US 20020122302A1

(19) United States

(12) Patent Application Publication (10) Pub. No.: US 2002/0122302 A1

Palmer (43) Pub. Date: Sep. 5, 2002

(54) NIGHT VISION BINOCULARS

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(21) Appl. No.: 09/774,506

(22) Filed: Jan. 31, 2001

Related U.S. Application Data

(63) Continuation of application No. 09/041,432, filed on Mar. 12, 1998, now Pat. No. 6,219,250.

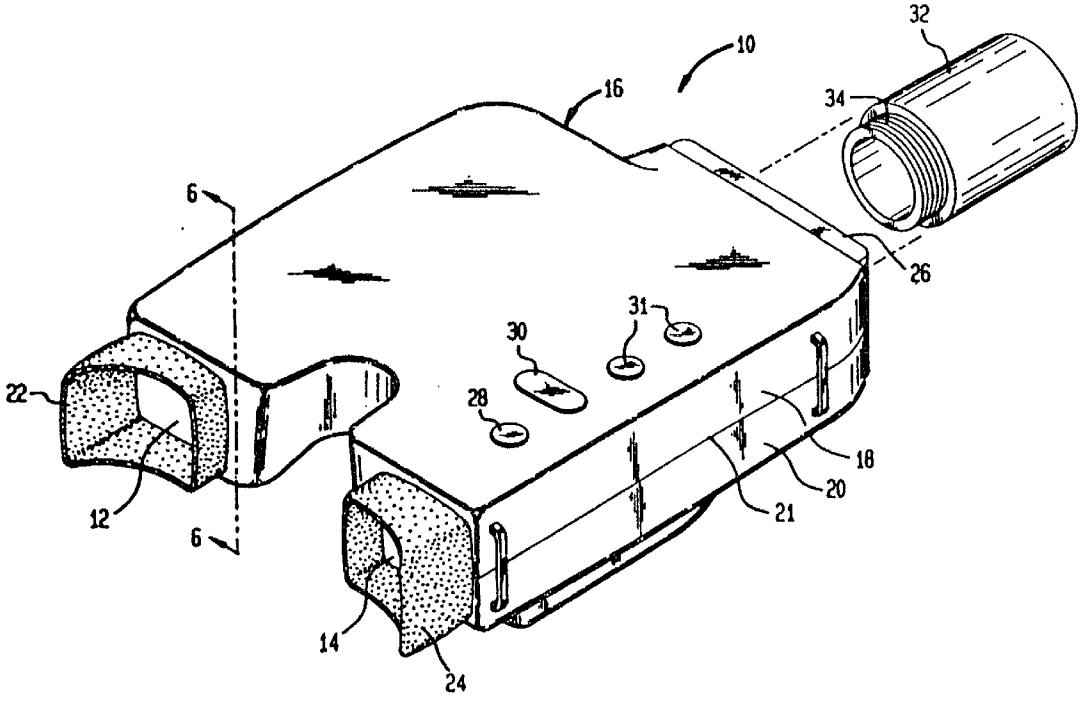
Publication Classification

(51) Int. Cl.[7] H05K 5/00; H05K 5/04; H05K 5/06

(52) U.S. Cl. 361/752

(57) ABSTRACT

A night vision binocular assembly (10) capable of converting low light and infrared energy into a visible image. The night vision binocular assembly (10) includes at least one objective lens assembly (62), image intensifier tube (64), collimator lens assembly (66) and diopter cell assembly (68) encased in an easy to assembly waterproof housing (16). The objective lens assembly (62), image intensifier tube (64), collimator lens assembly (66) and diopter cell assembly (68) are all supported by a common base structure (80) within the housing (16). As a result, variations caused by thermal expansions and contractions are evenly distributed among the various optical elements, thereby preserving a predetermined optical relationship between those elements. Simple button controls (28, 30, 31) are used to operate and adjust the night vision binocular assembly (10). The button controls (28, 30, 31) are disposed on a common circuit board (38). An elastomeric structure (36) is disposed between the circuit board (38) and the interior of the binocular housing (16). The circuit board (38) is affixed to the interior of the binocular housing (16) in a manner that compresses the elastomeric structure (36) against the binocular housing (16) to provide a water tight seal. The elastomeric structure (36) has switch membranes or domed portions which extend through apertures (37) in the housing (16) creating both a fluid impermeable seal with the housing (16) and a means for the tactile engagement of the switches on the below lying circuit board (38).



