IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

APPLICATION
FOR UTILITY PATENT

Floating Underwire- Weight Channeling Device

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BACKGROUND

[0001] The device can be inserted into any bra on the market to alleviate the weight of breasts.

[0002] The embodiments herein generally relate to women's undergarments and particularly relate to brassieres or bras. The embodiments herein more particularly relate to a weight transfer mechanism for brassieres or bras.

[0003] Brassieres, or bras as more commonly referred to, are garments worn by women to cover and support their breasts. Traditional bras consist of simply cups over the breasts which are held by a chest band that extends around the back and two straps on both sides of the shoulder going from the cups to the back where it attaches to the band and a fastening system for secure attachment of both the ends.

[0004] Current bras lift breasts and transfer the weight to the shoulders, neck and back portions of the body. The common problem with a shoulder strap of a bra is that the strap can be misaligned on a wearer's shoulder and thus, will dig into the shoulder due to the connection of the shoulder strap to the back panel of the bra. Even if the shoulder strap is aligned properly, it may nonetheless become uncomfortable after use due to the shape of the shoulder strap, its alignment with the back panel, and the anatomy of the shoulder and back of the wearer. Further, this shoulder strap can be extremely difficult when the bra has extremely high elastic properties which exist with many bras such as jogging and sports bra.

[0005] There is a need for a new and improved lift mechanism with a bra, especially one that keeps the weight of the breasts suspended up while exerting no pressure on the neck, back or shoulders of the wearer and transfers the weight directly to the band around the back instead for sharing the weight with the straps that go over the shoulders.

[0006] The above mentioned shortcomings, disadvantages and problems are addressed herein and which will be understood by reading and studying the following specification.

SUMMARY

[0007] The primary object of the embodiments herein is to provide a weight-channeling device that keeps the weight of the breasts suspended up and directs the total weight to the band, while exerting no pressure on the neck, back or shoulders of the wearer.

[0008] Yet another object of the embodiments herein is to provide a device that can be inserted into any bra which alleviates the weight of breasts from the shoulders of the wearer.

[0009] The embodiment functions by redirecting weight in a circular direction by introducing a fixed cylindrical position/epicenter connecting both sides of the underwire. Thus, if one lifts only the center fixed point, then the entire embodiment is lifted.

[0010] By connecting the side bands of a bra to the outer curve of the metal on both ends, one can direct the weight of breasts from the center closure to the bands.

[0011] An additional benefit to the wearer is also the ability to open the bra from the front by use of the same closure piece.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] The accompanying drawings illustrate a number of exemplary embodiments and are a part of the specification. Together with the following description, these drawings demonstrate and explain various principles of the instant disclosure.

[0013] Figure 1 is the floating underwire-weight channeling device.

[0014] Figure 2 is an exploded view of the device comprising internal springs (4) used to absorb the weight of the breasts. This view also shows arms (5) that can be attached to the frame of the device. These arms hold the bra cup and direct the weight of the bra cup to the frame of the underwire. The arms are spring loaded such that the springs within the device absorb the weight that arms sustain.

[0015] Figure 3 is the circular center closure on the end of the wire frame.

[0016] Figure 4 is a diagram showing how lines of force move in a circular direction when connected to fixed points.

[0017] Figure 5 is the two frames of the device connected together at the center.

[0018] Figure 6 is an exploded view of the device such that the right side is disassembled and the left side if fully assembled. On the right side one can observe that the embodiment comprises two panels that are attached together to for one. Additionally, the purpose of the two panels is the internal grooves on both panels such that when attached together forms a tubular channel/tunnel. This internal tubular channel houses a line of springs that commence from the center closure and end at the arms (Figure 3).

[0019] Furthermore, the line of springs within the internal channel is held within the channel by a series of shafts on ball bearings (Figure 2)(Part 6&7). These ball bearings reduce the friction of the springs against the internal channel of the device.

[0020] Figure 3 – Bra cups hold the breasts. When the embodiment is inserted into a bra, the arms (Part 5) hold up the bra cups. The internal springs (Part 4) hold up the arms. The internal springs direct all the weight from the arms to the center closure. The bands of a bra are connected to the entire embodiment on a horizontal plane parallel to the center closure, such that since the springs direct the total weight to the center closure, the bands then direct the weight from the center closure in the opposing direction so the band holds the total sum of the weight.

[0021] Figure 7 shows a labeled diagram of a bra standard bra, which the embodiment can be inserted into.

[0022] Figure 7 – The underwire section is the location of the embodiment. The “center front/gore” aligns with the center closure of the embodiment. The “band/under-band” holds up the entire embodiment/device. The arms of the embodiment, hold up the “point of bust’ part of the bra cup. The point of bust part of the bra cup is a single point from which if held up, will hold up the entire breast within that cup.

DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS

[0023] Whenever an object is tied to a fixed position, the gravitational force experienced by that object is directed in a circle. The curved underwire frame is that circle and the center closure is the fixed position (Figure 3) linking the two frames. A bra band is an interception of the circles of force, such that the entire weight is essentially re-directed to the band, by the introduction of the fixed position. This interconnected system of circular forces defines the floating lift.

