembly for repair or to replace it with another searchlight assembly fitted with a different type of optical or sensor system (e.g. light emitting diodes (LEDs), halogen lamps, high-intensity discharge (HID) lamps, cameras, infrared devices, heat sensitive devices, etc.). The mounting assembly **200** can remain installed on the automobile, ready for use with any searchlight assembly **300** configured to mate with the adapter **230**. Therefore, such a modular system **100** may realize substantial benefits in terms searchlight interchangeability and installation time/effort.

[0092] FIGS. **20**A-**20**B show another arrangement of the left A-pillar of a vehicle. The vehicle here is a 2020 Ford Explorer. Here, the A-pillar **5** does not comprise mating holes **30**. Rather, the base piece **15** is a metal piece welded onto the A-pillar **5**. The base piece **15** has openings **35** for attachment of the trim piece **10**. The trim cover **10** with the openings **20** introduced for installing a searchlight system according to the present disclosure is shown in FIG. **21**. As seen in FIGS. **22** and **23**, the rear side of the trim cover **10** has fittings **40** for snap fasteners (not shown) which couple into the openings **35** of the base piece **15**. FIGS. **24**-**26** show another embodiment of a mounting assembly **200** according to the present disclosure for this A-pillar arrangement. The above descriptions regarding the previous embodiment, including the attachment of the mounting assembly **200** and the searchlight assembly **300**, apply here unless otherwise specified and are therefore not repeated. This mounting assembly **200** has a one-piece construction, with the bracket **210** and the adapter **230** produced as a single component. In addition to not having a separate bracket piece **212**, this mounting assembly **200** also illustrates another possible arrangement of the bracket **210** with adapter **230** with respect to size, extension and positioning. Referring now to FIGS. **27**-**29**, the mounting assembly **200** further comprises clip nuts **250**. The clip nuts **250** couple to the fasteners **226**. The clip nuts **250** provide the mating or anchoring structure for the fasteners **226**, as the pillar **5** does not have the holes **30** to receive the fasteners **226**. The clip nuts **250** are provided adjacent the fittings **40** of the trim cover **10**. As best seen in FIG. **29**, the clip nuts **250** have a bracket or clip integral with the nut head. The clip nuts **250** are mounted in the openings **35** of the base piece **15**, with the bracket of the clip nut **250** holding the metal sheet material of the base piece **15**. In this way, the clip nuts **250** can be used to secure the mounting assembly **200** with respect to the vehicle pieces **10**, **15** and therefore with respect to the pillar **5**. The head and shank of the fastener **226** as well as the inclusion of a washer thereon, which is common with these types of

fastener arrangements, are also clearly visible in FIG. **29**. Of course, clip nuts **250** may be also used in other embodiments of the mounting assembly **200**, for example those with the bracket **210** and adapter **230** provided as separate components and/or including multiple brackets **210**, **212**, as in the previous example of FIGS. **8-13**, depending on the pillar mounting configuration.

[0093] FIGS. **47-50** show another example searchlight system **100**. In this embodiment, the mounting assembly **200** has a single bracket **210** like in the embodiment of FIGS. **24-26**, and the adapter **230** is provided as a separate piece connected to the bracket **210** like in the embodiment of FIGS. **8-13**. The above descriptions regarding the previous embodiments apply equally here unless otherwise indicated. The bottom edges or sides of the shell-shaped bracket **210** are provided with a gasket **252** for mounting to the vehicle surface **10** under tension. The gasket **252** may form a waterproof seal between the vehicle surface **10** and the bracket **210**. The gasket **252** may also prevent the mating surfaces from damaging one another under tension. As seen in FIG. **48**, openings **20** are formed in the vehicle surface **10** of the outermost component of the A-pillar structure. In this embodiment, rivet nuts **254** are installed into the openings **20**. The rivet nuts **254** provide the threaded anchors for the fasteners **226** to secure the mounting assembly **200** to the vehicle surface **10**. The view of FIG. **49** is provided for illustrative purposes, since in practice, the rivet nuts **254** would be installed in the openings **20** formed in the vehicle surface **10** and therefore the bottom of the mounting assembly **200** would be blocked by the vehicle surface in the view of FIG. **49**. FIG. **50** shows an installed rivet nut **254** fixed on the vehicle surface **10**, with the mounting assembly **200** mounted to the vehicle surface **10**. The body **256** of the rivet nut **254** has been collapsed to form a material bulge **258** on the blind side of the vehicle surface **10** using an installation tool. The rivet nut **254** is therefore securely clamped on either side of the vehicle surface **10** with its material bulge **258** and the top flange **260** of the rivet nut **256**. The non-collapsed portion of the tubular body **256** has threading for mating with the fastener **226**. In this embodiment, the projection **218** does not extend through the opening **20** formed in the vehicle surface **10**. This mounting method is highly adaptable across different vehicle designs. According to this method, the rivet nuts **256** are installed in the vehicle surface openings **20** after the step of forming the openings **20** and before the step of mounting the bracket **210** with the fasteners **226**.