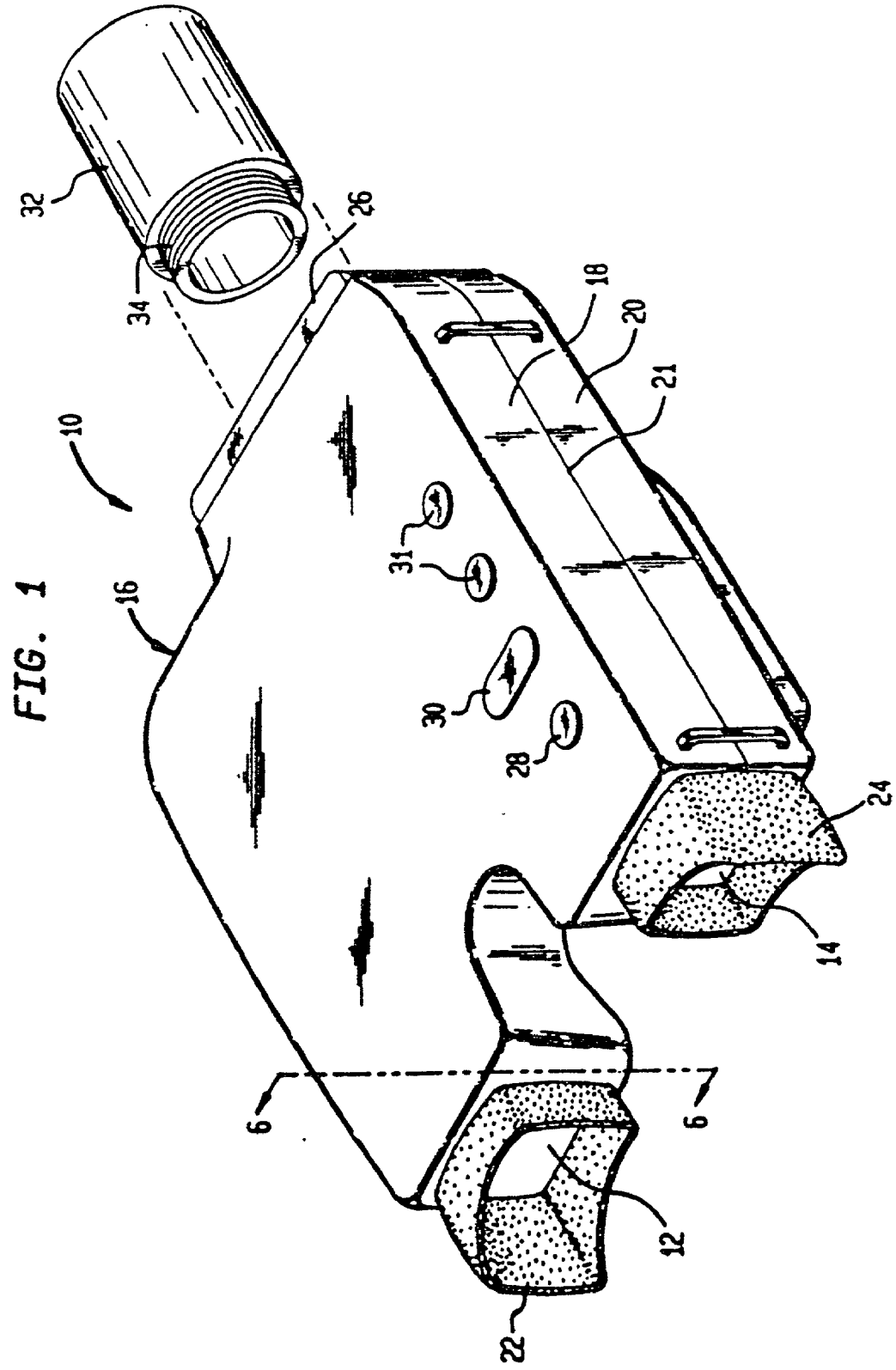


FIG. 1

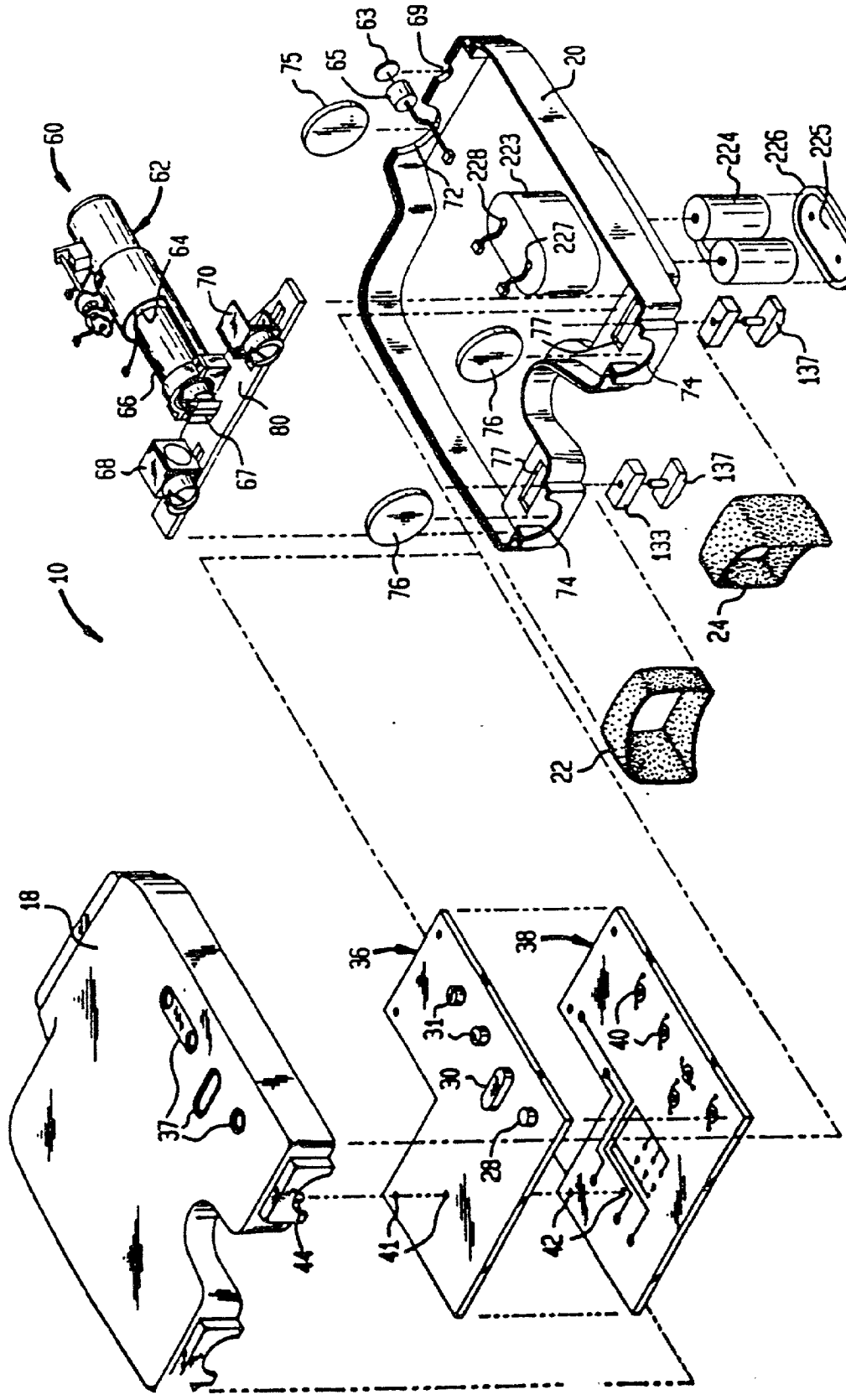

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FIG. 2

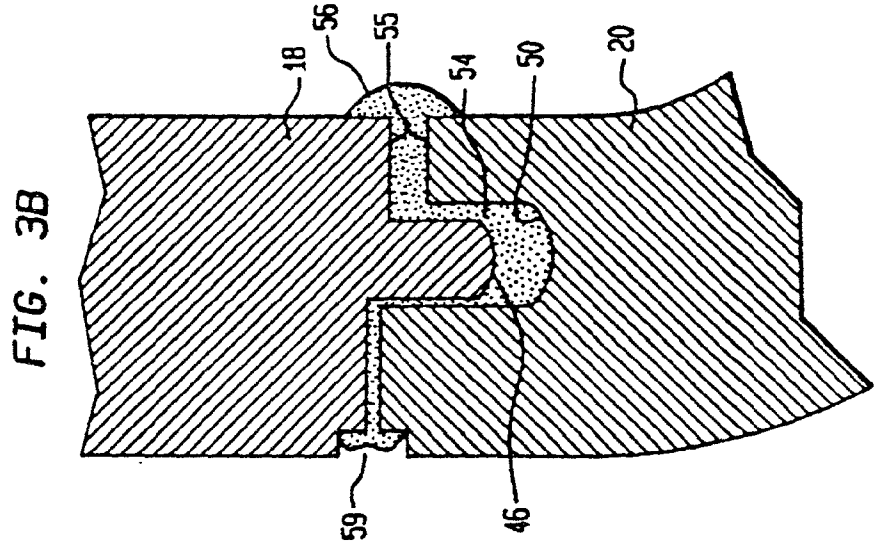


FIG. 3B

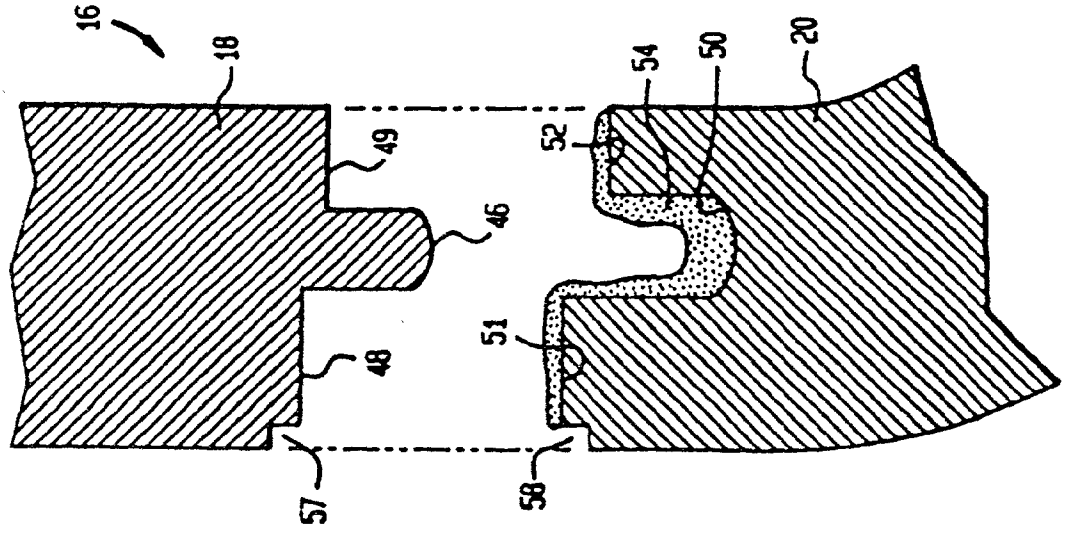


FIG. 3A

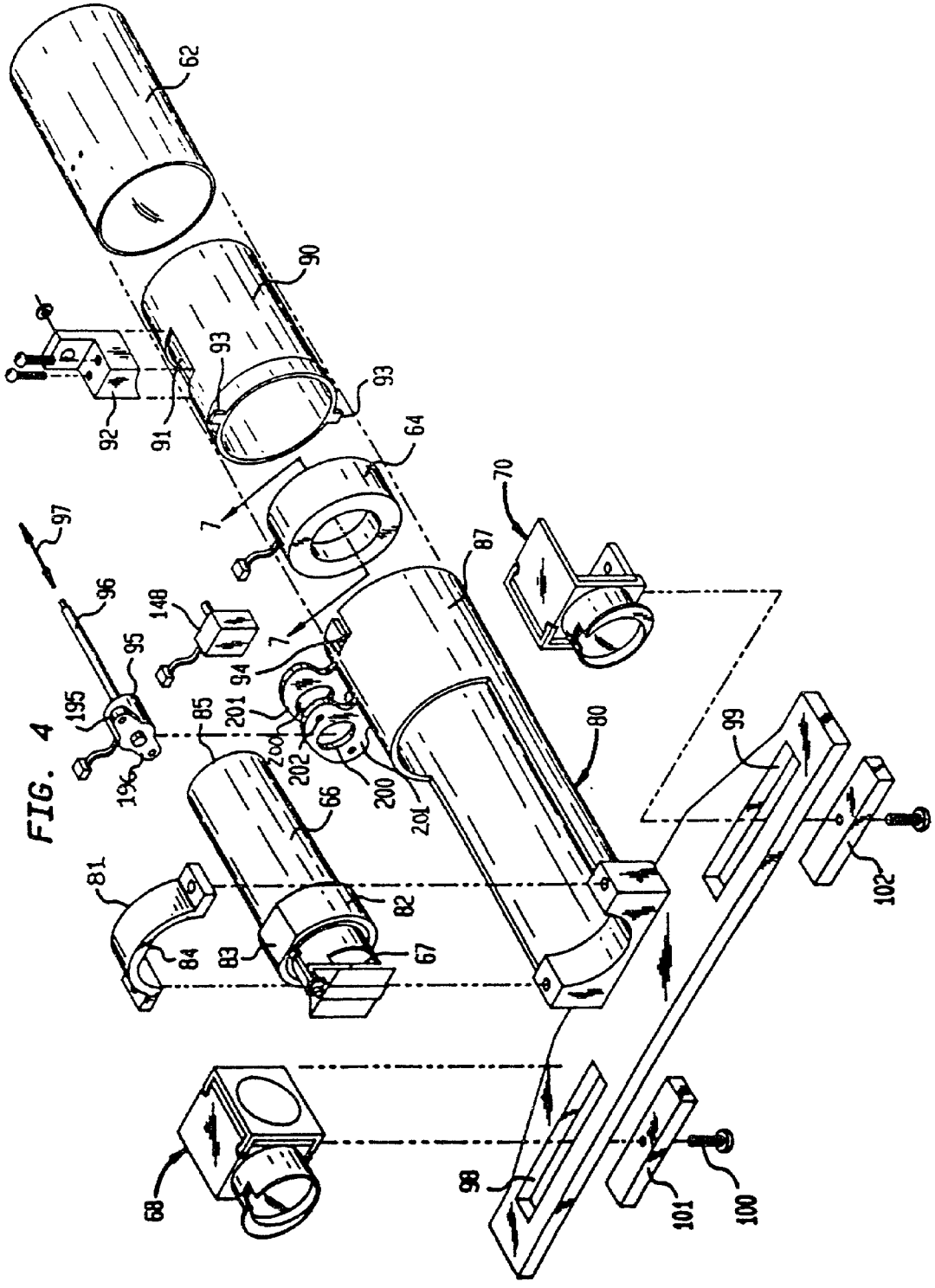

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102
68
98
101
100

FIG. 4

FIG. 5