[0024] Figure 4 - When a sphere is moved around its center it is always possible to find a diameter whose direction in the displaced position is the same as in the initial position.

[0025] To prove this, consider a great circle on the sphere and the great circle to which it is transported by the movement. These two circles intersect in two (opposite) points of which one, say *A*, is chosen. This point lies on the initial circle and thus is transported to a point *a* on the second circle. On the other hand, *A* lies also on the transported circle, and thus corresponds to a point *α* on the initial circle. Notice that the arc *aA* must be equal to the arc *Aα*.

[0026] Now one needs to construct point *O* in the surface of the sphere that is in the same position in reference to the arcs *aA* and *αA*. If such a point exists then: it is necessary, that the distances *OA* and *Oa* are equal to each other; the arcs *Oa* and *OA* must be equal.

[0027] Figure 4 - The angles *OAa* and *OaA* must also be equal, since *Oa* and *OA* have the same length. Thus *OAa* and *OAα* are equal, proving *O* lies on the angle bisecting *αAa*. To provide a complete construction for *O*, we need only note that the arc *aO* may also be constructed such that *AaO* is the same as *αAO*. This completes the proof.

[0028] A spatial rotation is a linear map in one-to-one correspondence with a 3×3 rotation matrix **R** that transforms a coordinate vector **x** into **X**, that is **Rx** = **X**. Therefore, another version of Euler's theorem is that for every rotation **R**, there is a vector **n** for which **Rn** = **n**. The line μ**n** is the rotation axis of **R**.

[0029] A rotation matrix has the fundamental property that its inverse is its transpose, that is $\mathbf{R}^\mathrm{T}\mathbf{R} = \mathbf{R}\mathbf{R}^\mathrm{T} = \mathbf{I}$, where **I** is the 3×3 identity matrix and superscript T indicates the transposed matrix.

[0030] Compute the determinant of this relation to find that a rotation matrix has determinant ±1. In particular,

$$1 = \det(\mathrm{I}) = \det(\mathrm{R}^\mathrm{T}\mathrm{R}) = \det(\mathrm{R}^\mathrm{T})\det(\mathrm{R}) = \det(\mathrm{R})^2 \quad \Longrightarrow \quad \det(\mathrm{R}) = \pm 1.$$

[0031] A rotation matrix with determinant +1 is a proper rotation, and one with a negative determinant −1 is an *improper rotation*, that is a reflection combined with a proper rotation.

[0032] It will now be shown that a rotation matrix **R** has at least one invariant vector **n**, i.e., **R n** = **n**. Because this requires that (**R** − **I**)**n** = 0, we see that the vector **n** must be an eigenvector of the matrix **R** with eigenvalue λ = 1. Thus, this is equivalent to showing that det(**R** − **I**) = 0.

[0033] Use the two relations:

$$\det(-\mathbf{R}) = (-1)^3 \det(\mathbf{R}) = -\det(\mathbf{R}) \quad \text{and} \quad \det(\mathbf{R}^{-1}) = 1,$$

to compute

$$\det(\mathrm{R}-\mathrm{I}) = \det\left((\mathrm{R}-\mathrm{I})^{\mathrm{T}}\right) = \det\left((\mathrm{R}^{\mathrm{T}}-\mathrm{I})\right) = \det\left((\mathrm{R}^{-1}-\mathrm{I})\right) = \det\left(-\mathrm{R}^{-1}(\mathrm{R}-\mathrm{I})\right)$$
$$= -\det(\mathrm{R}^{-1})\ \det(\mathrm{R}-\mathrm{I}) = -\det(\mathrm{R}-\mathrm{I}) \quad \Longrightarrow \quad \det(\mathrm{R}-\mathrm{I}) = 0.$$

[0034] This shows that λ = 1 is a root (solution) of the secular equation, that is,

$$\det(\mathbf{R} - \lambda\mathbf{I}) = 0 \quad \text{for} \quad \lambda = 1.$$

[0035] In other words, the matrix **R** − **I** is singular and has a non-zero kernel, that is, there is at least one non-zero vector, say **n**, for which

$$(\mathbf{R} - \mathbf{I})\mathbf{n} = \mathbf{0} \quad \Longleftrightarrow \quad \mathbf{R}\mathbf{n} = \mathbf{n}.$$

[0036] The line μ**n** for real μ is invariant under **R**, i.e., μ**n** is a rotation axis. This proves Euler's theorem.

[0037] Equivalence of an orthogonal matrix to a rotation matrix

[0038] Two matrices (representing linear maps) are said to be equivalent if there is a change of basis that makes one equal to the other. A proper orthogonal matrix is always equivalent (in this sense) to either the following matrix or to its vertical reflection:

$$\mathbf{R} \sim \begin{pmatrix} \cos\phi & -\sin\phi & 0 \\ \sin\phi & \cos\phi & 0 \\ 0 & 0 & 1 \end{pmatrix}, \qquad 0 \le \phi \le 2\pi.$$

[0039] Then, any orthogonal matrix is either a rotation or an improper rotation. A general orthogonal matrix has only one real eigenvalue, either +1 or −1. When it is +1 the matrix is a rotation. When −1, the matrix is an improper rotation.