[0094] FIGS. **30-34**, show an example pan/tilt mechanism of the searchlight assembly **300**. A controller **332** is provided within the searchlight head **330** which controls operation of the electronic components, such as the light source and motors, based on user input (e.g. wired or wireless). The internal components are covered, in part, by at least one housing shell **370**. The embodiment of FIGS. **30-34** comprises left and right housing shells **370**. Of course, other embodiments may have different configurations. For example, the searchlight head **330** shown in FIG. **47** has three housing shells: a bottom right, a bottom left, and a top half shell.

[0095] During horizontal pan movement, the pivot post **320** and the head **330** are both rotated relative to the support arm **310**. For the pan mechanism, a first reversible motor **334** drives belt **336**, which drives timing pulley or sprocket gear **338**. Therefore, in the depicted embodiment, the belt **336** is a toothed, timing, cogged or synchronous belt. Sprocket **338** is a double gear having another gear face which drives vertical gear **340**. Pan gear **340** is in a locked connection with the shaft of bevel or miter gear **342**, such that rotation of vertical gear **340** causes rotation of miter gear **342**. Rotating miter gear **342** acts against fixed bevel or miter gear **344**. Miter gear **344** is positionally fixed on the support arm **310**, thereby causing rotation of the pivot post **320** and head **330** relative to the support arm **310**.

[0096] In the depicted embodiment, the bottom end of miter gear **344** comprises threading which mates with the opposite end of the internal conduit **316** of the support arm **310** when the miter gear **344** is installed on the support arm **310**, although other configurations may also be used. The miter gear **344** has an internal conduit **346** for running wiring through the internal conduit **316** of the support arm **310** up into the pivot post **320**. Bearings **348** are provided between the miter gear **344** and the pivot post **320** for rotating the pivot post **320**, and therefore also the head **330**, relative to

the support arm **310**. The support arm **310** may further comprise a stop **318**, which sits within a stop channel **322** formed on the bottom of the pivot post **320**, to limit the degree of horizontal rotation. In the depicted embodiment, the available pan rotation arc is approximately 270°. The available pan rotation arc is preferably configured to prevent the optical device of the searchlight head **330** from being accidentally pointed into the passenger cabin of the automobile, whereby the approximately 90° arc through which the head **330** is unable to rotate corresponds to the facing direction of the optical device with respect to the passenger cabin area. The length and positional arrangement of the stop channel **322** on the pivot post **320** may be selected for a given application, for example, where the searchlight system **100** is to be mounted to the right A-pillar rather than the left A-pillar of the automobile.

[0097] During vertical tilt movement, the head **330** is rotated relative to both the pivot post **320** and the support arm **310**. For the tilt mechanism, a second reversible motor **350** drives belt **352**, which drives timing pulley or sprocket gear **354**. Therefore, in the depicted embodiment, the belt **336** is a toothed, timing, cogged or synchronous belt. Sprocket **354** is a double gear having another gear face which acts against fixed gear **356**. Gear **356** is fixed with respect to one of the support plates **358**. The support plates **358** are fixed with respect to the pivot post **320** via fasteners **360** in the depicted embodiment. The tilt mechanism may also include a torsion spring **362**, which is biased to assist in tilting the head **330** upwards against gravity. A tilt stop **368** is built into one or both support plates **358**. The stops **368** limit travel of the cradle **362** during tilt movement, which can be used to prevent over-rotation. The fixed gear **356** and its respective support plate **358** have an internal conduit for running wiring from the pivot post **320** into the interior of the head **330** (e.g. to the controller **332** and/or other electronic components). In other embodiments, the wiring exits through the top of the pivot post **210** and extends upward to enter a cable conduit of a motor cradle structure **362**.

[0098] The cradle **362** provides a mounting structure for the controller **332**, motors **334**, **350**, and sprockets **338**, **354**. The cradle **362** is fixed with respect to the housing shell **370**, both directly and indirectly through the motor caps **364** via fasteners **366** in the depicted embodiment. Sealed bearings (not shown) are provided between each of the support plates **358** and the cradle **362** for rotating the cradle **362**, and therefore the rest of the head **330**, relative to the support plates **358**, and therefore also the pivot post **320** and support arm **310**. On the pan mechanism side, bearings (not shown) are also provided between the respective support plate **358** and both the vertical gear **340** and miter gear **342**—which gears **340**, **342** rotate together relative to the support plate **358** in acting on the fixed miter gear **344** inside the pivot post **320**.

