No. 870,430. PATENTED NOV. 5, 1907.

H. A. HERVÉ.

CAPTIVE BALLOON.

APPLICATION FILED DEC. 9, 1902.

4 SHEETS—SHEET 1.

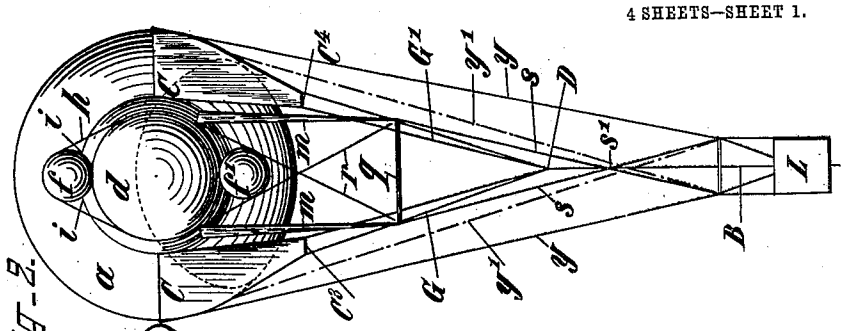


Fig. 2.

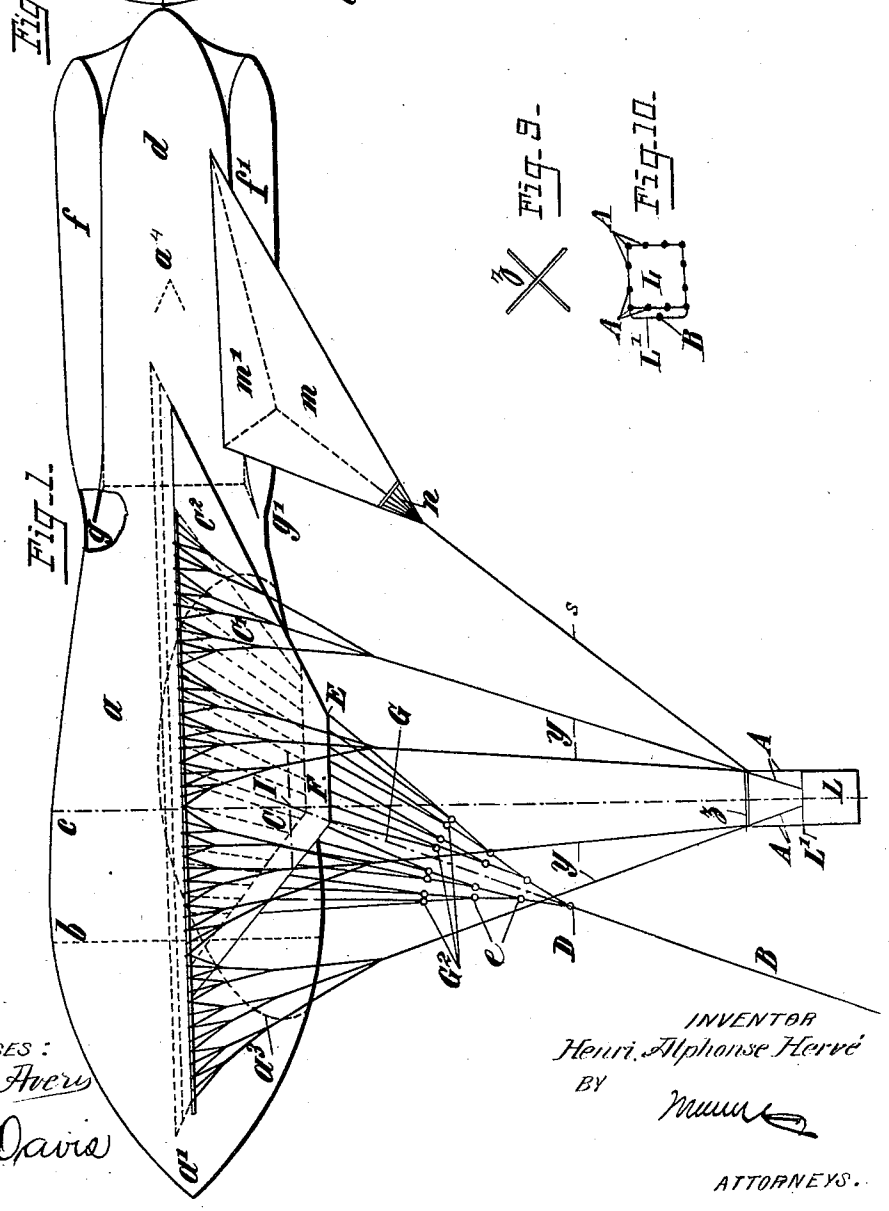


Fig. 1.