[0040] If **R** has more than one invariant vector then $\phi = 0$ and **R** = **I**. *Any* vector is an invariant vector of **I**.

Excursion into matrix theory

[0041] In order to prove the previous equation some facts from matrix theory must be recalled.

[0042] An $m \times m$ matrix **A** has *m* orthogonal eigenvectors if and only if **A** is normal, that is, if $\mathbf{A}^\dagger\mathbf{A} = \mathbf{A}\mathbf{A}^\dagger$.This result is equivalent to stating that normal matrices can be brought to diagonal form by a unitary similarity transformation:

$\mathbf{AU} = \mathbf{U}\ \mathrm{diag}(\alpha_1, \ldots, \alpha_m) \iff \mathbf{U}^\dagger\mathbf{AU} = \mathrm{diag}(\alpha_1, \ldots, \alpha_m)$, and **U** is unitary, that is, $\mathbf{U}^\dagger = \mathbf{U}^{-1}$.

[0043] The eigenvalues $\alpha_1, \ldots, \alpha_m$ are roots of the secular equation. If the matrix **A** happens to be unitary (and note that unitary matrices are normal), then

$\left(\mathbf{U}^\dagger\mathbf{AU}\right)^\dagger = \mathrm{diag}(\alpha_1^*, \ldots, \alpha_m^*) = \mathbf{U}^\dagger\mathbf{A}^{-1}\mathbf{U} = \mathrm{diag}(1/\alpha_1, \ldots, 1/\alpha_m)$ and it follows that the eigenvalues of a unitary matrix are on the unit circle in the complex plane:

$$\alpha_k^* = 1/\alpha_k \quad \Longleftrightarrow \alpha_k^*\alpha_k = |\alpha_k|^2 = 1, \qquad k = 1, \ldots, m.$$

[0044] Also an orthogonal (real unitary) matrix has eigenvalues on the unit circle in the complex plane. Moreover, since its secular equation (an *m*th order polynomial in λ) has real coefficients, it follows that its roots appear in complex conjugate pairs, that is, if α is a root then so is α*. There are 3 roots, thus at least one of them must be purely real (+1 or -1).

[0045] After recollection of these general facts from matrix theory, we return to the rotation matrix **R**. It follows from its realness and orthogonality that we can find a U such that:

$$\mathbf{RU} = \mathbf{U}\begin{pmatrix} e^{i\phi} & 0 & 0 \\ 0 & e^{-i\phi} & 0 \\ 0 & 0 & \pm 1 \end{pmatrix}$$

[0046] If a matrix **U** can be found that gives the above form, and there is only one purely real component and it is -1, then we define R to be an improper rotation. Let us only consider the case, then, of matrices R that are proper rotations (the third eigenvalue is just 1). The third column of the 3×3 matrix **U** will then be equal to the invariant vector **n**. Writing $\mathbf{u}_1$ and $\mathbf{u}_2$ for the first two columns of **U**, this equation gives

$$\mathbf{R}\mathbf{u}_1 = e^{i\phi}\,\mathbf{u}_1 \quad \text{and} \quad \mathbf{R}\mathbf{u}_2 = e^{-i\phi}\,\mathbf{u}_2 .$$

[0047] If $\mathbf{u}_1$ has eigenvalue 1, then φ= 0 and $\mathbf{u}_2$ has also eigenvalue 1, which implies that in that case **R** = **E**.

[0048] Finally, the matrix equation is transformed by means of a unitary matrix,

$$\mathrm{RU}\begin{pmatrix} \frac{1}{\sqrt{2}} & \frac{i}{\sqrt{2}} & 0 \\ \frac{1}{\sqrt{2}} & \frac{-i}{\sqrt{2}} & 0 \\ 0 & 0 & 1 \end{pmatrix} = \mathrm{U}\underbrace{\begin{pmatrix} \frac{1}{\sqrt{2}} & \frac{i}{\sqrt{2}} & 0 \\ \frac{1}{\sqrt{2}} & \frac{-i}{\sqrt{2}} & 0 \\ 0 & 0 & 1 \end{pmatrix}\begin{pmatrix} \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} & 0 \\ \frac{-i}{\sqrt{2}} & \frac{i}{\sqrt{2}} & 0 \\ 0 & 0 & 1 \end{pmatrix}}_{=\mathrm{I}}\begin{pmatrix} e^{i\phi} & 0 & 0 \\ 0 & e^{-i\phi} & 0 \\ 0 & 0 & 1 \end{pmatrix}\begin{pmatrix} \frac{1}{\sqrt{2}} & \frac{i}{\sqrt{2}} & 0 \\ \frac{1}{\sqrt{2}} & \frac{-i}{\sqrt{2}} & 0 \\ 0 & 0 & 1 \end{pmatrix}$$

which gives

$$\mathrm{U}'^{\dagger}\mathrm{R}\mathrm{U}' = \begin{pmatrix} \cos\phi & -\sin\phi & 0 \\ \sin\phi & \cos\phi & 0 \\ 0 & 0 & 1 \end{pmatrix} \quad \text{with} \quad \mathrm{U}' = \mathrm{U}\begin{pmatrix} \frac{1}{\sqrt{2}} & \frac{i}{\sqrt{2}} & 0 \\ \frac{1}{\sqrt{2}} & \frac{-i}{\sqrt{2}} & 0 \\ 0 & 0 & 1 \end{pmatrix}.$$