[0099] FIGS. **51-53** show another preferred design for the pan/tilt mechanism of the searchlight assembly **300**. As before, the post portion **320** is rotatably mounted to the base portion **310**, and the head portion **330** is pivotably mounted to the post portion **320** opposite the base portion **310**. However, in addition to vehicle pillar mounted searchlight assembly applications, it should be appreciated that the pan/tilt mechanism and various aspects disclosed herein may also be used in other applications. The above descriptions made in reference to FIGS. **30-34** apply equally here unless otherwise indicated. Although omitted in the depiction of this embodiment, the searchlight assembly **300** may also have the electronics controller **332**, motor caps **364**, and fasteners **366** seen in FIG. **32**. The post portion **320** has been removed in FIGS. **52**A and **53** for improved visibility. The post **320** and additional details thereof are seen in FIG. **52**B.

[0100] In FIGS. **51-53**, the left side drivetrain and the right side drivetrain of the pan-tilt mechanism are identical. Given the symmetry of this design, statements made in reference to one side also apply to the other side. In this pan/tilt mechanism, both motors are used to produce the pan motion and the tilt motion. Compared to embodiments having a dedicated pan motor and a dedicated tilt motor, this special pan/tilt mechanism cleverly doubles the amount of torque for each motion, without upgrading to bigger or more powerful motors with higher torque outputs. Due to the design redundancy, the symmetrical drivetrains also provide practical benefits with respect to

component part inventory and construction complexity.
[0101] The depicted pan/tilt mechanism comprises a plurality of components which form the two symmetrical drivetrains, including two reversible motors **334**, two belts **336**, two intermediary gears **338**, two rotatable lower gears **340**, two rotatable bevel gears **342**, and a stationary bevel gear **344**. In each drivetrain, the reversible motor **334** is preferably equipped with a drive shaft gear **335** which drivingly engages the toothed or timing belt **336**. However, other configurations are possible such as a friction belt tensioned around pulleys. In the depicted embodiment, the belt **336** drives the intermediary gear **338**, which in turn drives the lower gear **340**. In particular, the intermediary gear **338** is provided as a double gear with two teeth sets: one set intermeshes with the belt **336** and the other set intermeshes with the lower gear **340**. In other embodiments, the intermediary gear **338** is omitted and the belt **336** engages directly with the lower gear **340**. In which case, the lower gear **340** may be provided as either a single or double gear. The lower gear **340**, which is located in the internal component enclosure of the head portion **330**, is drivingly connected to the bevel gear **342**, which is located in the hollow interior of the post portion **320**. The lower gear **340** and the bevel gear **342** are positionally fixed relative to one another and drivingly connected together in a shaft-locked manner. The gears **340**, **342** are preferably axially aligned with the same axis of rotation. The two rotatable bevel gears **342** are in turn symmetrically mounted along the diameter of the stationary bevel gear **344**. The gears **342**, **344** are preferably axially aligned with an axis of rotation perpendicular to the center or long axis of the stationary bevel gear **344**. Angled bevel gear pairs may also be used within the left-right symmetrical framework. The stationary bevel gear **344** is positionally fixed relative to the base portion **310**.
[0102] The post portion **320** has a hollow interior with a transverse conduit **321** extending therethrough. The rotatable bevel gears **342** engage the stationary bevel gear **344** via the transverse conduit **321** on either side. The ends of the transverse conduit **321** are capped off by the support plates **358**, which are fastened to the post portion **320** via fasteners **360** with interposed seals **323**. The shaft structure **343** connecting the shaft-locked gears **340**, **342** is rotatably mounted through the support plate **358** with bearing **359**, and the motor cradle structure **362** is rotatably mounted to the support plate **358** with bearing **363** (see FIG. **52**C). The gears **340**, **342** are therefore rotatably mounted relative to the motor cradle structure **362**. The reversible motors **334** are fixedly mounted to the motor cradle structure **362**. The intermediary gear **338** is rotatably mounted on a fixed shaft which is mounted to the motor cradle structure **362** at shaft mount **365** (see FIG. **52**C). In the depicted embodiment, the post portion **320** again comprises a neck structure **324** and a body structure **326**, with the body structure **326** arranged above the neck structure **324** and extending laterally outward from the neck structure **324** to attach to the support plates **358**. In this way, the neck structure **324** and the body structure **326** form a T shape similar to a PVC tee pipe fitting. The post portion **320** also comprises a vertical conduit **325** to accommodate the stationary bevel gear **344**, bearings **348**, and wave spring **349**. The wave spring **349** supports the post portion **320** at a desired position and thus guards against resistance load conditions which would prevent pan motion of the post portion **320** relative to the base portion **310**. Preferably, the stationary bevel gear **344** has the vertical conduit **346** extending therethrough for internal wiring. In which case, the vertical conduit **325** also extends through to the top and bottom sides of the post portion **320**. In the depicted embodiment, the top end of the vertical conduit **325** is capped off by a separate cap piece **327** fastened to the body **326**. The opening in the top of the post portion **320**, in this case the cap piece **327**, is provided with a rubber cable insert or grommet seal **418** for running cable wiring in a sealed manner. The post portion **320** also comprises a collar or shoulder structure **328** which interfaces with the base portion **310**. The base portion **310** again carries the pan stop **318** which engages within the stop channel **322** formed on the bottom of the post portion **320**.
[0103] FIGS. **54** and **55** show the action of the components of the pan/tilt mechanism during pan left movement (FIGS. **54**A and **55**A), pan right movement (FIGS. **54**B and **55**B), tilt down movement (FIGS. **54**C and **55**C) and tilt up movement (FIGS. **54**D and **55**D). In FIG. **54**, the