Fig. 9.

Fig. 10.

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4 SHEETS—SHEET 2.

Fig. 8.

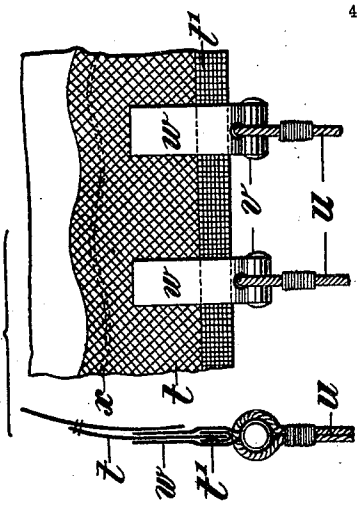


Fig. 3.

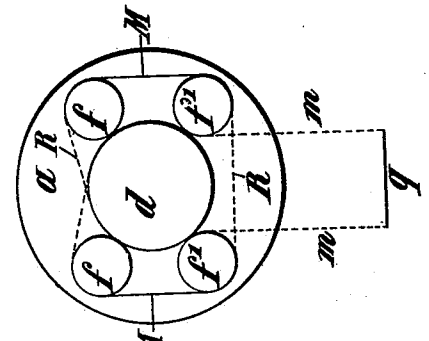
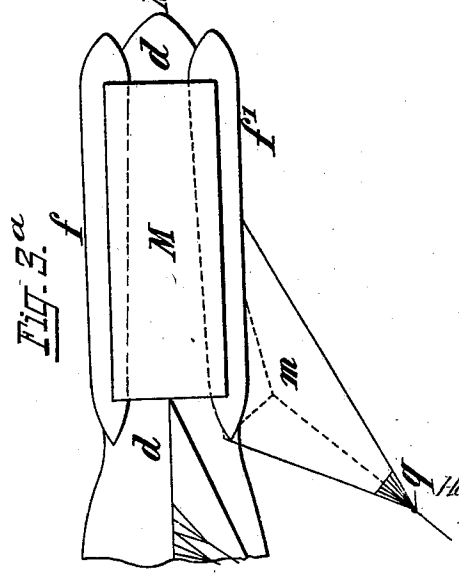


Fig. 3ª.