[0049] The columns of **U′** are orthonormal. The third column is still **n**, the other two columns are perpendicular to **n**. We can now see how our definition of improper rotation corresponds with the geometric interpretation: an improper rotation is a rotation around an axis (here, the axis corresponding to the 3rd coordinate) and a reflection on a plane perpendicular to that axis. If we only restrict ourselves to matrices with determinant 1, we can thus see that they must be proper rotations. This result implies that any orthogonal matrix **R** corresponding to a proper rotation is equivalent to a rotation over an angle φ around an axis **n**.

[0050] Equivalence classes

[0051] The trace (sum of diagonal elements) of the real rotation matrix given above is 1+2cosφ. Since a trace is invariant under an orthogonal matrix similarity transformation,

$$\mathrm{Tr}[\mathbf{A}\mathbf{R}\mathbf{A}^{\mathrm{T}}] = \mathrm{Tr}[\mathbf{R}\mathbf{A}^{\mathrm{T}}\mathbf{A}] = \mathrm{Tr}[\mathbf{R}] \quad \text{with} \quad \mathbf{A}^{\mathrm{T}} = \mathbf{A}^{-1},$$

it follows that all matrices that are equivalent to **R** by such orthogonal matrix transformations have the same trace: the trace is a *class function*. This matrix transformation is clearly an equivalence relation, that is, all such equivalent matrices form an equivalence class.

[0052] In fact, all proper rotation 3×3 rotation matrices form a group, usually denoted by SO(3) (the special orthogonal group in 3 dimensions) and all matrices with the same trace form an equivalence class in this group. All elements of such an equivalence class *share their rotation angle*, but all rotations are around different axes. If **n** is an eigenvector of **R** with eigenvalue 1, then **An** is also an eigenvector of $\mathbf{ARA}^{\mathrm{T}}$, also with eigenvalue 1. Unless **A** = **E**, **n** and **An** are different.

Applications

Generators of rotations

Main articles: Rotation matrix, Rotation group SO(3) and Infinitesimal transformation

[0053] Suppose we specify an axis of rotation by a unit vector [x, y, z] , and suppose we have an infinitely small rotation of angle Δθ about that vector. Expanding the rotation matrix as an infinite addition, and taking the first order approach, the rotation matrix ΔR is represented as:

$$\Delta R = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} + \begin{bmatrix} 0 & z & -y \\ -z & 0 & x \\ y & -x & 0 \end{bmatrix} \Delta\theta = \mathbf{I} + \mathbf{A}\,\Delta\theta.$$

[0054] A finite rotation through angle θ about this axis may be seen as a succession of small rotations about the same axis. Approximating Δθ as θ/N where N is a large number, a rotation of θ about the axis may be represented as:

$$R = \left(\mathbf{1} + \frac{\mathbf{A}\theta}{N}\right)^N \approx e^{\mathbf{A}\theta}.$$

[0055] It can be seen that Euler's theorem essentially states that <u>all</u> rotations may be represented in this form. The product $\mathbf{A}\theta$ is the "generator" of the particular rotation, being the vector (*x*,*y*,*z*) associated with the matrix A. This shows that the rotation matrix and the axis-angle format are related by the exponential function.

[0056] One can derive a simple expression for the generator G. One starts with an arbitrary plane defined by a pair of perpendicular unit vectors a and b. In this plane one can choose an arbitrary vector x with perpendicular y. One then solves for y in terms of x and substituting into an expression for a rotation in a plane yields the rotation matrix R which includes the generator G = ba^T - ab^T.

$$x = a\cos(\alpha) + b\sin(\alpha)$$
$$y = -a\sin(\alpha) + b\cos(\alpha)$$
$$\cos(\alpha) = a^T x \quad \sin(\alpha) = b^T x$$
$$y = -ab^T x + ba^T x = \left(ba^T - ab^T\right) x$$

$$x' = x\cos(\beta) + y\sin(\beta)$$
$$= \left[I\cos(\beta) + \left(ba^T - ab^T\right)\sin(\beta)\right] x$$

$$R = I\cos(\beta) + \left(ba^T - ab^T\right)\sin(\beta)$$
$$= I\cos(\beta) + G\sin(\beta)$$

$$G = ba^T - ab^T$$

[0057] To include vectors outside the plane in the rotation one needs to modify the above expression for R by including two projection operators that partition the space. This modified rotation matrix can be rewritten as an exponential function.

$$P_{ab} = -G^2$$
$$R = I - P_{ab} + \left[I\cos(\beta) + G\sin(\beta)\right] P_{ab} = e^{G\beta}$$

[0058] Analysis is often easier in terms of these generators, rather than the full rotation matrix. Analysis in terms of the generators is known as the Lie algebra of the rotation group.