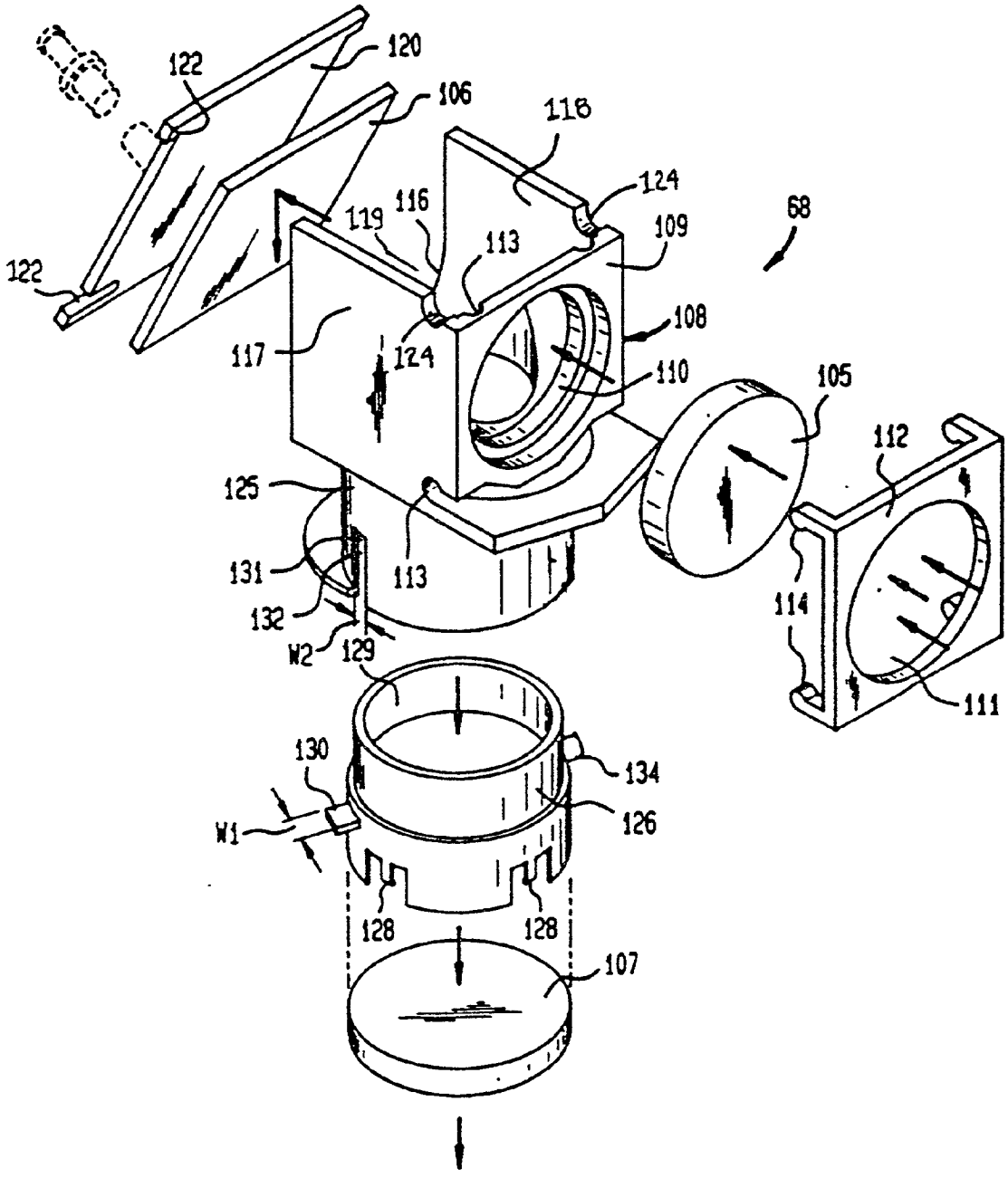

122
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106
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W2
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134
W1
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FIG. 6

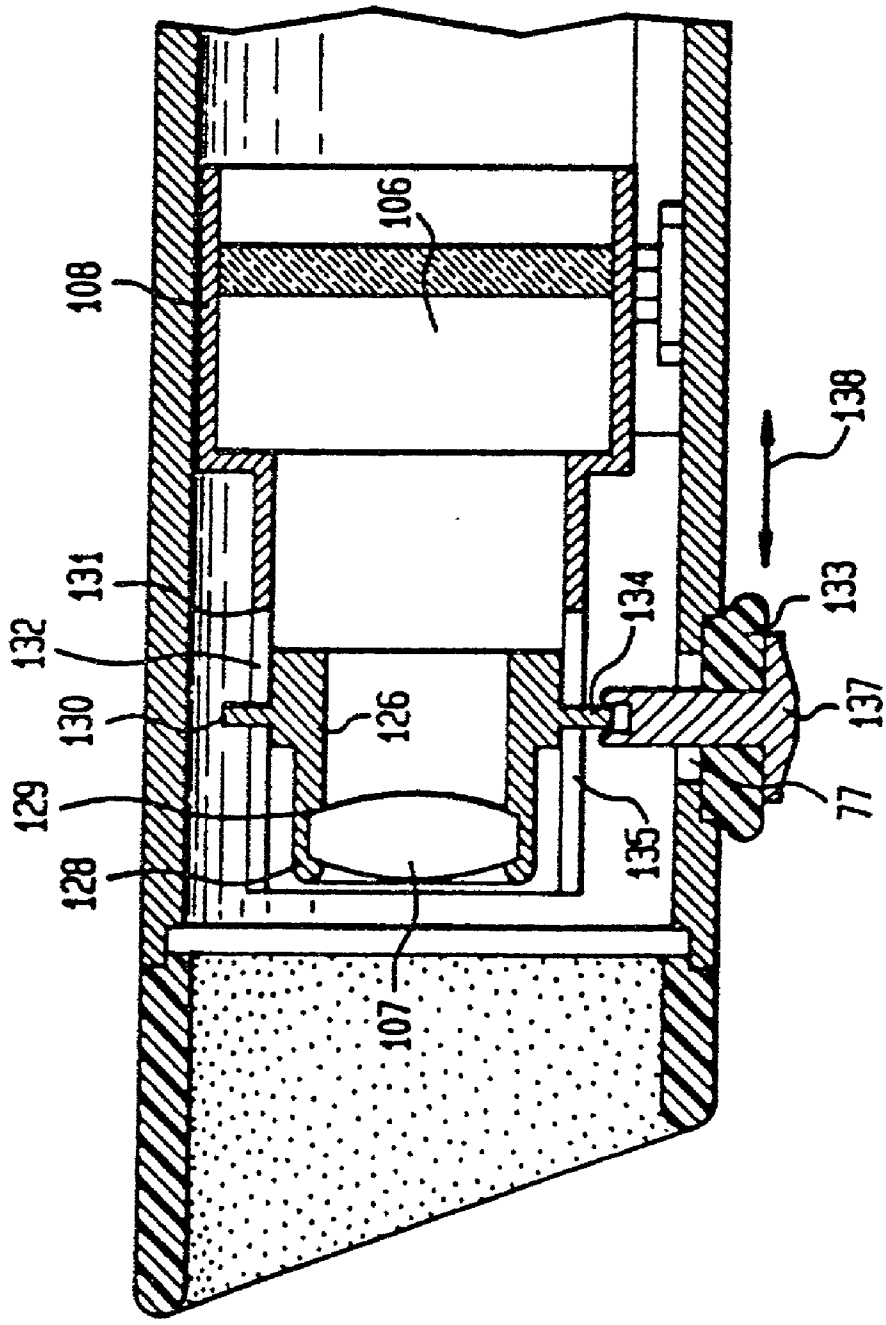


FIG. 7

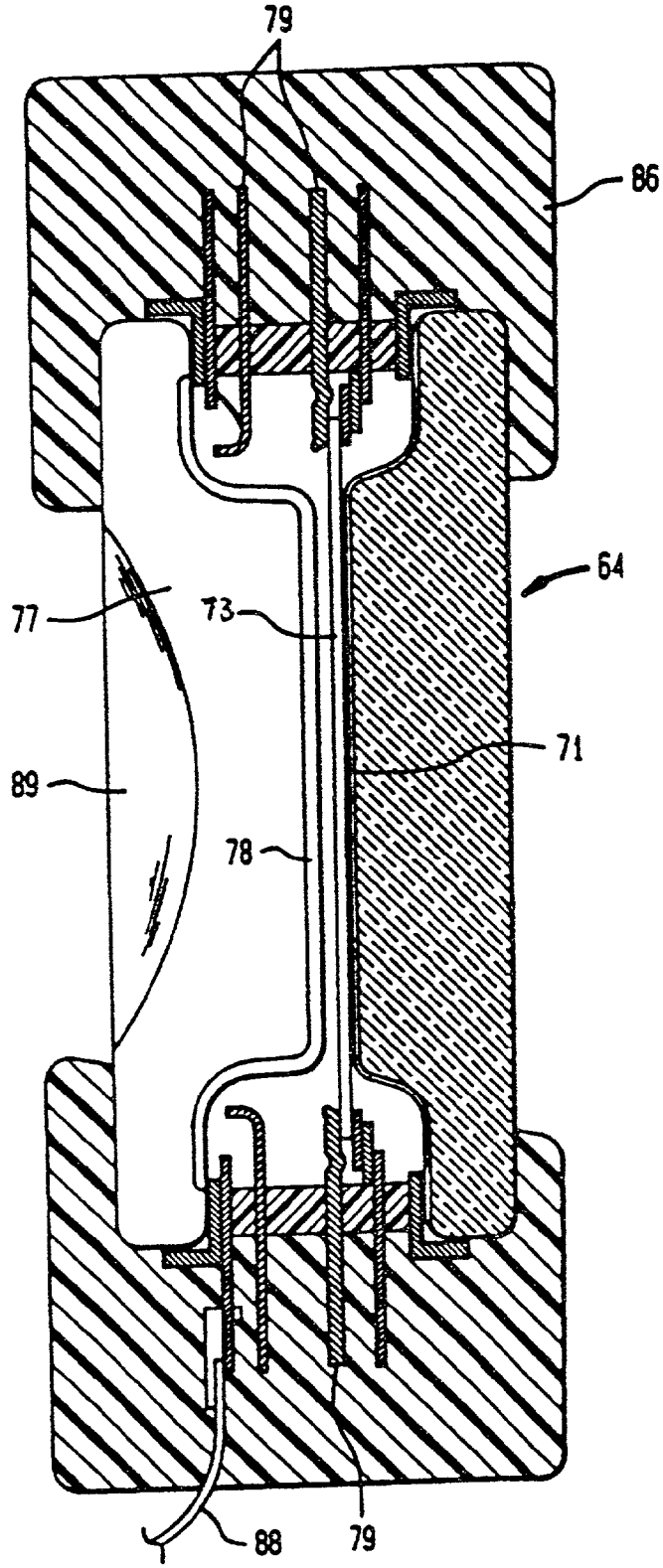
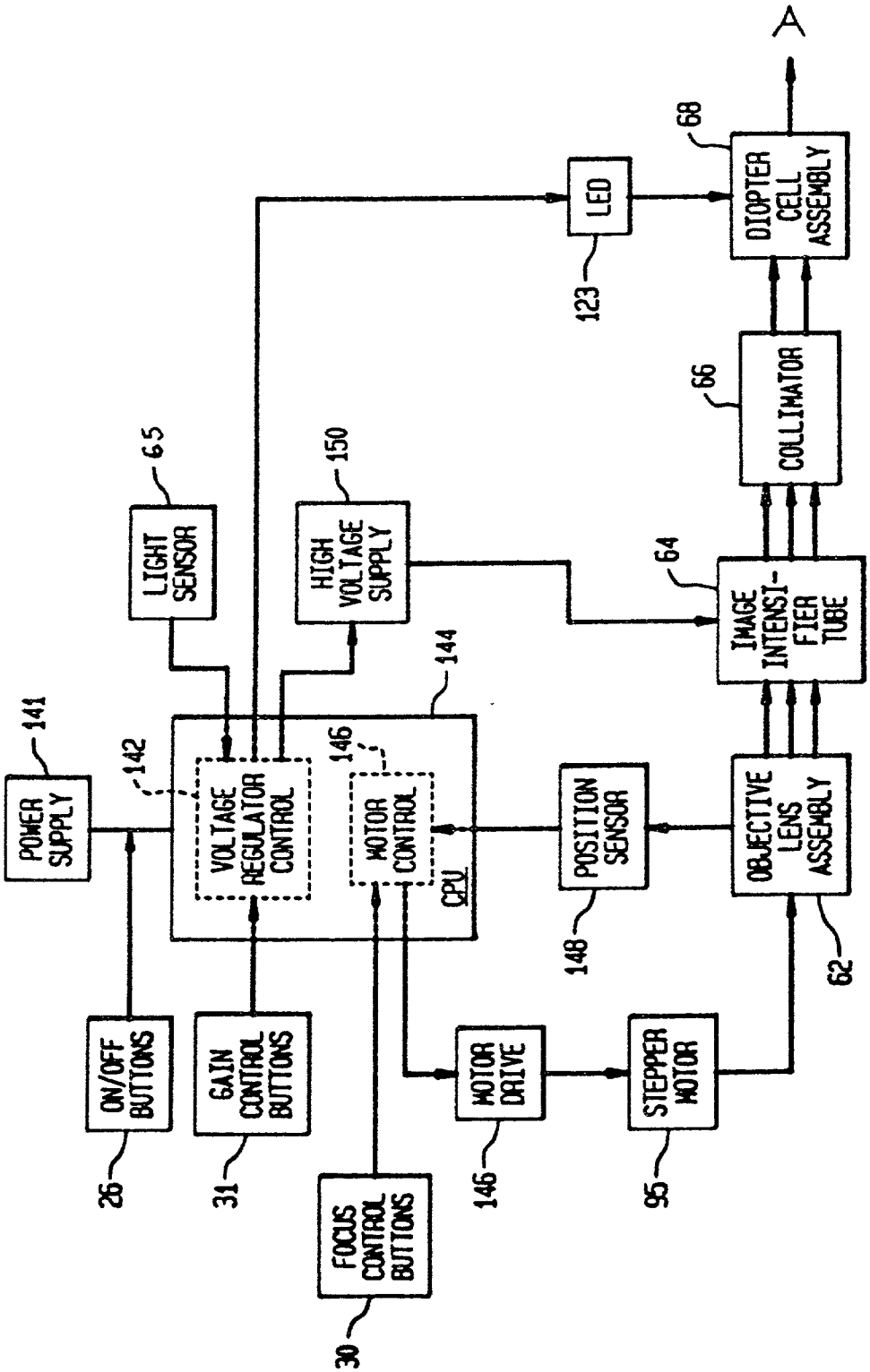