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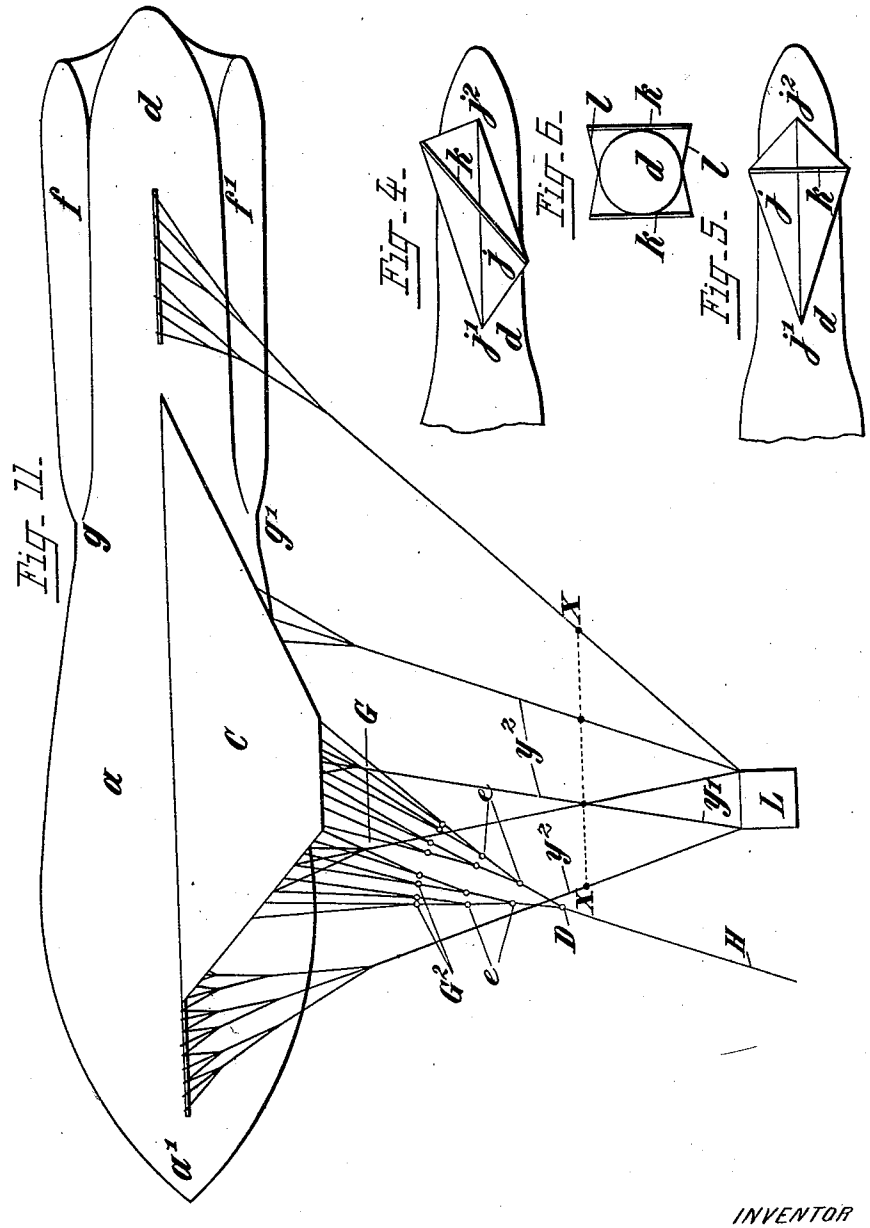
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4 SHEETS—SHEET 3.



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4 SHEETS—SHEET 4.

Fig. 12.

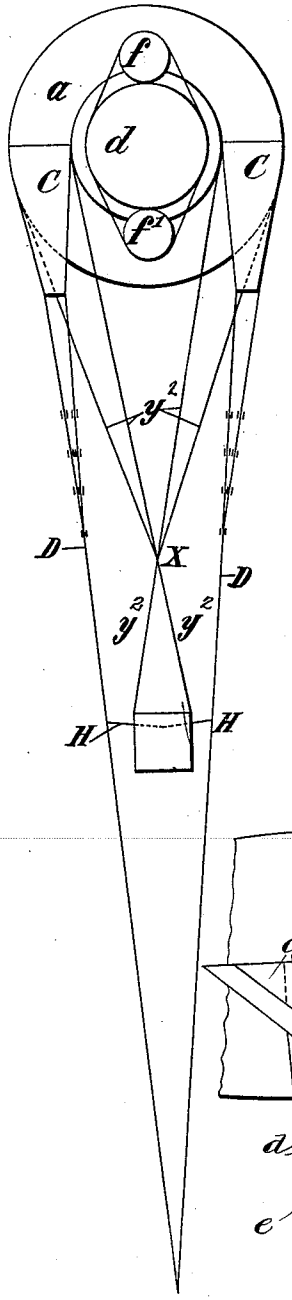


Fig. 7.

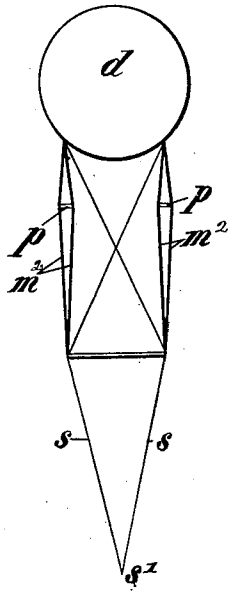
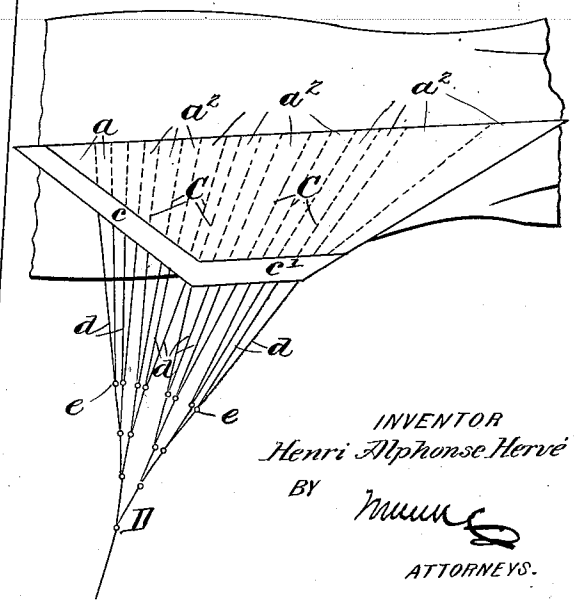