rotational direction of the gears **335**, **338**, **340** is shown using right hand rule convention where the axial arrows indicate the orientation of the thumb pointing along the axis of rotation and the direction of rotation corresponds to the curl of the fingers. FIG. **55** shows the shaft-locked gears **340**, **342** and the stationary gear **344** from above, where each arrow indicates the direction in which the respective gear **342** is being driven. By definition, the reversible motors **334** are bidirectional. The two operating directions are arbitrarily termed positive (P) and negative (N) here. The four combined motor states are then P/P, P/N, N/P, and N/N. The operating direction of the page-right motor **334** in FIG. **54**A is arbitrarily designated as the positive direction. It should be appreciated that, since the motors **334** mounted on the motor cradle structure **362** oriented in opposite directions, both motors **334** are operating in the positive direction in FIG. **54**A. If separately viewed from the side as in FIG. **53**, it would be seen that both motors **334** are rotating counterclockwise. In FIG. **54**B, the motors **334** have switched operating directions and are thus operating in the negative direction. They would be seen rotating clockwise when viewed from either side. Accordingly, the motors **334** operate in the same direction (P/P or N/N) for pan motion, and the gears **342** are driven in the same direction around the fixed gear **344**. From the perspective of FIGS. **55**A and **55**B, the gears **342** travel in the counterclockwise direction for the pan left movement and the clockwise direction for the pan right movement. In this way, the post portion **320** and head portion **330** rotate relative to the base portion **310**. For tilt motion, the motors **334** operate in different directions from one another (P/N or N/P). The page-right motor **334** is operating in the positive direction in FIG. **54**C for the tilt down movement and in the negative direction in FIG. **54**D for the tilt up movement. The other motor **334** is therefore operating in the negative direction in FIG. **54**C and in the positive direction in FIG. **54**D. As seen in FIGS. **55**C and **55**D, the opposing driving forces transmitted to the gears **342** on the fixed gear **344** counteract and balance each other, such that the gears **342** remain stationary in the same position on the fixed gear **344**. Due to the shaft-locked connection to the motionless gears **342**, the gears **340** are also held motionless during the tilt motion. As a result, the torques output from the motors **334** driving the belt drive components causes the head portion **340** to rotate relative to the arrested gears **340**. In the depicted embodiment, the gears **338** travel clockwise or counterclockwise around the arrested gears **340** for tilt motion. In this way, the head portion **330** pivots relative to the post portion **320** and base portion **310**, without the post portion **320** rotating on the base portion **310**.