FIG. 8


A
68
DIOPTER CELL ASSEMBLY
LED
123
66
COLLIMATOR
65
LIGHT SENSOR
150
HIGH VOLTAGE SUPPLY
64
IMAGE INTENSI-FIER TUBE
144
141
142
146
POWER SUPPLY
VOLTAGE REGULATOR CONTROL
MOTOR CONTROL
CPU
POSITION SENSOR
148
OBJECTIVE LENS ASSEMBLY
62
ON/OFF BUTTONS
26
GAIN CONTROL BUTTONS
31
FOCUS CONTROL BUTTONS
30
MOTOR DRIVE
146
STEPPER MOTOR
95

NIGHT VISION BINOCULARS

FIELD OF THE INVENTION

[0001] The present invention relates to optical devices that enable a viewer to observe objects at night or during other low-light conditions. More particularly, the present invention relates to a handheld binocular system that can be manufactured at low cost for sale to the general public.

BACKGROUND OF THE INVENTION

[0002] Night vision devices are widely used in the military to provide soldiers, aviators and sailors with the ability to view objects at night or during other low light conditions. As a result, many night vision devices are currently being manufactured according to exacting military specifications and designs. Similarly, many such night vision devices are being manufactured for specific military applications such as part of the sights of various weapons or as part of goggle assemblies that attach to an aviator's or soldier's helmet. As a consequence, many of the night vision devices currently being manufactured are neither affordable nor easily adapted to non-military uses by the general public.

[0003] Night vision devices typically include an image intensifier tube that converts infrared energy into visible light. Such night vision devices typically require sophisticated power supplies and circuitry to control the operation of the image intensifier tube and sophisticated optical arrangements that direct the infrared energy into the image intensifier tube and visible fight away from the image intensifier tube. In military applications, the various military personnel are trained in how to use and adjust the night vision devices they are issued. However, a night vision device designed for use by the general public would have to provide simple adjustments that can be readily operated by a variety of different users in a dark environment. Furthermore, a night vision device designed for use by the general public would also require various adjustable optical characteristics that would be easy to operate and adjust. Such a consumer oriented night vision device would have wide ranging application in regard to nighttime marine piloting, nighttime security, surveillance, hunting, fishing, backpacking, navigation, underwater vision, search and rescue and law enforcement.

[0004] ITT Corporation, the assignee herein, manufactures many night vision devices for various applications. Night vision devices for military applications are exemplified by U.S. Pat. No. 5,084,780 to Phillips entitled TELESCOPIC SIGHT FOR DAY/NIGHT VIEWING and U.S. Pat. No. 5,029,963 to Naselli entitled REPLACEMENT DEVICE FOR A DRIVER'S VIEWER. ITT Corporation, also has designed handheld night vision binoculars devices. Such a binocular device is exemplified in U.S. patent application Ser. No. 07/954,006, entitled CONSUMER NIGHT VISION VIEWING APPARATUS and filed on Sep. 30, 1992. In this application, a night vision binocular device is disclosed having simplified adjustment controls, interpupillary adjustments and diopter cell focus adjustments. Related optical components that can be utilized in the construction of night vision binocular devices are shown in U.S. patent application Ser. No. 08/039,755 entitled DIOPTER CELL ASSEMBLY FOR A BINOCULAR VIEWING SYSTEM, and U.S. Pat. No. 5,117,553, entitled COLLIMATOR FOR A BINOCULAR VIEWING SYSTEM, both of which are assigned to the assignee herein. These references show a diopter cell design and a collimator lens assembly for night vision binoculars, respectively. The assignee holds many other patents and applications related to image intensifier tubes and related devices which are of interest in regard to the present subject matter.

[0005] As has been previously mentioned, an important application for publicly available night vision devices will be for use on recreational boats. Boats often run at night utilizing only their running lights for illumination. The use of night vision devices by the pilots of boats will greatly increase visibility, resulting in less nighttime collisions and similar accidents. The night vision binoculars will enable boaters to identify objects detected on radar, see land marks, read channel markers, detect navigational hazards, identify approaching vessels and much more. The environment of a recreational boat is less than ideal for a sophisticated electro-optical device such as a handheld night vision instrument. To survive in such an environment, the night vision instrument must be capable of withstanding large temperature changes, impacts, and must be hermetically sealed to withstand the high humidity environment and the possibility of being dropped into the water. Furthermore, since most recreational boats are small, inexpensive craft, the night vision device must provide the same performance as military specificating night vision devices but at a greatly reduced cost so as to be affordable to the average boater.

[0006] It is therefore the object of the present invention to provide a night vision device that is easy to hold, easy to operate, water proof and provides the same performance as military night vision devices at a greatly reduced cost.

[0007] It is a further object of the present invention to provide component parts for the above-mentioned night vision device that are easy to manufacture and assembly, thereby further reducing the cost of manufacturing the night vision device.

SUMMARY OF THE INVENTION

[0008] The present invention is a night vision binocular assembly capable of converting low intensity light and infrared energy into a visible image. The night vision binocular assembly includes at least one objective lens assembly, image intensifier tube, collimator lens assembly and diopter cell assembly encased in an easy to ASSEMBLY waterproof housing. The objective lens assembly, image intensifier tube, collimator lens assembly and diopter cell assembly are all supported by a common optical base or bed structure within the housing. As a result, variations caused by thermal expansions and contractions are evenly distributed among the various optical elements, thereby preserving a predetermined optical relationship between those elements.

[0009] Simple button controls are used to operate and adjust the night vision binocular assembly. The button controls include an on/off switch, a brightness switch and a focus switch, all of which being surface mounting switching elements that are disposed on a common circuit board within the binocular housing. An elastomeric planar sheet having domed sloped integral switching actuating projections is disposed between the circuit board and the interior of the binocular housing. The circuit board is affixed to the interior

of the binocular housing in a manner that engages the elastomeric structure. The elastomeric structure is glued by means of a waterproof epoxy or adhesive to the internal surface of the housing and is held and maintained in position by a plurality of extending pegs of projections which align the elastomeric switch sheet with the circuit board. The domed projections of elastomeric structure extend through apertures in the binocular housing creating both a fluid impermeable seat with the housing and with the domed projections providing a means for the tactile engagement of the switching elements on the circuit board.

[0010] The present invention night vision binocular assembly is manufactured in a manner that promotes both ease of use and case of assembly. The primary optical elements of the night vision binoculars all interconnect onto the common optical base or bed structure with a minimal number of mechanical fasteners. The diopter cell assemblies require no mechanical fasteners in their assembly and the binocular housing can be assembled to be water tight without the use of a gasket. As a result, the present invention night vision binoculars can be manufactured and assembled in a highly reliable and cost efficient manner, thereby making the night vision binoculars affordable to the general consuming public.