Fig. 13.



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CAPTIVE BALLOON.

No. 870,430. Specification of Letters Patent. Patented Nov. 5, 1907.

Application filed December 9, 1902. Serial No. 134,533.

To all whom it may concern:

Be it known that I, HENRI ALPHONSE HERVÉ, of 1 Rue Hautefeuille, in the city of Paris, Republic of France, engineer, have invented Improvements in Captive Balloons, of which the following is a full, clear, and exact description.

This invention relates to improvements in captive balloons, and has for its object to enable observations for military or scientific purposes to be made under a greater wind pressure or at a greater altitude for a given pressure of wind, while insuring greater stability of the car with a smaller tractive effort than in known systems of captive balloons under the combined conditions of strength and lightness necessary in such structures.

My invention has for object: 1st. To reduce the normal resistance of the system below that of ordinary captive balloons of spherical form or those in which a sustaining reaction is provided as by aeroplanes or kite balloons; 2nd. To increase the vertical and horizontal stability by the employment of a rudder, such as a plane or other surface, which temporarily and slightly increases the general resistance, or which has a constant action. 3rd. To render the car unaffected by the variations in the tension of the cable and of the direction of the traction. 4th. To dispense with all rigid structure or frame.

My improved captive balloon comprises the sustaining means viz, the hull or buoyant chamber and the auxiliary arrangement for steering and the suspension and towage systems of cords. The sustaining means consists of (1) an elongated dissymmetrical hull or bag having its section of greatest area at the bow and having continuous lines and ogival extremities and normally occupying a horizontal position whereby to diminish resistance and reduce the deviating moment; (2) a self-steadying steering chamber attached at the rear end of the main portion of the hull of approximately cylindrical form and of reduced diameter for producing a lateral steadying action in steering, without greatly assisting in sustaining the balloon, that is to say, without throwing sensibly towards the rear the center of buoyancy whereby a long leverage is obtained; (3) auxiliary steering surfaces or bags carried by the cylindrical steadying prolongation previously referred to, having for object to considerably increase the steering properties of the latter by modifying the action of the fluid streams or currents upon its surface.

The cordage is composed of the car suspension system and a towage system always independent of the former, the moment of this towage system being small or even null relatively to the center of the inertia of the whole system within the practical limits of angular variation of the direction of the resistance.

The invention is illustrated by way of example in the accompanying drawings in which

Figure 1 represents a side elevation and Fig. 2 a rear view of the improved captive balloon. Fig. 3 is an end view and Fig. 3ª a part side elevation of a modified form of the steadying cylinder having four auxiliary steering bags. Figs. 4 and 5 are side elevations and Fig. 6 an end view of the steadying cylinder provided with auxiliary sail-like steering surfaces. Fig. 7 is an end view of the rear part of the balloon showing a modification in the arrangement of the sail steadying surfaces. Fig. 8 is a detail in elevation and transverse section of the attachment for the car-suspension cords. Fig. 9 is a plan of the cross-piece for the car-suspension cords. Fig. 10 is a plan showing the points of attachment of the car. Figs. 11 and 12 respectively represent a side and rear elevation of a modified arrangement of balloon in which the towage system is placed externally of the suspension cords, and Fig. 13 is a detail view of the towing distributer.

The same letters of reference indicate the same parts in all the figures.