What is claimed is:

LISTING OF CLAIMS:

1. A weight channeling underwire that re-directs the weight of the breasts directly to the band.

2. An apparatus of claim 1 wherein a center closure that directs the weight in a circular motion so it is intercepted by the bra band as shown by Euler’s theorem.

3. An apparatus of claim 1 wherein a center busk closure connecting both frames of the underwire.

4. An apparatus of claim 1 wherein the arms attached to the underwire frame that attach to the cup of a bra to direct the entire weight of the cup to the underwire frame.

5. An apparatus of claim 1 wherein internal springs within the device that absorb the weight sustained by the arms.

Floating Underwire- Weight Channeling Device

ABSTRACT

The Floating underwire-weight channeling device can be inserted into any bra to alleviate the weight of breasts. It functions by both redirecting weight in a circular direction by introducing a fixed position/epicenter from which weight moves about as explained by Euler's theorem. By connecting the bands of a bra to the curve of the metal, one can direct the weight of breasts from the center closure to the bands. An additional benefit to the wearer is also the ability to open the bra from the front by use of the same closure piece. Its application is simply replacing the underwire of any bra with this floating underwire device.

In summary, whenever an object is tied to a fixed position, the gravitational force experienced by that object is directed in a circle. Think of the curved underwire frame as that circle and the center closure as the fixed position. Lastly think of a bra band as an interception of the circles of force, such that the entire weight is essentially re-directed to the band. This interconnected system of circular forces defines the floating lift.

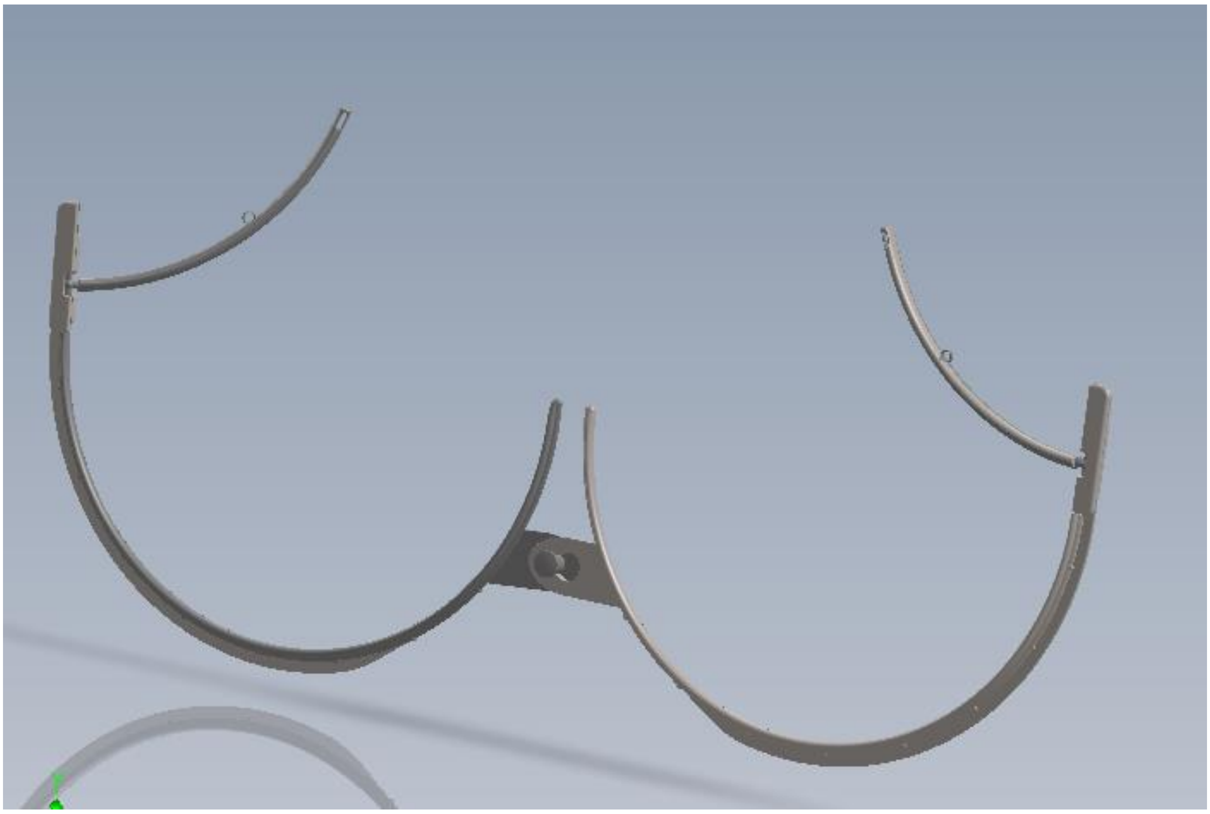
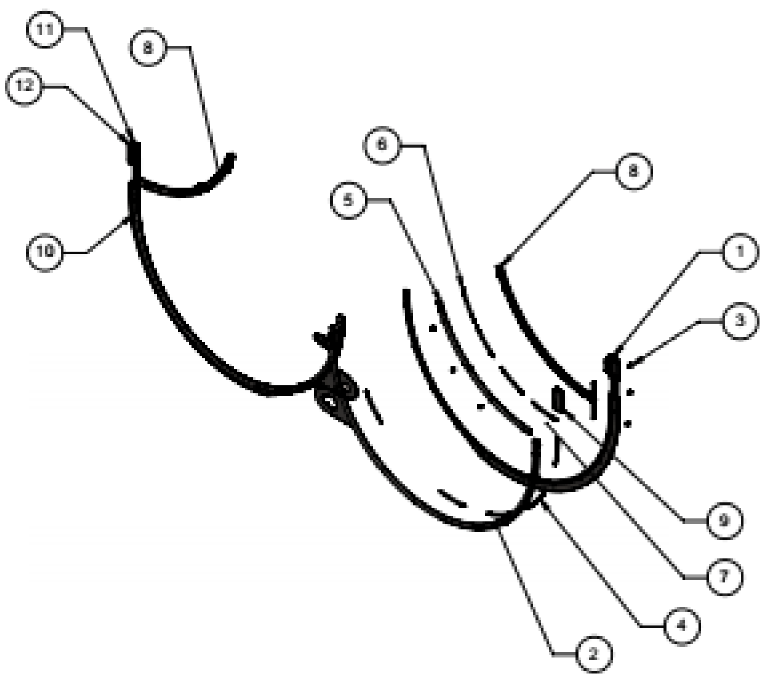