[0104] Referring also now to FIGS. **35**-**37**, the head **330** further comprises a heat sink **372**. The heat sink **372** is made of a material with good heat-dissipation properties. For example, aluminum or other metals may be used. Those of skill in the art will understand that any material having similar heat-exchange properties could also be used. The heat sink **372** comprises cooling fins **374**, which help dissipate heat, and a heat sink ring structure **376**. The heat sink ring **376** forms a part of the exterior surface of the head **330** and is therefore exposed to the ambient environment, which promotes substantial heat dissipation between the head **330** and its outside surroundings. In the depicted embodiment, the heat sink ring **376** is integral with the remainder of the heat sink **372**; the heat sink **372** with its fins **374** and ring **376** being formed from a single cast. In other embodiments, the heat sink ring **376** may be provided as a separate component which contacts the heat sink **372** to establish thermal communication therebetween, whereby heat from the heat sink **372** is transferred to the heat sink ring **376** and then dissipated to the exterior environment. A ring gasket **378** is provided between the heat sink ring **376** and the housing shells **370**, which helps seal against the ingress of water and/or dirt into the interior of the head **330**. On its other side, the heat sink ring **376** abuts a bezel **380**. The bezel **380** holds the lens cover **382** (see also FIG. **38**) in place which in turn supports the optical or sensor device system against the heat sink **372**. For illustrative clarity, the lens cover **382** is depicted being opaque; it being understood that the lens cover **382** is transparent or at least partially translucent for purposes of light emission. For attachment, fasteners **384** are inserted through the bezel **380** (which provides the fastener head contact surface), through the heat sink **372** and anchored into bosses **386** of the housing shells **370**.

[0105] Referring also now to FIGS. **38-41**, one possible optical device configuration is described. Although the optical device of the depicted embodiment is an LED lamp, other optical or sensor systems (e.g. halogen or HID lamps, cameras, infrared sensors, heat sensors, etc.) may also be used according to the present disclosure. Indeed, one aspect of the searchlight system **100** is the modular exchange of different searchlight assemblies **300** with respect to an already-installed mounting assembly **200**, including for the purpose of switching out different optical or sensor device systems as desired under the circumstances. Further, although the depicted optical device has a reflective design which utilizes a reflective surface to redirect and concentrate light emitted by one or more LEDs into an output beam, other embodiments comprise a refractive design which utilizes at least one projection lens to redirect and concentrate emitted light into an output beam. Some embodiments incorporate both reflective and refractive designs. A searchlight system according to the present disclosure and the various aspects thereof may be used with any suitable optical device system; no limitation is intended nor should be inferred.
[0106] In the depicted embodiment, a reflector **388** is provided under the lens cover **382**. The surface of the reflector **388** is configured to redirect and concentrate light emitted through LED openings **390** in the reflector **388**. The reflector **388** is positioned adjacent a front surface **392** of the heat sink **372** (opposite the fins **374**). The geometry of the front surface **392** may correspond to the geometry of the reflector **388**, as in the depicted embodiment, which helps to correctly align the reflector **388** between the heat sink **372** and the lens cover **382**. As such, this front surface **392** generally defines the cavity **396** for accommodating optical device components. The front surface **392** includes apertures **394** for running wiring to the controller **332** within the head **330**. The front surface **392** also has a further recessed cavity portion indicated by **396** which receives a LED mounting bracket **400**. Bores **398** (see also FIG. **35**) are provided in the upper portion of the cavity **396** to receive fasteners (not shown) for coupling the heat sink **372** to the mounting bracket **400**.
[0107] Referring also now to FIGS. **42-44**, the LED mounting bracket **400** is arranged within the cavity **396** between the reflector **388** and the heat sink **372**. The top surface of the mounting bracket **400** has anchor holes for mating with fasteners (not shown) which extend through the heat sink bores **398** in coupling the bracket **400** to the heat sink **372**. LEDs **402** are provided on circuit board **404**, which is mounted to the mounting bracket **400**. The LEDs **402** are positioned to emit light through the reflector openings **390** onto the surface of the reflector **388**, which may be configured to redirect and concentrate the light into a beam as in the depicted embodiment. In other embodiments, one or more LEDs **402** are positioned along the front surface **392** of the heat sink **372**, and at least one projection lens (not shown) is arranged between the LEDs **402** and the lens cover **382**, the at least one projection lens configured to redirect and concentrate light into a beam, in which case the front surface **392** of the heat sink **372** may be flat or take on different shapes and the reflector **388** omitted entirely. FIGS. **56-57** show such an example heat sink **372** with a flat front surface **392** for mounting multiple LEDs **402** beneath such a condenser lens, or other types of devices as desired.
[0108] Referring now to FIGS. **56-57**, the above statements regarding the heat sink **372** of FIGS. **35-37** apply equally here, and vice versa, unless otherwise indicated. The heat sink ring structure **376** comprises a first or rear mating surface **377.1**, a second or front mating surface **377.2**, and an exterior or lateral surface **377.3** which extends between the two mating surfaces **377.1**, **377.2** and faces outward away from the head portion **330**. The ring gasket **378** is positioned between the rear mating surface **377.1** and a complimentary mating surface of the at least one housing shell **370** to form a waterproof seal therebetween (see also FIGS. **35-37**). It should be appreciated that the ring gasket **378** is shaped according to the junction geometry and therefore would be elliptical rather than circular in this case. Seals are preferably also provided at interfaces between different housing shells **370**. In this way, the one or more housing shells **370** and heat sink **378** form at least part of the enclosure for internal components of the head **330**. On the bottom side, this enclosure is completed by the motor cradle structure **362** and housing insert pieces **406** discussed below.