BRIEF DESCRIPTION OF THE FIGURES

[0011] For a better understanding of the present invention, reference may be had to the following description of an exemplary embodiment thereof, considered in conjunction with the accompanying drawings in which:

[0012] **FIG. 1** is a front perspective view of one preferred embodiment of the present invention night vision binocular assembly;

[0013] **FIG. 2** is an exploded view of the embodiment shown in **FIG. 1** to facilitate consideration and discussion;

[0014] **FIG. 3***a* is a cross-sectional view of a section of the housing of the present invention binocular assembly, shown prior to assembly;

[0015] **FIG. 3***b* is a cross-sectional view of a section of the housing of the present invention binocular assembly, shown after assembly;

[0016] **FIG. 4** is an exploded view of the electro-optical subassembly contained within the present invention binocular assembly;

[0017] **FIG. 5** is an exploded view of a diopter cell subassembly contained within the present invention binocular assembly;

[0018] **FIG. 6** is a cross-sectional view of the region of the present invention binocular assembly containing the diopter cell subassembly, viewed along section line **6-6** as expressed in **FIG. 1**; and

[0019] **FIG. 7** is a cross-sectional view of the image intensifier tube contained within the present invention binocular assembly, viewed along section line **7-7** as expressed in **FIG. 4**; and

[0020] **FIG. 8** is a block diagram illustrating the electrical operations of the present invention binocular assembly.

DETAILED DESCRIPTION OF THE INVENTION

[0021] Referring to **FIG. 1**, there is shown one preferred embodiment of the present invention night vision binoculars **10**. As will be explained, the night vision binoculars **10** have a single objective lens for receiving infrared and low intensity light and two eye piece assemblies **12, 14** for viewing a visible image created from the received light. As will be later explained, the objective lens and the two eyepiece or ocular assemblies **12, 14** are adjustable to the physical and optical needs of the viewer that is utilizing the night vision binoculars **10**.

[0022] The optics and electronics of the night vision binoculars **10** are encased in a waterproof housing **16**. The housing **16** itself includes a upper half or section **18** and a lower half or section **20** that are joined together by a fluid impermeable seal, **21** formed about the peripheral edges of section **118** and **20** when the sections are coupled together. The housing **16** is preferably made of a material that is highly impact resistant, corrosion resistant and is light weight. In a preferred embodiment, the housing **16** is made of a thermoplastic material such as XENOY® PC/PBT resin alloy. However similar thermoplastic materials such as the XENOY® 2000 & 5000 Series thermoplastic alloys can also be used. These generally are polyester bond urethanes. These thermoplastics are supplied by the General Electric Company via the GE Plastics Division. Such materials are light weight and provide the needed corrosion resistance and impact resistance. Furthermore, such materials can be manufactured in a variety of bright colors. It is desirable to produce the night vision binoculars **10** with a brightly colored housing to facilitate the location of the binoculars should they be misplaced or accidentally dropped into a body of water such as a lake or the ocean. The water tight housing **16** of the night vision binoculars **10** is sized to make the night vision binoculars **10** buoyant. Furthermore, the components of the night vision binoculars **10** are so distributed within the housing **16** so that the night vision binoculars **10** will float in the upright position shown in **FIG. 1** or in the upside down position. This exposes the maximum surface area of housing **16** which floats above the water and thereby making the binoculars **10** more easy to spot in the water.

[0023] Since the water tight housing **16** is preferably a thermoplastic material, the housing **16** is relatively rigid. To enhance the impact resistance of the night vision binoculars **10**, elastomeric material in the form of eyeshades **22, 24** are placed around each of the eyepiece assemblies **12, 14**. Similarly, a elastomeric bumper **26** is disposed around the objective lens of the night vision binoculars **10**. The elastomeric material at these positions helps absorb the energy of an impact should the binoculars **10** be dropped. By placing the elastomeric material around the region of the eyepiece assemblies **12, 14** and the objective lens, it is less likely that the force of impact will be transferred to these optical elements with enough energy to damage these elements. Furthermore, the elastomeric eyeshades **22,24** surrounding each of the eyepiece assemblies, **12, 14** shade a persons eyes from secondary light and provide comfort when viewing the night vision binoculars **10**.

[0024] Some of the electronic components contained within the night vision binoculars **10** are controlled by actuatible elastomeric switch projections employed as actual

buttons that extend through associated apertures in the upper half **18** of the housing **16**. The control buttons include an on/off button **28** for controlling the activation and deactivation of the binoculars **10**, a focus button **30** for controlling the focus conjugate of the objective lens and a set of two brightness buttons **31** for controlling the brightness of the viewed image.

[**0025**] As will be later explained, the night vision binoculars **10** are manufactured with one set power of magnification. The night vision binoculars **10** may also be joined with a supplemental magnification lens **32** to increase the power of magnification. For instance, the night vision binoculars **10** may come with an initial power of magnification of **3**×, however when the supplemental magnification lens **32** is added, the power of magnification may be increased to **8**×. The supplemental magnification lens **32** shown has a threaded end **34** that engages the night vision binoculars **10**. Such interconnections systems are well known for joining telephoto lenses to cameras and any such know interconnection system may be employed. Similarly, interference fit connections or other such mechanical interconnection systems may also be employed.

[**0026**] Referring to **FIG. 2**, in conjunction with **FIG. 1**, it can be seen that doomed projections creating the on/off switch **28**, focus button **30** and brightness control buttons **31** are all unistructurally formed form a single molded piece of elastomeric material. The elastomeric structure **36** is water impermeable and the various domed projections are formed in the elastomeric structure **36** so that they pass through an associated button aperture **37** in the upper half **18** of the housing **16**. Some identifying indicia may be molded onto the buttons to help a person easily identify the function of the button. A circuit board **38** is disposed against the elastomeric structure **36** within the housing **16**. Membrane switches, such as keyboard type switches **40**, or other pressure sensitive switches are disposed on the circuit board **38** directly below the on/off button **28**, focus button **30** and brightness control buttons **31**. As a result, as the on/off **28**, focus button **30** or brightness control buttons **31** are depressed, the membrane of the switch is actuated thus closing or opening the switch. These switches are bipolar as normally open or normally closed and when activated operate in the opposite state (ON or OFF) a corresponding signal is generated within the circuitry of the circuit board **38** by the below lying pressure switch **40**.

[**0027**] Connecting apertures **41**,**42** are disposed in the elastomeric structure **36** and the circuit board **38**, respectively. In one embodiment, locking pegs or extensions **44** extend downwardly from the upper half **18** of the housing **16**. The elastomeric sheet or structure **36** with the extending elastomeric domed buttons **28**, **30** and **31** is placed over the plurality of pegs or locking extensions **44** via the apertures, **41** so that it is precisely located due to the plurality of spaced pegs and apertures. The sheet **36** is glued securely in place to the housing by means of a waterproof adhesive such as methyl acrylate or a similar viscous waterproof epoxy. As a result, the sheet **36** is joined to the housing section **18** and provides a water tight seal. The locking extensions **44** pass through the connecting apertures **41**, **42** in the elastomeric structure **36** and the circuit board **38**, wherein the locking extensions **44** are heat sealed or otherwise formed to secure and locate the circuit board **38** improper position with respect to the elastomeric sheet. As a result, the elastomeric sheet structure **36** is retained between the circuit board **38** and the upper half **18** of the housing **10** assisting in the invention of a water impermeable seal with the housing **18**. The resultant compression of the elastomeric structure **36** helps the elastomeric structure **36** to further act as a gasket and create a seal around each of the button apertures **37**. Consequently, should the night vision binoculars **10** be submerged in water, the water cannot enter the housing **16** through the button apertures **37** in the housing **16**. It will be understood that the use of a plurality of locking and locating extension **44** is merely exemplary and the circuit board **38** uses may be joined to the housing **16** using other schemes. In any event, the above techniques is extremely effective and inexpensive as the elastomeric sheet when glued in position and located by the pegs automatically is aligned with the membrane switches **40** on the board **38** and forms a waterproof cover and seal for both the board and the housing.

[**0028**] As can be seen from **FIG. 2**, the upper half **18** and the lower half **20** of the binocular housing **16** join together along a complex peripheral path which path is defined by the peripheral edge of the corresponding openings of the upper and lower housing halves **18** and **20**. However, it is necessary to join the upper half **18** and the lower half **20** of the housing **16** together to create a fluid impermeable seal along the common joint **21** (**FIG. 1**). Such a seal may be accomplished through the use of a suitably shaped gasket placed between upper half **18** and the lower half **20** of the housing **16**. However, due to the complex shape of the peripheral edges, a gasket that would operate to join and seal the edges would be expensive to manufacture and highly labor intensive to install. Thus, in order to avoid the use of a gasket the peripheral edge of the upper housing section **18** is formed with a depending peripheral projection (**46** of **FIG. 3A**) while the corresponding edge of the lower housing section **20** is provided with a corresponding peripheral groove (**50** of **FIG. 3A**). The projection and groove are specially shaped to enable a inner seal formation as will be further explained when referring to **FIGS. 3A and 3B**. In this mariner, when the top housing section **18** is placed in congruency with the bottom housing section **20** the projection engages the groove to enable insertion of the top half housing section **18** into the lower half. As will be explained, both the projection **18** and groove **50** are specially shaped to contain a suitable adhesive enabling an inner peripheral housing seal to be formed to thus provide a waterproof seal for the housing **10** between the upper and lower halves without the need for a gasket. Referring to **FIG. 3***a*, there is shown a section of the upper half **18** of the housing **16** just prior to its being inserted into the corresponding groove of the bottom half **20** of the housing **16**. The upper section **18** of the housing **16** has a projection **46** extending downwardly therefrom. The bottom surfaces **48**, **49** on either side of the projection **46** lay in two different planes, with the bottom surface **48** proximate the exterior of the housing being higher than the bottom surface **49** proximate the interior of the housing. The lower section **20** of the housing **16** has a shaped groove or receptacle **50** formed along the edge that faces the upper section **18** of the housing **16**. The top surfaces **51**, **52** on either side of the receptacle **50** also lay in two different planes with the top surface **51** proximate the exterior of the housing being higher than the top surface **52** proximate the interior of the housing. For a purpose which will later be explained, the receptacle **50** on the lower section **20** of the housing **16** is

sized to be significantly larger than the projection **46** extending from the upper section **18** of the housing **16**.