Figure 1



1. Outer panel
2. Outer panel
3. Screws
4. Springs
5. Arm (optional)
6. Internal shafts
7. Ball bearings
8. Arm (optional)
9. Outer panel
10. Outer panel frame
11. Outer panel head
12. Outer panel head

Figure 2

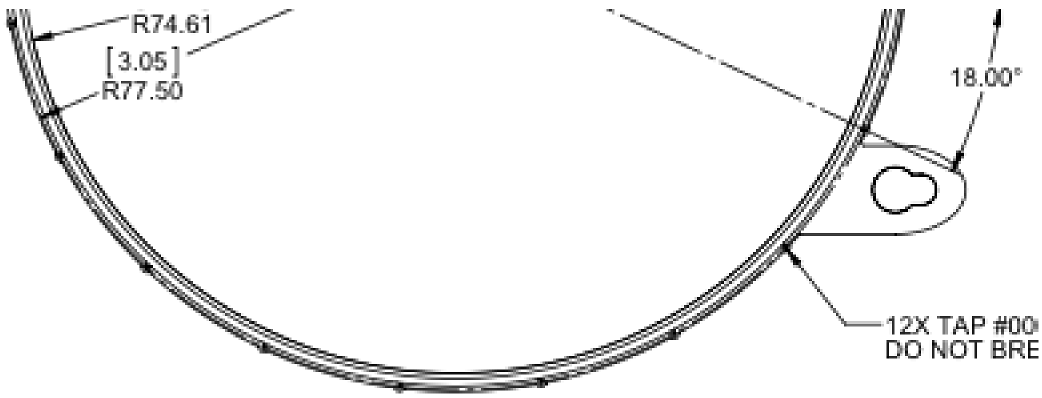


Figure 3

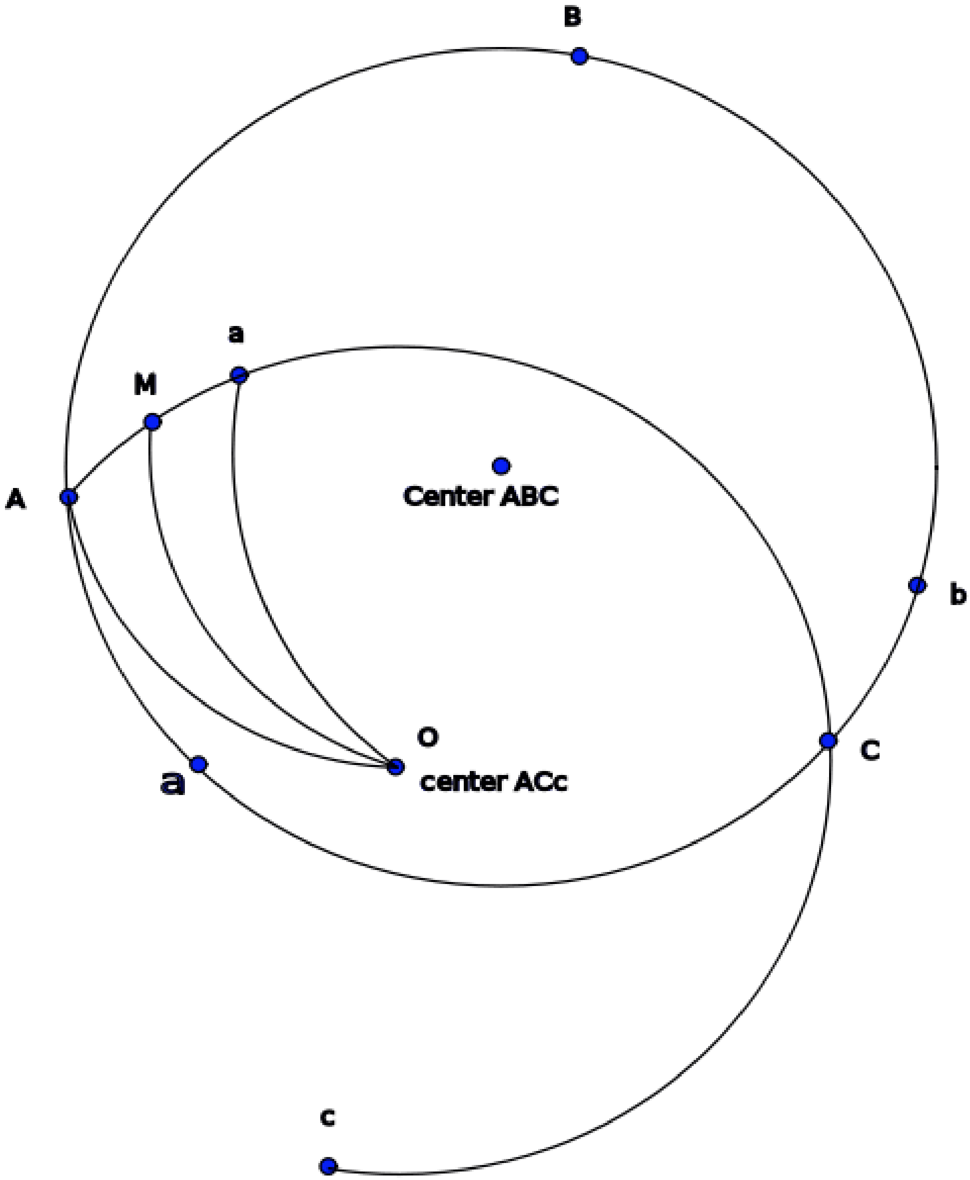


Figure 4

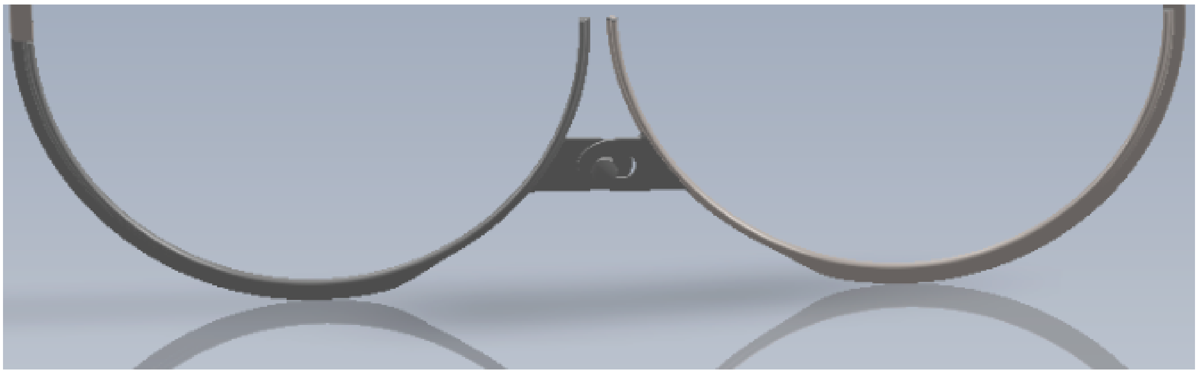


Figure 5

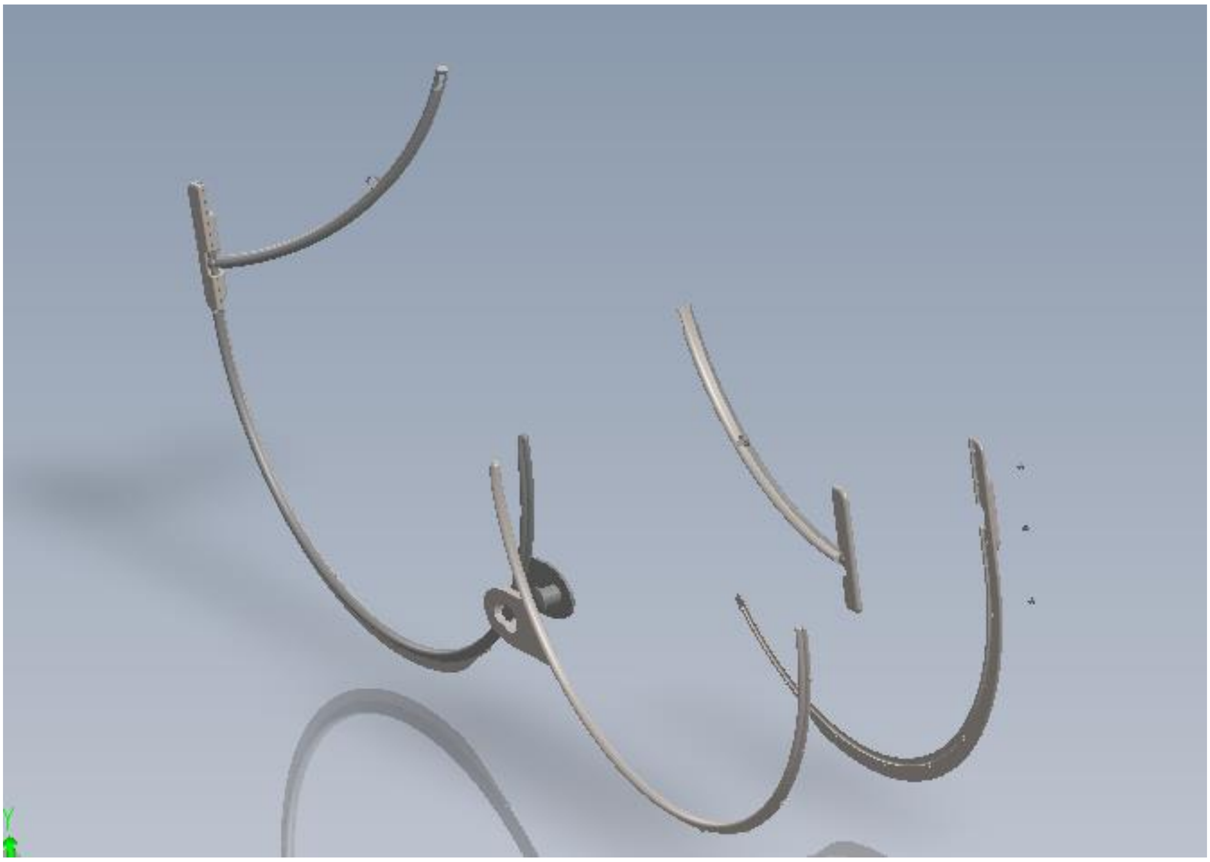