Accordingly, the exterior surface of the head portion **330**, which is outermost surface exposed to the ambient environment and its elements, is formed at least in part by the heat sink ring **376**, in particular the exterior surface **377.3** thereof, as well as the at least one housing shell **370**. In this way, the heat sink ring **376** is in direct thermal communication with the outside environment. This clever design allows the heat sink **372** to efficiently dissipate heat from the head **330** to the surrounding environment. This is significant since the housing shells **370** are typically made from molded plastic, which as good insulators, would otherwise trap excess heat within the head **330**. As discussed, the heat sink **372** is made from a thermally conductive material, such as aluminum for example, and preferably cast as a single integral piece. In this example, the heat sink **372** has a flat front surface **392**. The cooling **374** are formed on the backside of the front surface **392** indicated by reference numeral **393**. The front surface **392** is set back from the heat sink ring **376**, and along with the sidewalls **395**, defines the cavity **396** for accommodating the optical device components. The heat sink ring **376** is laterally offset from the sidewalls **395** and center region of the heatsink **370**, which contains the heat fins **374**, by a peripheral flange **397**. The peripheral flange structure **397** is profiled on the front side for lens mounting and on the back side for reinforcement. Fastener openings **385**, which receive the fasteners **384** for connecting the heat sink **372** and bezel **380** to the housing shells **370**, are formed in this periphery flange portion **397** between the sidewalls **395** and the heat sink ring **376**. When fastened together, the bezel **380** which abuts the mating surface **377.2** of the heat sink ring **372**.

[0109] Reference is also now made to FIGS. **45-46** and **58-60**. In the tilt mechanisms described above, the head **330** (including housing shells **370**) rotates relative to both the stationary pivot post **320** and fixed support plates **358**. Therefore, at least some clearance space is provided between a lower edge **406** of each housing shell **370** and the pivot post's neck **324** and body **326** (see FIG. **34**) and the support plates **358** to accommodate this motion. However, water, dust and the like could potentially enter through such clearance space into the interior of the head **330** and negatively affect mechanical or electronic components. To mitigate against this problem, a special insert piece **408** is provided for each housing shell **370**. Together with the housing shells **370** and cradles **362**, the insert pieces **408** seal the area of the head **330** occupied by the pivot post **320** and support plates **358** from the rest of the interior of the head **330** containing parts that might be negatively affected by moisture/particle ingress. The internal surface **410** of each housing shell **370** comprises fitting projections **412** for positioning the insert piece **408** thereon. Sealant or adhesive is provided along the contact points between each housing shell **370** and its respective insert piece **408**. In other embodiments (not shown), one or more rubber, elastomer or like seals may be provided along these contact points, for example positioned in grooves formed by the housing shell fittings **412**. On the opposite interior-facing end of each insert piece **408**, one or more rubber, elastomer or like seals **414** is/are provided along the contact points with the other insert piece **408** and the cradle **362**. FIG. **58** shows the motor cradle structures **362** and special insert structures **408** with seals **414**. FIG. **59** omits the motor cradle structures **362**. FIG. **60** omits the special inserts **408** to show the system configuration of sealing structures. The interface or mating surfaces of the insert pieces **408** and the motor cradle structures **362** are provided with grooves **415** for the seals **414** (see FIG. **52**C). Both surfaces may have complimentary grooves **415**, or one surface may have a groove **415** with the other surface having no groove or having a complimentary protrusion pressing into the opposing groove **415**. These grooves **415** can be used with either adhesive or compression (e.g. rubber) seals, or a combination of both adhesive and compression seals. It should be appreciated that there is another seal (not shown) along the midline between the two motor cradle structures **362**. Preferably, a rubber cable insert or grommet seal **418** is positioned in the cable conduit of the motor cradle structure **362** as well as at the top of the pivot post **320** (see FIG. **52**B). Since the geometry provided by the special insert pieces **408** is not integrated into the housing shells **370** themselves, the housing shells **370** may be readily produced by efficient processes such as injection molding.

[0110] While a number of aspects and embodiments have been discussed, those of skill in the art

will recognize certain modifications, permutations, additions and sub-combinations are possible. It is intended that the following claims are interpreted to include all such modifications, permutations, additions and sub-combinations, as they are within the true spirit and scope of the present disclosure and the claims. Each embodiment described herein has numerous equivalents.