In my improved balloon, the hull or chamber *a* is made of elongated form, the axial length from the nose a^1 to point a^4 (the point at which the lines of the hull would converge if not provided with a cylindrical extension) is equal to about three times the diameter of the major section of the hull. The front end of the hull *a* is of ogival form in order to offer but slight resistance to the wind. The generatrix of the hull proper *a* does not present any rectilinear surface nor any re-entering curve so that the air will be deflected equally in all directions.

The major section *b* is situate forward of a vertical line *c* passing through the center of gravity of the balloon, which arrangement besides its advantages as regards stability and low resistance, permits of the towage system passing in the forward direction clear of the suspension cordage as hereinafter specified. At the rear part of the hull *a* is joined a cylindrical prolongation *d* the diameter of which is so calculated that its ascensional force will be sufficient to sustain itself as well as the auxiliary arrangements, said cylindrical body does not sensibly contribute to the support of the car.

In order to diminish the general resistance of the hull to towage and to increase the resistance to flexure of the prolongation *d*, it is of advantage to make the latter very slightly conical (1° 30′ to 2°). The length of the cylindrical body *d* is equal to about two and a half times its mean diameter. The cylinder *d* terminates in the rear in an ogival rounded point so as to avoid this part of the hull becoming distorted and producing less disturbance of the air at the rear of the balloon. The prolongation *d* permits of bringing at least to the point a^2 or even beyond it, towards the right of

the drawing the center of gravity of the steadying steering surfaces hereinafter described and of thus obtaining a sufficient leverage. Moreover it forms the means of making the stabilitating surfaces integral with the buoyant hull *a* without the employment of any rigid structure. The stabilitating effect of the cylindrical prolongation *d* is increased by the addition of auxiliary chambers so disposed as to increase its resistance to the wind in the transverse direction by increasing the deflection of the molecules of air in this direction, whence a better utilization of their *vis-viva*. The cylindrical chamber *d* thus constitutes at the same time both a stabilitating device independent of all tension of the cordage and also a support for devices designed to increase the effect of the steering prolongation and in themselves produce an auxiliary steering or guiding effect. These auxiliary devices may either consist of secondary cylindrical chambers or of sail-like surfaces.

The steadying cylinder *d* may carry at its upper part as shown in Figs. 1 and 2, a small tubular chamber *f* terminating in ogival ends, and of a length approximately equal to that of cylinder *d* and which is in communication at *g* with the buoyant chamber *a*. This secondary chamber *f* is secured upon the cylinder *d* by means of light cords *h* at a certain pressure, so as to obtain a plane of contact. This secondary chamber has for its object not only to increase the steering surface but also to increase its effect by the presence of a longitudinal reëntering cavity *i* formed on each side between the adjacent surfaces of the chambers *d* and *f*. Another secondary chamber f^1 similar to the upper one *f* may similarly be attached to the extension *d*. These secondary chambers may communicate with the interior of the main chamber through openings *g*, g^1 and they are then supplied with gas by the main chamber, or they may communicate with the external air either directly or by means of a displacer chamber a^3 contained within the chamber *a*, the pressure within these secondary chambers corresponding then to the power of the wind. Or the prolongation *d* may be provided as shown in Figs. 3 and 3^a with four such secondary chambers placed two *f* at the upper part and two others f^1 symmetrically at the lower part. Each lateral pair may serve as a support for a sail-like surface M which owing to its extreme lateral position is particularly adapted to prevent yawing. In this case the secondary cylinders f^1 are held in position upon the extension *d* by means of light cords *k*. This arrangement may be employed in combination with a double rudder composed of two sails *m*, the distance apart of which is maintained by the cross bar *q*.

The pneumatic or sail-like surfaces above described are distended independently of the rigging so that the functions of the surfaces will not be affected even when the tension of the rope becomes reduced, as for instance by the car resting on the ground.

Figs. 4 to 6 show a modification in which the auxiliary sail-like surfaces are independently distended by a rigid frame. The cylindrical extension *d* carries at each side a fixed sail *j* distended by a spar *k* of bamboo for example, and fixed to the cylinder *d* tangentially to the line j^1, j^2, the two spars *k* being held parallel by means of cords *l* and being either vertical as in Fig. 5 or inclined as in Fig. 4. These sail surfaces *j* may be employed in combination with one or more of the auxiliary chambers *f*. It should be observed that the use of sail surfaces independently distended and without the use of any rigid spar is illustrated in Figs. 3 and 3^a already described.