[**0029**] Prior to the upper section **18** of the housing **16** being joined to the lower section **20**, an adhesive **54** is applied within the groove **50** of the lower section **20**. The adhesive **54** is material that bonds to the thermoplastic material of the housing **16** and cures to become water impermeable. A suitable and preferable adhesive contains methyl acrylate as a component which can be applied and employed similar to an epoxy using an activator which is mixed with the adhesive material. Such materials are available from ITW adhesive systems, of 30 Endicatt Street Danvers, Mass. 01923. There are other adhesives which will operate as well. The adhesive has to be relatively viscous and hence not pour but act as an epoxy as being thick so it can be extruded to form the seal. Referring to **FIG. 3***b*, it can be seen that as the upper section **18** of the housing **16** is joined to the lower section **20**, a larger gap **55** is created proximate the interior of the housing than is created proximate the exterior of housing. As a result, the adhesive **54** present between the upper section **18** and the lower section **20** is directed toward the inside of the housing structure. Excess adhesive that is extruded from the joint creates a bead **56** on the inside of the housing. The bead **56**, created by the surface tension of the adhesive **54**, covers the entire joint along the inside of the housing **16**. Notches **57**, **58** are disposed on the upper section **18** and the lower section **20** of the housing **16** at points proximate the exterior of the housing **16**. As the upper and lower sections **18**, **20** are joined, a semi-rectangular relief **59** is formed on the exterior of the housing **16** that runs along the joint between the upper and lower sections **18**, **20**. Excess adhesive **54** that is extruded from the joint fills the back of the semi. rectangular relief **59** thereby providing a clean assembly without a highly visible line of adhesive. The presence of the adhesive **54** between the upper and lower section **18**, **20**, in the semi-rectangular relief **59** and along the bead **56** inside the housing **16**, creates a barrier that hermetically seals the interior of the housing **16**. Once the adhesive **54** cures, a fluid impermeable seal is created between the upper and lower sections **18**,**20** of the housing **16** without the use of a gasket. As a result, the upper and lower sections **18**, **20** of the housing **16** can be joined in a cost effective and labor efficient manner.

[**0030**] Returning to **FIG. 2**, primary electro-optical subassembly **60** is shown and to be positioned within the internal hollow of the housing below the circuit board **38**. The electro-optical subassembly **60** includes an objective lens assembly **62** for receiving and focusing infrared energy, an image intensifier tube **64** for converting the infrared energy from the objective lens **62** into a visible image, a collimator lens assembly **66** for collimating the visible image, a beam splitter **67** for dividing the collimated image and two diopter or ocular cell assemblies **68**, **70** through which the divided image is viewed with binocular vision. Each housing half section **18** and **20** have partial apertures which form full window apertures as **74** and **72** when the housings sections or halves are secured or joined together. Accordingly, window apertures **72**,**74** are formed in the housing **16**. The aperture **72** aligns with the objective lens assembly **62** allowing infrared energy to pass into the housing **16** and impinge upon the objective lens assembly **62**. A protective window **75** is positioned within the aperture **72** through which the infrared energy passes. The window **75** is secured to the housing **16** with a fluid impermeable seal or adhesive thereby preventing the flow of water into the housing **16** through the aperture **72**. In a similar arrangement, two viewing apertures **74** align with the diopter cell assemblies **68**, **70** to provide the ocular viewing paths. Protective windows **76** are positioned within the view apertures **72**. The protective windows **76** are joined to the housing **16** with a fluid impermeable seal, (using the above described adhesive), thereby isolating the environment contained within the housing **16**. A light sensor **65** is disposed within the housing **16**. The light sensor **65** senses light through an aperture **69** in the housing **16**. The complete aperture **69** is formed when sections **19** and **20**. The aperture **69** is aligned along an axis parallel to the longitudinal axis or optical axis of the objective lens assembly **62**. As such, the light sensor **56** operates detect the intensity of radiant energy that is impinging upon the objective lens assembly **62**. This enables one to operate circuitry to block or deactivate the image intensifier tube **64** for excessive light levels which could damage the screen of the tube. See for example, U.S. Pat. No. 5,146,077 entitled "GATED VOLTAGE APPARATUS FOR HIGH LIGHT RESOLUTION AND BRIGHT SOURCE PROTECTION OF IMAGE INTENSIFIER TUBE by Casert et al., issued on Sep. 8, 1992 and assigned to the assignee herein. That patent describes protection circuits as well as describing GEN II and GEN III image intensifier. A protective window **63** covers the aperture **69** in a fluid impermeable manner, thereby protecting the light sensor **65** and the interior of the housing **16** from moisture and other contaminants.

[**0031**] Referring to **FIG. 4** in conjunction with **FIG. 2**, it can be seen that the objective lens assembly **62**, image intensifier tube **64**, collimator lens assembly **66** and diopter cell assemblies **68**, **70** all are supported by a common optical base or support structure **80**. The common optical base **80** is "T" shaped having the top arm of the "T" of a planar configuration with a right and left slots **98** and **99** positioned on either side of the central arm of the "T". The central arm of a semi-cylindrical shape extending from the top arm and for accommodating the objective lens, the image intensifier and so on. Because of the common base configurations thermal expansion or contraction caused by a change in temperature will cause the objective lens assembly **62**, image intensifier tube **64**, collimator lens assembly **66** and diopter cell assemblies **68**, **70** to be integrally effected thus maintaining the exact alignment for all such changes. As a result, the distances between the optical components remains generally constant, eliminating distortions that could be caused by uneven thermal expansions and contractions. In the preferred embodiment the casings surrounding the lenses in the objective lens assembly **62**, collimator lens assembly **66** and diopter cell assemblies **68**, **70** have the same general coefficient of thermal expansion as does the base structure **80** so as to promote a uniform response to any change in temperature and maintain the preset relationships between the various optical components. A suitable material for the common optical bed or base **80** is a poly carbonate plastic.

[**0032**] In the shown embodiment, the beam splitter **67** is coupled to the collimator lens assembly **66** and is attached to the optical base structure **80** by a semicircular clamp **81**. The casing **82** of the collimator lens assembly **66** has a flat region **83**. Similarly, the semicircular clamp **81** also has a flat region **84**. Consequently, as the collimator lens assembly **66**

is connected to the base structure **80** by the semicircular clamp **81**, the two flat regions **83, 84** align and the collimator lens assembly **66** with beam splitter **67** are automatically held in a predetermined set orientation. As such, by simply clamping the collimator lens assembly **66** to the base structure **80**, the collimator lens assembly **66** and beam splitter **67** are properly optically aligned with the other optical elements within the binocular housing. Collimator lens assemblies for night vision binoculars are known devices as is exemplified by U.S. Pat. No. 5,117,553 to Phillips entitled COLLIMATOR FOR A BINOCULAR VIEWING SYSTEM and assigned to ITT Corporation the assignee herein. This patent is incorporated herein by reference. The operative of collimator lens assemblies are well known.

[**0033**] An image intensifier tube **64** interconnects with the distal end **85** of the collimator lens assembly **66**. Although the image intensifier tube **64** can be of any type, in the preferred embodiment, the image intensifier tube is similar to a Generation II (GEN II) tube of a type manufactured by ITT Corporation, the assignee herein. In the shown embodiment, the image intensifier tube **64** has an elastomeric casing **86**. The base structure **80** includes an enclosed tubular region **87** that has a diameter slightly smaller than the elastomeric casing **86** of the image intensifier tube **64**. The elastomeric casing **86** of the image intensifier tube **64** passes into the enclosed tubular region **87** where it is retained by an interference fit. The lateral movement of the image intensifier tube **64** back and forth within the enclosed tubular region **87** is prevented by the interference fit and the abutment of the image intensifier tube **64** against the collimator lens assembly **66** and the sleeve **90** surrounding the objective lens assembly **62**.

[**0034**] The objective lens assembly **62** is surrounded by a circular sleeve **90** in such a manner so that the objective lens assembly **62** is free to move axially or reciprocate along the longitudinal axis of the tubular sleeve **90**. An aperture **91** is formed in the peripheral wall of the tubular sleeve **90**. A stop block **92** is connected to the objective lens assembly **62** and extends radially away from objective lens assembly **62** through the aperture **91**. As such, the stop block **92** contacts the edges of the aperture **91** as the objective lens assembly **62** moves back and forth. As a result, the stop block **92** limits the axial movement of the objective lens assembly **62** along the longitudinal axis of the tubular sleeve **90**.

[**0035**] Locking projections **93** extend radially from the tubular sleeve **90**. The locking projections **93** engage locking slots **94** formed in the tubular region **87** of the base structure **80**. By passing the projections **93** into the locking slots **94** and turning the tubular sleeve **90** relative the base structure **80**, the tubular sleeve **90** is locked into a desired set position on the base structure **80**.

[**0036**] A stepper motor **95** is connected to the base structure **80**. The stepper motor **95** has extending flanges **195** and **196** which enable the body of the motor to be inserted into the apertures **200** of a motor bracket **201** formed integrally or otherwise located on the common optical bed **80**. The flanges **195** and **196** of the motor **95** are secured to the bracket **201** via apertures as **202**. The shaft **96** of the motor as indicated is coupled to the stop block **92** to thus prove the objective lens **62** according to the motor operation. The stepper motor shaft **96** interconnects with the stop block **92** extending from the objective lens assembly **62**. As will later be explained, the stepper motor **95** can be activated to move its shaft **96** back and forth in the directions of arrow **97** utilizing incremental steps. This movement moves the objective lens assembly **62** within the tubular sleeve **90**, which therefore moves the lens **62** in relation to the image intensifier tube **64**. Small stepper motors capable of moving in small increments such as 0.0005 inches to 0.004 inches per step are commercially available such as those manufactured by Haydon Switch Instruments, Inc. of Connecticut and sold under the designation HSI miniature motors.

[**0037**] A position sensor such as a micro switch or pressure optical switch **148** is attached to the optical base structure **80** proximate to the stepper motor **95**. The position sensor **148** is contacted by the stop block **92** as the stepper motor **92** moves the stop block **92** back and forth. The distance between the position sensor **148** and the stop block **92** is set so that the position sensor **148** is triggered when the stop block **92** moves the objective lens assembly **62** to a position relative the image intensifier tube **64** to image the incoming energy at an infinite conjugate.

[**0038**] As indicated, slots **98, 99** are formed in the upper arm of the "_____" sloped base structure **80**. A mechanical fastener **100** or other similar element joins each of the diopter call assemblies **68,70**, to slide blocks **101, 102** through the slots **98, 99**. As a result, each of the diopter cell assemblies **68, 70** is joined to the base structure **80**, yet sill can move along the length of each of the slots **98,99**. The purpose of each of the diopter cells **68,70** is to redirect fight emanating from the collimator lens assembly **66** and split by the beam splitter **67** into the viewer's eyes.