Figure 6

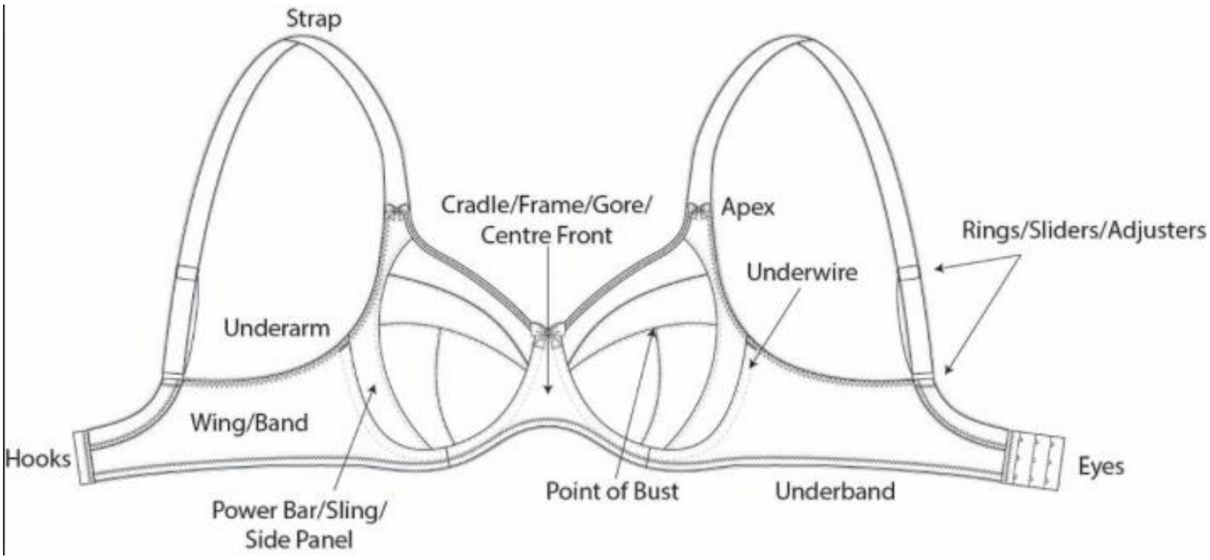

Strap
Cradle/Frame/Gore/
Centre Front
Apex
Rings/Sliders/Adjusters
Underwire
Underarm
Wing/Band
Hooks
Eyes
Point of Bust
Underband
Power Bar/Sling/
Side Panel

Figure 7