As before stated the cylindrical chamber *d* is provided on its under side with two sails *m* which increase the area of the directive surfaces and spaced sufficiently apart so as not to blanket each other to any extent even during heavy lurches. The sails are of triangular form and are distended in the following manner:—Each sail *m* is composed of an assemblage of three triangles having for their common vertex the point of intersection m^1 of the lines bisecting the angles of the whole sail *m* whose sides form the bases of the three smaller triangles, each of these elementary triangles being formed of widths perpendicular to said bases so that the outside will be straight with the weft along the edges and on the bias at the bisecting lines. The stiffening of each sail is further insured by the distributing cords *n* at the point of attachment of the ropes *s*.

In order to avoid the formation under the action of the wind of the inward bellying of the sail which would retard its steadying action and cause yawing, the stiffness of the sail is considerably increased by making it of two triangular sails m^2 having bi-convex form, as shown in Fig. 7 each composed by the connection of three triangles as hereinbefore described, and sewed edge to edge, the bi-convex or trussed form being produced by the interposition of a stretcher *p* as shown in Fig. 7. The fixity of the two sails m^2 is insured in the following manner. The fixity of the base of each sail is obtained by its connection with the cylindrical extension *d* while the fixity of the apex of each sail should be determined in relation to the general system of the aerostat with a view to prevent or to reduce the retarding influence of any flapping or shivering movements which would prejudice the directive or steering action and also with regard to the other sail in order that the action of their twin surfaces should be identical. For this purpose the parallelism of the front edges of the two sails is maintained by a cross bar *q* (Fig. 2) while crossed stay ropes *r* prevent any distortion, and furthermore the system of ropes *s* fixed to the suspension cross frame of the car co-acts to prevent transverse flexure of the whole arrangement. The resistance of the sails to transverse flexure is considerably increased by making the sail distending system of two rope triangles joined together at their apex produced by crossing two cables *s* united at their point of intersection s^1 (see Fig. 2). This system of hull also possesses horizontal stability or longitudinal stability while the proportions of its elongated form insure a suitable position of the static metacenter. Longitudinal stability also results from the permanence and regularity of form of the hull insured in the ordinary manner by the addition of a small distender or displacer. The distender a^3 may therefore be put in communication with the exterior air by means of an injector nozzle, an automatic discharge valve being added in order to maintain the desired pressure in the small distender. The centers of gravity of the distender and of the system as a whole are in the same vertical plane.

A partition or diaphragm perpendicular to the axis composed of a disk of fabric may be disposed in the

interior of the balloon, for example at the junction between it and the steadying cylinder, if thought desirable, to prevent the internal movement of the gases in certain cases. The horizontal stability of the balloon is also insured by the independence of the two following functions: the static vertical pull due to the car and the traction exerted by the particular arrangement of cordage which leaves to the car its entire independence for maintaining longitudinal stability. Transverse stability is insured by a crossing of the ropes comprising the rigging as hereinafter described, the rigging essentially comprising the suspension gear and the towing gear.

For insuring permanence of the stability relatively to the three principal axes of equilibrium and particularly the horizontal stability, it is essential that the center of gravity and the center of buoyancy should remain in the same vertical line and that the point of intersection I (center of inertia) of this vertical line and of the directions of power and resistance should be invariable. As the liability to deformation of suspension netting excludes its employment, the suspension cords are attached directly to the envelop in the following manner: To the envelop is sewed as shown in Figs. 1 and 8, a band of fabric t termed a distributing band, to which are attached the terminal branches u of the suspension cords, each of which passes around a small toggle pin v held in the bight of a looped strap w between the two thicknesses of which is stitched the band t.

In order to distribute over the whole line of the seam to the body of the balloon the strains exerted at the points of attachment of the suspension cords, the longitudinal intermediate band is made either of diagonal fabric or of two pieces of straight woven fabric cut on the bias cemented one on the other with the warps crossed. The line of stitching x is double and preferably sinuous as shown.