[0111] The terms and expressions which have been employed are used as terms of description and not of limitation, and there is no intention in the use of such terms and expressions to exclude any equivalents of the features shown and described or portions thereof, but it is recognized that various modifications are possible within the scope of the invention claimed. Accordingly, it should be understood that although the invention has been specifically disclosed by selected embodiments and optional features, modification and variation of the concepts herein disclosed may be resorted to by those skilled in the art, and that such modifications and variations are considered to be within the scope of this invention as defined by the appended claims. Whenever a range is given in the specification, all intermediate ranges and subranges, as well as all individual values included in the ranges given are intended to be included in the disclosure. When a Markush group or other grouping is used herein, all individual members of the group and all combinations and sub-combinations possible of the group are intended to be individually included in the disclosure.

[0112] In general, the terms and phrases used herein have their art-recognized meaning, which can be found by reference to standard texts, journal references and contexts known to those skilled in the art. The above definitions are provided to clarify their specific use in the context of the invention.

TABLE-US-00001 LIST OF REFERENCE NUMERALS 5 A-pillar 10 trim cover/exterior vehicle surface 15 base trim piece or tracking 20 surface openings 25 fasteners 30 A-pillar mating holes 35 base piece openings 40 trim cover fittings 100 mounted searchlight system 200 mounting assembly 210 upper bracket 212 lower bracket 214 interior bracket surface 216 exterior bracket surface 218 projection 220 bore 222 end wall 224 bore 226 fastener 230 adapter 232 adapter mounting collar 234 bracket opening 236 bracket interface surface 238 fasteners 240 first adapter projection 242 second adapter projection 244 fasteners 246 adapter internal conduit 248 adapter collar conduit 250 clip nuts 252 mounting gasket 254 rivet nuts 256 nut body 258 material bulge 260 top flange 300 searchlight assembly 310 support arm/base 312 projections 314 fastener mating bores 316 arm internal conduit 317 arm external aperture 318 pan stop 320 pivot post/yoke 321 transverse conduit 322 stop channel 323 pivot post seal 324 pivot post neck 325 vertical conduit 326 pivot post body 327 pivot post cap 328 pivot post collar 330 head 332 electronics controller 334 reversible motor 335 drive gear 336 belt 338 sprocket 340 gear 342 rotating bevel/miter gear 343 shaft 344 fixed bevel/miter gear 346 miter gear conduit 348 post bearings 349 post wave spring 350 tilt reversible motor 352 tilt belt 354 tilt sprocket 356 tilt fixed gear 358 support plates 359 plate-shaft bearings 360 fasteners 362 cradle 364 motor caps 366 fasteners 368 tilt stop 370 housing shell 372 heat sink 374 cooling fins 376 heat sink ring 377 heat sink ring surfaces 378 heat sink ring gasket 380 bezel 382 lens cover 384 fasteners 385 fastener openings 386 housing bosses 388 reflector 390 LED reflector openings 392 heat sink front surface 393 heat sink rear surface 394 heat sink apertures 395 heat sink sidewall 396 heat sink cavity 397 heat sink peripheral flange 398 heat sink bores 400 LED mounting bracket 402 LEDs 404 LED circuit board 406 housing edge 408 insert piece 410 internal housing surface 412 insert piece fittings 414 seals 415 grooves 416 cable 418 cable seal

Claims

1. A searchlight assembly comprising: a base portion and a head portion movably mounted relative to the base portion, the head portion comprising at least one housing shell, a heat sink, a ring gasket, and an optical device, wherein the housing shell and the heat sink are coupled together to form at least part of an enclosure for internal components of the head portion, wherein the heat sink comprises a peripheral heat sink ring having a first mating surface, a second mating surface

opposite the first mating surface, and a lateral surface which extends between the first and second mating surfaces and faces outward away from the head portion, wherein the ring gasket is positioned between the first mating surface of the heat sink ring and the at least one housing shell to form a seal therebetween, wherein an exterior surface of the head portion, which is exposed to ambient surrounding environment, is formed at least in part by the lateral surface of the heat sink ring and the housing shell, such that the heat sink ring is in direct thermal communication with the ambient surrounding environment.

2. The searchlight assembly of claim 1, wherein the heat sink further comprises a plurality of cooling fins extending from a rear surface thereof into the enclosure of the head portion.

3. The searchlight assembly of claim 1, wherein the heat sink is made of a thermally conductive material.

4. The searchlight assembly of claim 3, wherein the heat sink is cast as a single integral piece from the thermally conductive material.