[**0039**] Referring to **FIG. 5**, it can be seen that each of diopter cell assemblies is a snap-together assembly requiring no adhesives or mechanical fasteners. **FIG. 5** shows one of the diopter cell assemblies **68** as used in the present invention night vision binoculars. Each cell is identical. Light (designated by the arrows) entering the diopter cell assembly **68** passes through a first lens **105**, where it is reflected 45° by a mirror **106** and redirected through an ocular lens **107**. The first lens **105** and the mirror **106** are both connected to a common cell housing **108**. The cell housing **108** has a face surface **109** through which an aperture **110** is formed. The aperture **110** has a stepped rim sized to accommodate the first lens **105**. As a result, the first lens **105** can pass into, and become seated within, the aperture **110**. A snap-on cover **112** connects to the cell housing **108** over the first lens **105**. The cover **112** has an aperture **111** formed through it that is smaller than the diameter of the first lens **105**. Consequently, when the cover **112** is joined to the cell housing **108**, the first lens **105** becomes entrapped in a set position between the cover **112** and the cell housing **108**. The aperture **111** in the cover **112** is positioned to enable light to pass into the, first lens **105** and into the cell housing **108**. Pawl receptacles **113** are formed on the cell housing **108** points proximate the face surface **109**. The cover **112** has locking pawls **114** that extend into and engage the pawl receptacles **113** on the cell housing **108**, thereby interconnecting each of the two components with a snap fit.

[**0040**] Within the cell housing **108** a 45° sloped surface **116** extends between two side walls **117, 118**. An aperture **119** is disposed in the sloped surface **116** at a position that aligns with the aperture **110** in the face surface **109** of the cell housing **108**. A mirror **106** lays across the sloped surface

116 covering the aperture 119 in the sloped surface 116. The mirror 106 is held in one set position over the sloped surface 116 by a black plate 120. Projecting arms 122 extend from the four corners of the back plate 120. These projecting arms 112 engage notches 124 formed in the side walls 117, 118 as the back plate 120 passes between sidewalls 117, 118. The position of the notches 124 and the size of the back plate 120 correspond so that the back plate 120 engages the notches 124 with a slight interference fit, thereby enabling the projecting aims 122 to snap fit into the notches 124 and retain the back plate 120 in one set position. The back plate 120 biases the mirror 106 against the sloped surface 116, thereby retaining the mirror 106 over the aperture 119 in the sloped surface 116.

[0041] The mirror 106 directs light passing through the first lens 105 into the tubular region 125 of the cell housing 108. The tubular region 125 of the cell housing 108 is sized to receive a sliding collar 126 therein. Referring to FIG. 6 in conjunction with FIG. 5, it can be seen that the sliding collar 126 is a tubular structure that has locking fingers 128 proximate its distal end. The ocular lens 107 is inserted into the sliding collar 126 wherein the locking fingers 128 engage the lens 107 and forces the lens against an internal rim structure 129. As a result, the locking fingers 128 retain the lens 107 into a set position within the sliding collar 126. A key projection 130 extends radially from the exterior surface of the sliding collar 126. The key projection 130 has width W1 (FIG. 5) that is slightly smaller than the width W2 of a corresponding slot 132 in the cell housing 108. The sliding collar 126 fits within the tubular region 125 of the cell housing 108 wherein the key projection 130 enters the slot 132. The sliding collar 126 is free to move back and forth within the cell housing 105 provided the key projection 130 does not contact the back edge 131 of the slot 132. The presence of the key projection 130 in the slot 132 prevents the sliding collar 126 from rotating within the cell housing 108 to thus retain the viewing lens 107 in its proper orientation as it is moved back and forth with the sliding collar 126.

[0042] An adjustment shaft 134 also extends radially from the exterior of the sliding collar 126. The adjustment shaft 134 passes into a second slot 135 in the cell housing 108 as the sliding collar 126 is positioned within the cell housing 108. As the overall diopter cell 68 is assembled within the night visi on binoculars, the adjustment shaft from each of the two diopter cells aligns with slots 77, formed in the bottom of the lower half of the housing as is shown in FIG. 2. Adjustment knobs 137 extend through each of the slots 77 in the housing and engage the adjustment shafts 134. As can be ascertained from FIG. 6, the adjustment knobs 137 can be moved back and forth in the directions of arrow 138 and also back and forth into and out of the plane of the paper. As the adjustment knobs 137 are moved back and forth in the directions of arrow 138, the sliding collar 126 is caused to move back and forth within the cell housing in the same direction. This changes the position of the ocular lens 107 with respect to the other optical elements in the binoculars. Consequently, the movement of the ocular lenses 107 acts as a focus adjustment, whereby the binoculars can be individually adjusted for each eye. As the adjustment knobs 137 are moved back and forth into and out of the plane of the paper, each of the diopter cell assemblies are caused to move with the adjustment knobs 137. Such a manipulation various the distance in between the diopter cell assemblies thereby providing an interpupillary adjustment to the night vision binoculars. The movement of the adjustment knobs 137 causes the diopter cell assemblies to move back and forth in the slots 98, 99, shown in FIG. 4. As a result, the distance between each of the diopter cell assemblies and the beam splitter can be varied individually and the diopter cell assemblies can be individually adjusted as desired. This type of operation interpupillary adjustment and focus is described in the copending application Ser. No. 07/954,006 indicated above. Elastomeric grommets 133 seal the slots 77 around each of the adjustment knobs 137, thereby creating a fluid impermeable seal that prevents water and other contaminants from entering the binocular housing. The grommets are secured to the housing by adhesive seals.

[0043] Referring now solely to FIG. 2, the optical operation of the night vision binoculars 10 can be described. To activate the night vision binoculars 10, the on/off button 26 is depressed. Upon activation, the stepper motor 95 is enabled whereby the stepper motor 95 focuses the objective lens assembly 62 at a generally infinite conjugate. The focus of the objective lens assembly 62 can be changed by the manipulation of the focus button 30. By depressing either side of the focus button 30, the stepper motor 95 can be controlled in a manner that provides a variable adjustment to the objective lens assembly 62 between an infinite conjugate and a conjugate of one meter. For example, by depressing the elastomeric switch activator or button on the left side, the stepper motor rotate the shaft 96 counter clock wise (CCW) to cause the motor shaft 96 to move forward and by depressing the elastomeric switch activator the right side the motor move clock wise (CW) to cause the motor shaft to move in the appropriate direction of vice versa.

[0044] Infrared or low intensity visible light is directed through the objective lens assembly 62 onto the image intensifier tube 64. The image intensifier tube 64 produces a visible image which is then directed to the collimator lens assembly 66. The brightness of the image produced by the image intensifier tube 64 is controlled by the manipulation of the brightness buttons 31. By depressing one of the brightness buttons 31, the gain of the image intensifier tube 64 can be increased or decreased, thereby increasing or decreasing the brightness of the image produced. Brightness controls for image intensifiers are well known. Since the image intensifier tube 65 is highly sensitive to light, a light sensor 65 is also made part of the night vision binoculars assembly. The light sensor 65 is coupled to a control circuit on the circuit board 38 that compares the detected light level to a threshold level and automatically turns off the image intensifier tube 64 should the threshold light level be surpassed.

[0045] The image produced by image intensifier tube 64 is directed through the collimator lens assembly 66 that reimages the image at a generally infinite conjugate. The conjugated image is then split in two by the beam splitter 67 and directed toward the two diopter cell assemblies 68, 70. The split image passes through each of the diopter cell assemblies where it is viewed with binocular vision and focused to the requirements of the user. The focusing and interpupillary positioning of each of the diopter cell assemblies 68, 70 is controlled by the adjustment knobs 137 as has been previously explained.

[0046] Referring to FIG. 7, a cross section of one preferred embodiment of the image intensifier tube 64 and its

elastomeric casing **86** are shown. Although the image intensifier tube **64** can be of any known design, it is preferably a GEN II image intensifier tube. The operation of the GEN II image intensifier tube is known in the art. In the shown embodiment, the image intensifier tube **64** is a type of GEN II tube that has been modified to be produced at a much lower cost than typical GEN III tubes for military applications. The image intensifier tube **64** has a photocathode **71**, microchannel plate **73**, and a optical window **77** coated with a phosphor screen **78**. To operate the image intensifier tube **64** various known electrical biases are applied to the photocathode **71**, microchannel plate **73** and phosphor screen **78** to promote the flow of electrons from the photocathode **71** to the phosphor screen **78**. In the prior art, electrical potentials were supplied to these components utilizing connector pins that extended into the evacuated housing of the image intensifier tube. Typically, the connector pins were disposed as far away form one another as possible to prevent any arcing from accuring the various connector pins. In the shown embodiment, electrical bias is supplied to the photocathode **71**, microchannel plate **73**, and phosphor screen **78** via conductive annular flanges **79** that radially extend from the image intensifier tube **64**. Wires **88** are then joined to the annular flanges **79** at the most convenient point and need not be directed to a single connector pin.

[**0047**] The elastomeric casing **86** that surrounds the image intensifier tube **64** is molded around the image intensifier tube **64**. As such, the elastomeric material of the casing **86** fills the spaces between the various annular flanges **79**. The elastomeric casing **86** therefore acts to encapsulate each of the annular flanges **79** and electrically isolates the annular flanges **79** from one another. The elastomeric casing **86** further acts to encapsulate the interconnection point between the various annular flanges **79** and wires **88**, thereby deterring the wires **88** from detaching from the annular flange **79**. The glass input and output plates as **78** and **77** are the same exact configuration with the exception of the domed portion **89**. The annular connecting rings and the plate shape enable a inexpensive tube to be provided.

[**0048**] Referring to **FIG. 8**, there is shown a block diagram detailing the operational logic for the electrical components of the present invention night vision binoculars. As has been previously described, the optical components of the night vision binoculars include an objective lens assembly **62**, and an image intensifier tube **64**, a collimator lens assembly **66** and at least one diopter cell assembly **68**. In the preferred embodiment, the night vision binoculars are a self contained transportable unit. As such, the power supply **141** to the binoculars are preferably batteries. Referring to, **FIG. 2, a** battery housing compartment **123** in the bottom half section **20** accommodates a buttery **124**. The batter **124** is held in the housing compartment **123** by a cover **125** having a flange **126** and gasket which seals the battery within the compartment **123**. The battery terminals are connected to terminals **126** and **127** which in turn operate to power the elastomeric. The batteries can be disposable or rechargeable and are preferably widely commercially available. The on/off operation of the power supply **141** is controlled by the tactile manipulation of the on/off button **20** that is operational from the exterior of the binocular housing.