In order that the tensions may be equalized before reaching the line of stitching, the looped straps w do not extend the full width of the band t but for about two-thirds only of its breadth measuring from its lower edge. The band is reinforced at its lower edge by a flat web t' cut on the straight which prevents that part of the band from stretching or getting out of shape under horizontal strains. The width of the band and the distance between consecutive loops are such that a certain number of diagonal threads of the fabric of the band shall cross the lower part of one loop and that portion of the band situated above the next loop. The band may at its extremities where the strains are very oblique, be cut on the straight and the loops be diagonally disposed.

Above the band t may extend transverse encircling bands of fabric connecting the port and starboard members of the band in order to lessen the wear of the envelop and the seams, if the envelop is made of longitudinal strips. On the other hand if the envelop is composed of transverse zones or even of panels, these encircling bands are not indispensable for balloons of very small capacity owing to the considerable reduction in the resistance due to the form and horizontal attitude of this type of aerostat and the light amount of the transverse tensions. For large balloons the encircling bands are brought so close together as to form a continuous jacket.

The suspension of the car is effected by means of eight cords y disposed in equal numbers on either side of the symmetrical plane; each set of four suspension cords situate on the same side being attached to two ends of a rigid spider or cross frame z (Figs. 1 and 9) extending diagonally of the plane of the car. To avoid any oscillating movement of the car in a longitudinal plane relatively to the body of the balloon, the cords or ropes are so arranged, the one with respect to the others, that they constitute triangles which oppose themselves to every oscillating motion of the car. To each of the four ends of the cross, two cords are attached, there being two sets of cords symmetrically arranged relatively to a common longitudinal vertical median plane. For this purpose at each end of the arms of the spider z—see Fig. 9—are attached two suspension cords, two series of suspension cords being arranged symmetrically with reference to a longitudinal vertical median plane.

To counteract any oscillating movement of the car in a transverse plane a complementary triangular arrangement of the cords or ropes may be effected as indicated in Fig. 2, by means of crossed suspension cords y^1 disposed either in a transverse plane containing the vertical passing through the center of gravity or slightly in rear of it and each connecting with the two extremities of the cross frame situated at the opposite sides by means of a bifurcation extending from the crossing point of the two suspension cords.

The car is suspended from the cross frame at each angle by means of a group of three suspension cords A (Fig. 10) this triangular arrangement sufficing to prevent any oscillatory movements of torsion of the lower suspension while it does not incommode the aeronauts.

The towing cable B exerts its action on the aerostat by means of a distributer formed partly of fabric and partly articulated or formed of bridle ropes running round sheaves. The fabric portion of the distributer has for its object to furnish beyond the hull an invariable base of attachment for the ramifying ropes and to distribute the tension between said base and the line of attachment to the balloon. The fabric portion of the distributer is composed of strips of fabric a^2 stitched together on lines c converging to the points D, which is the apex of the articulated distributer, and the strips c and c' secured to the strips a^2, the strip c' being horizontal and the strips c inclined upwardly and forwardly—see Fig. 13—. To this fabric portion of the distributer is secured the cords d of the bridle ropes, the pulleys over which the cords pass being shown at e. The distributer instead of being constructed of fabric may be formed of lattice or net work narrow webbing connected together at the crossing points so as to be unchangeable in their relation to one another.

In order that the stability of the car may be as great as possible the mode of application to the aerial system of the traction strain should be such that the equilibrium of the aerostat in its plane of symmetry is obtained without compensating movement. This result is obtained by giving to the tractive resultant such a direction that it has a moment which is constantly *nil* relatively to the point of intersection I of the axis of

sustentation (the vertical through the centers of bouyancy and of gravity) and of the axis of resistance that is to say, that it shall pass through the intersection of these two axes. But on the one hand the effort cannot be applied at a single point at the center of inertia I by reason of the situation of this point which is often within the hull and also for evident reasons of safety. On the other hand for reasons of stability of orientation of the hull the use of a single fixed point of attachment would deprive it of the powerful righting moment due to the articulation of the distributer relatively to the vertical axis. It is therefore necessary to employ two lateral points or preferably two lateral lines of attachment c^3, c^4, Fig. 2, connected to the tow line by two similar convergent distributers G, G′ each constructed as hereinbefore described and constituting a duplex distributer. The rope systems of the distributer should not under any normal circumstances come in contact with the suspensory system; this condition and the condition of stability of orientation conduce to give to the combined rope systems a transverse triangular form (Fig. 2) so as to insure the permanence of the apex D (the point of attachment of the tow line B) in the plane of symmetry and to arrange the traction system within the suspension system. Under these conditions not only the suspension system but the car itself is maintained out of contact with the movable part of the traction system.