5. The searchlight assembly of claim 3, wherein the thermally conductive material comprises aluminum.

6. The searchlight assembly of claim 1, wherein the housing shell is made of a molded plastic.

7. The searchlight assembly of claim 1, wherein the heat sink further comprises a plurality of fastener openings extending therethrough, and the heat sink is coupled to the housing shell via fasteners inserted through the fastener openings.

8. The searchlight assembly of claim 7, further comprising a bezel which abuts the second mating surface of the heat sink ring, wherein the bezel is coupled to the heat sink via the fasteners.

9. The searchlight mounting system of claim 1, wherein the optical device is an LED lamp, halogen lamp, HID lamp, camera, infrared sensor, or heat sensor.

10. The searchlight assembly of claim 1, wherein the head portion is movably mounted relative to the base portion via a post portion, which has a hollow interior with a transverse conduit extending therethrough, with the post portion being rotatably mounted to the base portion, and the head portion being pivotably mounted to the post portion opposite the base portion, the searchlight assembly further comprising: a pan/tilt mechanism comprising a plurality of components including two reversible motors, two belts, two rotatable lower gears, two rotatable bevel gears, and a stationary bevel gear, with the plurality of components forming two symmetrical drivetrains of the pan/tilt mechanism, wherein, in each drivetrain of the two symmetrical drivetrains, a respective reversible motor is drivingly connected to a respective belt, the belt is drivingly connected to a respective lower gear, the lower gear is drivingly connected to and positionally fixed relative to a respective rotatable bevel gear, and the rotatable bevel gear is drivingly connected to the stationary bevel gear, wherein the reversible motors are fixedly mounted to the head portion, and the lower gears are rotatably mounted relative to the head portion, wherein the stationary bevel gear is located in the hollow interior of the post portion and positionally fixed relative to the base portion, and the rotatable bevel gears engage the stationary bevel gear via the transverse conduit of the post portion, wherein for pan motion, the rotatable bevel gears are driven in the same rotational direction around the stationary bevel gear, such that the post portion and head portion rotate relative to the base portion, and wherein for tilt motion, the rotatable bevel gears are held motionless on the stationary bevel gear due to counteracting torques applied to the rotatable bevel gears, such that the head portion pivots relative to the post portion and the base portion.

11. The searchlight assembly of claim 10, wherein the pan/tilt mechanism further comprises two intermediary gears, and in each drivetrain of the two symmetrical drivetrains, a respective intermediary gear is drivingly engaged between the belt and the lower gear.

12. The searchlight assembly of claim 11, wherein the belts are toothed belts which intermesh with drive shaft gears of the reversible motors, and wherein the intermediary gears are double gears which intermesh with the toothed belts and with the lower gears.

13. The searchlight assembly of claim 10, wherein the belts are toothed belts which intermesh with

the lower gears and with drive shaft gears of the reversible motors.

14. The searchlight assembly of claim 10, wherein the rotatable bevel gears have an axis of rotation which is perpendicular to a center axis of the stationary bevel gear.

15. The searchlight assembly of claim 10, wherein the head portion contains a motor cradle structure, the reversible motors are fixedly mounted to the motor cradle structure, and the lower gears and the rotatable bevel gears are rotatably mounted relative to the motor cradle structure.

16. The searchlight assembly of claim 15, wherein the motor cradle structure is pivotably mounted to the post portion at either end of the transverse conduit, with the motor cradle structure positioned between the lower gears and the rotatable bevel gears.

17. A searchlight mounting system comprising a searchlight assembly according to claim 1, wherein the base portion is a support arm for mounting to a vehicle pillar, and a mounting assembly which comprises: a bracket having an interior surface configured to face toward a vehicle surface, an exterior surface opposite the interior surface, and fastener openings which extend through the bracket, wherein the fastener openings are provided as counterbores or countersinks each having a first bore diameter and a second bore diameter, and wherein the first bore diameter is formed into the exterior surface and larger than the second bore diameter, an adapter projecting out from the exterior surface of the bracket, the adapter configured to attach to the searchlight assembly, and fasteners for mounting the bracket to the vehicle surface via the fastener openings, each fastener having a head and a shank, wherein a diameter of the head diameter is smaller than the first bore diameter but larger than the second bore diameter, and wherein a diameter of the shank is smaller than the second bore diameter.

18. The searchlight mounting system of claim 17, wherein the mounting assembly further comprises threaded rivet nuts for installing into openings formed in the vehicle surface to receive the fasteners.

19. The searchlight mounting system of claim 17, wherein the adapter and the support arm comprise complimentary projections configured to form a dovetail joint.

20. The searchlight mounting system of claim 19, wherein the projections of the adapter and the support arm are arranged such that the searchlight assembly is slid downwardly onto the adapter to form the dovetail joint.