[**0049**] A C.P.U. **144** or suitable programmed logic array (PLA or PLD) controls the electrical operation of the night vision binoculars. The C.P.U. **144** is contained within the circuit board assembly **38** previously shown in **FIG. 2**. Although several other functions may be incorporated, the C.P.U. **144** serves primarily as a voltage regulator control **142**, a motor control **146** and brightness operative. A high voltage supply **150** is coupled to the C.P.U. **144**. The C.P.U. **144** directs current from the power supply **141** to the high voltage supply **150**, where the initial six volt power supply is amplified to the voltage requirements of the components within the image intensifier tube **64**. The voltage requirements of various image intensifier tubes are well known in the art and need not be disclosed in detail herein. Gain control buttons **31** are coupled to the C.P.U. **144**. The gain control buttons **31** control the operation of the high voltage supply **150**. As a result, by manipulating the gain control buttons **31**, the voltages supplied to the different components of the image intensifier tube **64** can be changed. By varying the voltages supplied to the image intensifier tube **64** the gain of the tube can be controlled, thereby controlling the brightness of the image that the image intensifier tube **64** produces.

[**0050**] A light sensor **89** is coupled to the C.P.U. **144**. The light sensor **89** detects the intensity of light that is impinging upon the objective lens assembly **62**. The C.P.U. **144** reads the signal from the light sensor **65** and automatically adjusts the gain of the image intensifier tube **64** to optimize the contrast of the image being viewed. Furthermore, the C.P.U. **144** compares the signal from the light sensor **89** to a predetermined threshold valve. If the light sensor **89** detects a light intensity greater than the threshold valve, the gain controller **144** can deactivate the image intensifier tube **64** to prevent damage to the image intensifier tube **64**.

[**0051**] As has been previously described, the objective lens assembly **62** is coupled to stepper motor **95** that is capable of focusing the objective lens assembly **62** between an infinite conjugate and a conjugate of one meter. The operation of the stepper motor **95** is controlled by the motor drive **146**. The C.P.U. **144**, via the motor drive **146**, automatically focuses the objective lens assembly **62** to an infinite conjugate each time the night vision binoculars are turned on. Such an automatic adjustment is made utilizing a position sensor **148** that is coupled to the objective lens assembly **62**. The position sensor **148** signals the C.P.U. **144**, thereby deactivating the motor drive **146** when the objective lens assembly **62** is properly focused at an infinite conjugate. Adjustments away from the infinite conjugate are made via the focus control buttons **30** that cause the motor drive **146** to advance the stepper motor **95** and change the position of the objective lens assembly **62**.

[**0052**] An LED **123** is disposed in the diopter cell assembly **68** in a manner that enables the light from the LED to be viewed by the viewer. The LED **132** is coupled to the C.P.U. **144** and lights when the power supply **141** is drained, thereby indicating that the batteries are low to the viewer.

[**0053**] The above described night vision binocular device enables the amplification of light up to 20,000 times for optimum night viewing. The power focus and interpupillary adjustment ensure easy and simple operation. The apparatus with the battery is light and a typical device weighs less than 30 ounces and can float. The device is battery operated, provides a 40 degree flied of view (FOV) and has an automatic shut off to protect the image intensifier. The device is 74¾" (length) 5½ (width) and $2\frac{3}{5}$" (height). The casing is waterproof and impact resistant.

[0054] It will be understood that the night vision binocular assembly described herein is merely exemplary and that a person skilled in the art may make many variations and modifications to the described embodiments utilizing functionally equivalent components to those described. All such variations and modifications are intended to be included within the scope of this invention as defined by the appended claims.

What is claimed is:

1. A night vision apparatus, comprising:

a housing;

at least one objective lens arrangement; image intensifier means for producing an intensified visible image from energy directed to said image intensifier means by said objective lens arrangement;

at least one eyepiece lens arrangement for viewing said intensified visible image; and

a unistructural support member, positionable within said housing, upon which said objective lens arrangement, said image intensifier means and said eyepiece lens arrangement attach, wherein thermal contractions and expansions caused by changes in temperature are evenly distributed between said objective leans arrangement, said image intensifier means and said eyepiece lens assembly, maintaining a predetermined optical relationship therebetween within said housing.

2. The apparatus according to claim 1, wherein said objective lens arrangement and said eyepiece lens arrangement both include optical elements held in casings, wherein said support member has generally the same coefficient of thermal expansion as does each of said casings.

3. The apparatus according to claim 1, further including a collimator lens assembly disposed between said image intensifier means and said at least one eyepiece for collimating said intensified optical image, wherein said collimator lens assembly is attached to said support member and is maintained at a predetermined optical relationship with respect to said eyepiece lens assembly and said image intensifier means within said housing.

4. The apparatus according to claim 3, wherein said collimator lens assembly includes optical elements held in a casing and said casing has generally the same coefficient of thermal expansions as said support member.

5. The apparatus according to claim 3, further including a beam splitting means for splitting the intensified visible image exiting said collimator lens assembly and directing the split image to two eyepiece lens assemblies for binocular viewing.

6. The apparatus according to claim 5, wherein the two eyepiece lens assemblies have a interpupillary distance therebetween and said support member includes a means thereon for enabling a change in said interpupillary distance without disconnecting either of said eyepiece lens assemblies from said support member.

7. The apparatus according to claim 1, wherein said image intensifier tube includes an elastomeric casing and said support member includes a structure capable of retaining said elastomeric casing of said image intensifier tube with an interference fit.

8. The apparatus according to claim 1, wherein said objective lens assembly includes a lens arrangement subassembly and a tubular structure that surrounds said lens arrangement; wherein said lens arrangement can move reciprocally along the longitudinal axis of said tubular structure within a given range and said tubular structure interconnects with said support structure.

9. The apparatus according to claim 8, further including a positioning means for selectively adjusting the position of said lens arrangement in said tubular structure, wherein said positioning means directly interconnects said lens arrangement to said support member.

10. The apparatus according to claim 10, wherein said position means is a stepper motor having a variable length drive shaft.

11. A waterproof electronic assembly, comprising:

a housing, having any internal hollow made from a fluid impervious material, having at least one button aperture located on a surface thereof;

at least one circuit board disposed in said housing hollow and having at least one tactile controlled element located thereon that is positioned below said button aperture; an elastomeric member disposed between said circuit board and said housing, said elastomeric member being sealed to said housing within said hollow, wherein said elastomeric member has a projecting portion which extends through said button aperture to enable said tactile control element to be activated by depressing said elastomeric member through said button aperture; and

means for fastening said circuit board to said housing, wherein said circuit board contacts said elastomeric member and compresses said member against said housing to enable a fluid impervious seal to be formed about said button aperture.

12. The assembly according to claim 11, wherein said housing has a plurality of button apertures thereon and said elastomeric member extends through each of said button apertures, said elastomeric member being a single unistructural member.

13. The apparatus according to claim 11, wherein said elastomeric member has indicia formed thereon, said indicia extending through said button apertures so as to be identifiably by a person engaging said elastomeric member through said button apertures.

14. The apparatus according to claim 11, wherein said elastomeric member is generally planar in shape having at least one button projection extending upwardly therefrom, said button projection s extending through said button apertures in said housing when assembled between said housing and said circuit board.

15. A housing assembly for encasing an optical apparatus within the interior of said housing assembly, comprising:

a first housing section having a bottom rim;

a second housing section having a top rim adapted to interconnect with said bottom rim of said first housing section along. a common interface joint;

adhesive means disposed between said bottom rim and said top rim for adhesively joining said first housing section to said second housings section, wherein the interconnection of said top rim to said bottom rim is adapted to extrude some of said adhesive into said interior of said housing assembly, said adhesive cov-

ering said interface joint on the interior of said housing assembly creating a fluid impervious seal.

16. The assembly according to claim 15, wherein said first housing section and said second housing sections are made from an impact resistant material.

17. The assembly according to claim 15, wherein said bottom rim has a male projection extending therefrom and said top rim has a female receptacle formed therein to receive said male projection.

18. The assembly according to claim 15, wherein a gap exits between said bottom rim and said top rim as said bottom rim and top rim are joined, said gap being largest proximate said interior of said housing assembly promoting the extrusion of adhesive toward said interior of said housing assembly.

19. The assembly according to claim 15 further including apertures in said first housing section and said second housing assembly to enable light energy to interact with said optical apparatus and window elements attachable to said first housing section and said second housing section in a fluid impervious manner to cover said apertures an isolate said interior of said housing assembly.

20. The assembly according to claim 15 further including a recess formed along said interface joint on the exterior of said housing assembly, wherein said recess is sealed in a fluid impervious manner by said adhesive means extruded from said interface joint as said first housing section is joined to said second housing section

21. A night vision apparatus comprising:

a watertight housing, the outer surface of which is configured to have generally upper, lower and side faces, the combined surface arm of said upper and lower facts being substantially greater than the surface areas of said side faces and said housing being further configured for enabling said apparatus to float in water; and

an optical assembly contained within the interior of said housing positioned therein for causing said apparatus, when immersed in water, to float in a manner that either said upper face or said lower face is exposed above and substantially parallel to the surface of the water.

22. The apparatus according to claim 21 wherein said optical assembly includes an objective lens and said apparatus is configured for receiving a supplemental magnification lens external to said housing and in optical alignment with said objective lens.

23. The assembly according to claim 19 further comprising elastomeric material disposed adjacent at least one of said apertures for providing impact protection.

24. The apparatus of claim 1 wherein said eyepiece lens arrangement comprises a snap-together assembly.

25. The apparatus of claim 24 wherein said eyepiece lens arrangement comprises a cell housing, at least one lens and a mirror, wherein said lens and said mirror are snap-connected to said cell housing.

26. The apparatus of claim 24 wherein said eyepiece lens arrangement comprises:

a collar configured to slidably engage said cell housing;

a first lens snap-connected to said cell housing; and

a mirror snap-connected to said cell housing;

wherein said collar is configured to enable said second lens to be selectively positionable relative to said mirror while remaining in optical alignment with said mirror.

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