The arrangement of the traction system outside of the suspension system is more difficult to effect and does not constitute a very efficient means of insuring stability of orientation, but in such case the arrangement illustrated in Figs. 11 and 12 might be adopted. The fabric part C of the distributer enables the movable portions of the articulated distributer to be arranged below the region where contact would be prejudicial and if the car be raised towards the aerostat by its dispensing with the external suspension attachments y shown in Fig. 2, and using only the suspension attachments y^2 as shown in Figs. 11 and 12, the traction system will be sufficiently clear and as a consequence a longitudinal axis of articulation of the lower suspension system will be at X. A cross connection at H would serve to prevent the passage of the traction system behind the car in maneuvering. The articulated distributer is so arranged as to satisfy this characteristic condition of my system, viz, the constant nullity of the moments relatively to the center of inertia in the plane of symmetry.

Figs. 1 and 11 show a practical arrangement of my system of distributer. The tractive system comprises in this example thirty two points of attachment (16 at each side) and four series of articulations. In the distributers G′ G^2 the angle of the running cords of each of the triangular elements of the upper series is very acute both with a view to satisfy the conditions of equilibrium and to bring as low as possible the first series of sheaves or pulleys which separates them still further from the suspensory system. Stops are provided on all the running cords to prevent unreeving in case of breakage of one of the elementary cords.

The car L is of the ordinary construction, but it should be provided with a rigid guard rail L^1 (Fig. 10) to protect the hands of the aeronaut placed on the front edge of the car from contact with the tow rope should the latter rub against the car.

My improved system of captive balloon may be made of any desired dimensions and the accessory arrangements may be varied in accordance with the circumstances of each application.

Claims.

1. A captive balloon comprising a hull of elongated shape, a cylindrical body being a prolongation of the hull at the rear part without assisting in the general sustentation so as not to bring backwards the center of buoyancy and simply adapted to insure the stability of orientation, auxiliary cylindrical bodies arranged on the cylindrical prolongation with the purpose to increase the transverse resistance, lateral sail surfaces also mounted on the cylindrical prolongation, a suspension system, a towage system independent of the former and so arranged that the line of the tractive force will pass through the crossing point of the sustaining axis and of the axis of resistance.

2. A captive balloon, comprising an elongated hull having a pointed forward end and provided with a cylindrical extension at its rear end, a pair of auxiliary cylindrical bodies on each side of the extension of the hull, a sail-like surface extending between each pair of said bodies, a sail on each side of the lower portion of the said extensions, a series of suspension ropes connected with the hull, and a series of towing ropes also connected with the hull.

3. A captive balloon, comprising an elongated hull having an ogival front end and provided with a cylindrical extension at its rear end, the major transverse axis of the hull being forward of the center of gravity of the balloon, and cylindrical bodies secured upon the said extension.

4. A captive balloon, comprising an elongated hull having an ogival front end and provided with a cylindrical extension at its rear end, cylindrical bodies secured upon the extension, and sail-like surfaces at the sides of said extension.

5. A captive balloon, comprising an elongated hull having an ogival front end, and provided with a cylindrical extension at its rear end, cylindrical bodies secured upon the extension, sail-like surfaces at the sides of the extension, and sails secured to the extension below the sail-like surfaces.

6. A captive balloon, comprising an elongated hull having an ogival front end and provided with a cylindrical extension at its rear end, cylindrical bodies secured upon the extension, sails secured to the sides of the extension, and triangular sails secured to the extension below the first named sails, said triangular sails extending below the extension and connected together.

7. A captive balloon, comprising an elongated hull having an ogival front end and provided with a cylindrical extension at its rear end, cylindrical bodies secured upon the extension, sails at the sides of the extension, sails secured to the extension below the first named sails, said last named sails extending below the extension and connected together, suspension ropes secured to the sides of the hull, and towing ropes secured to the hull between the suspension ropes.

The foregoing specification of my "improvements in captive balloons" signed by me this 26th day of November 1902.

HENRI ALPHONSE HERVÉ.

Witnesses:
AUGUSTUS E. INGRAM,
MAURICE H. PIGNET.