United States Patent [19]

Bentley

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[54] **SIGN AND SUPPORT APPARATUS**

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[22] Filed: **Jan. 17, 1973**

[21] Appl. No.: **324,349**

Related U.S. Application Data

[63] Continuation of Ser. No. 99,000, Dec. 17, 1970, abandoned.

[52] **U.S. Cl.** ..... **40/125 H,** 40/125 N, 40/145 R

[51] **Int. Cl.** **G09f 7/18**

[58] **Field of Search** ..... 40/125 R, 125 H, 125 N, 40/37.1, 212, 217, 129 C, 145, 145 A

[56] **References Cited**

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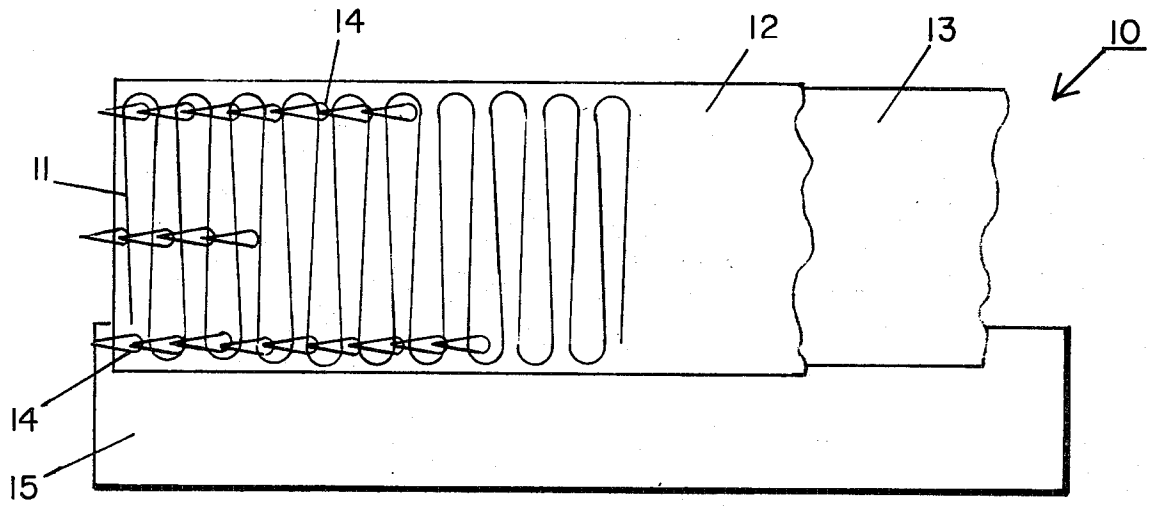
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Assistant Examiner—John F. Pitrelli

[57] **ABSTRACT**

The sign has an aerodynamic cross-sectional shape, is supported along a center of gravity line and is normally prevented from rotating by a releasable support member that is coupled to the main sign support structure. The sign may be supported either horizontally or vertically along a hingeline that passes through the sign. Both the sign and support are fabricated with a light-weight core material surrounded by a stronger, relatively thin skin material. An optimum strength support is obtained by providing a circular cross-section in a plane that passes through the normal (perpendicular) force center on the sign and the support for each incremental section of the support.

18 Claims, 17 Drawing Figures



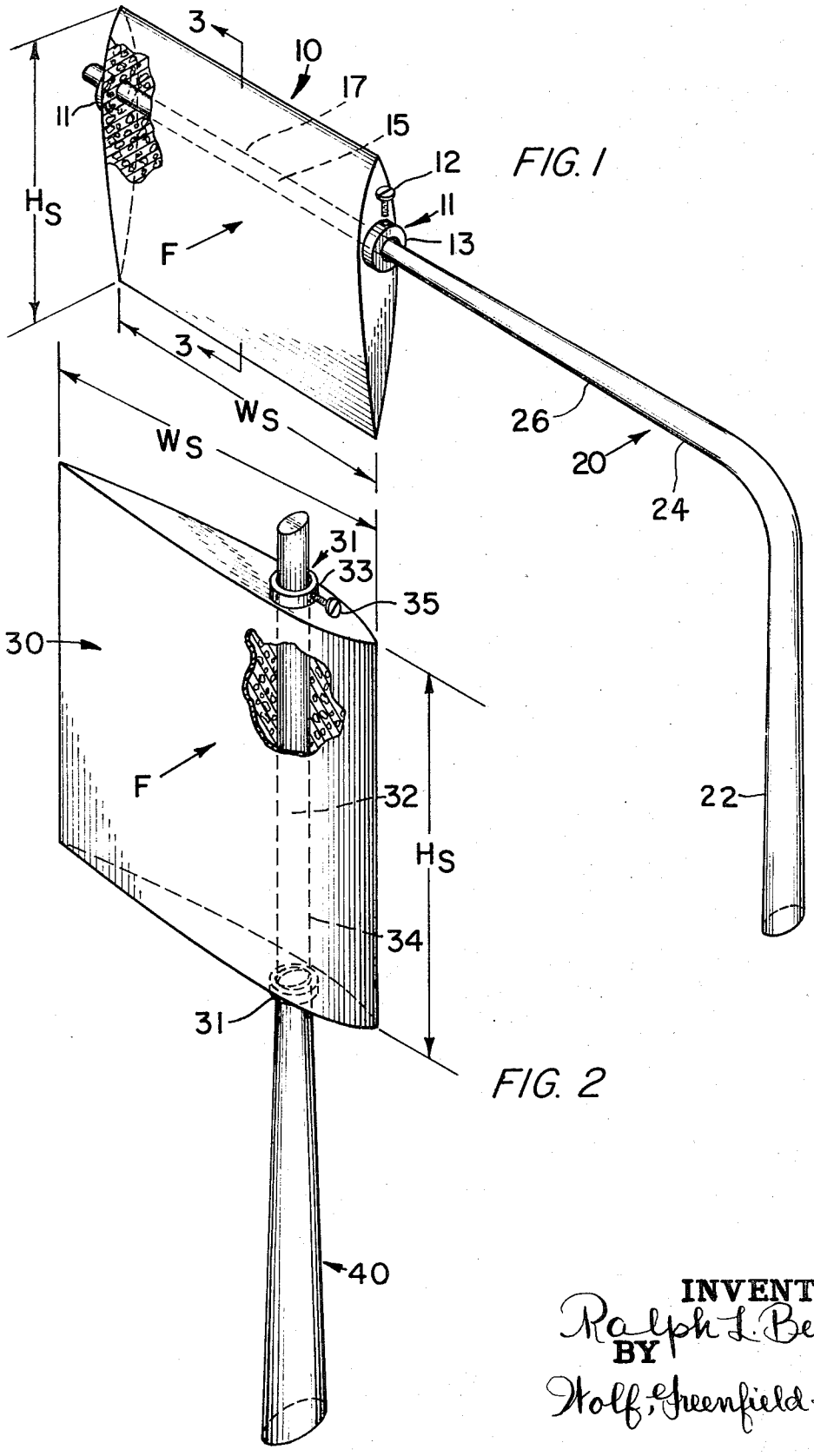


FIG. 1

FIG. 2

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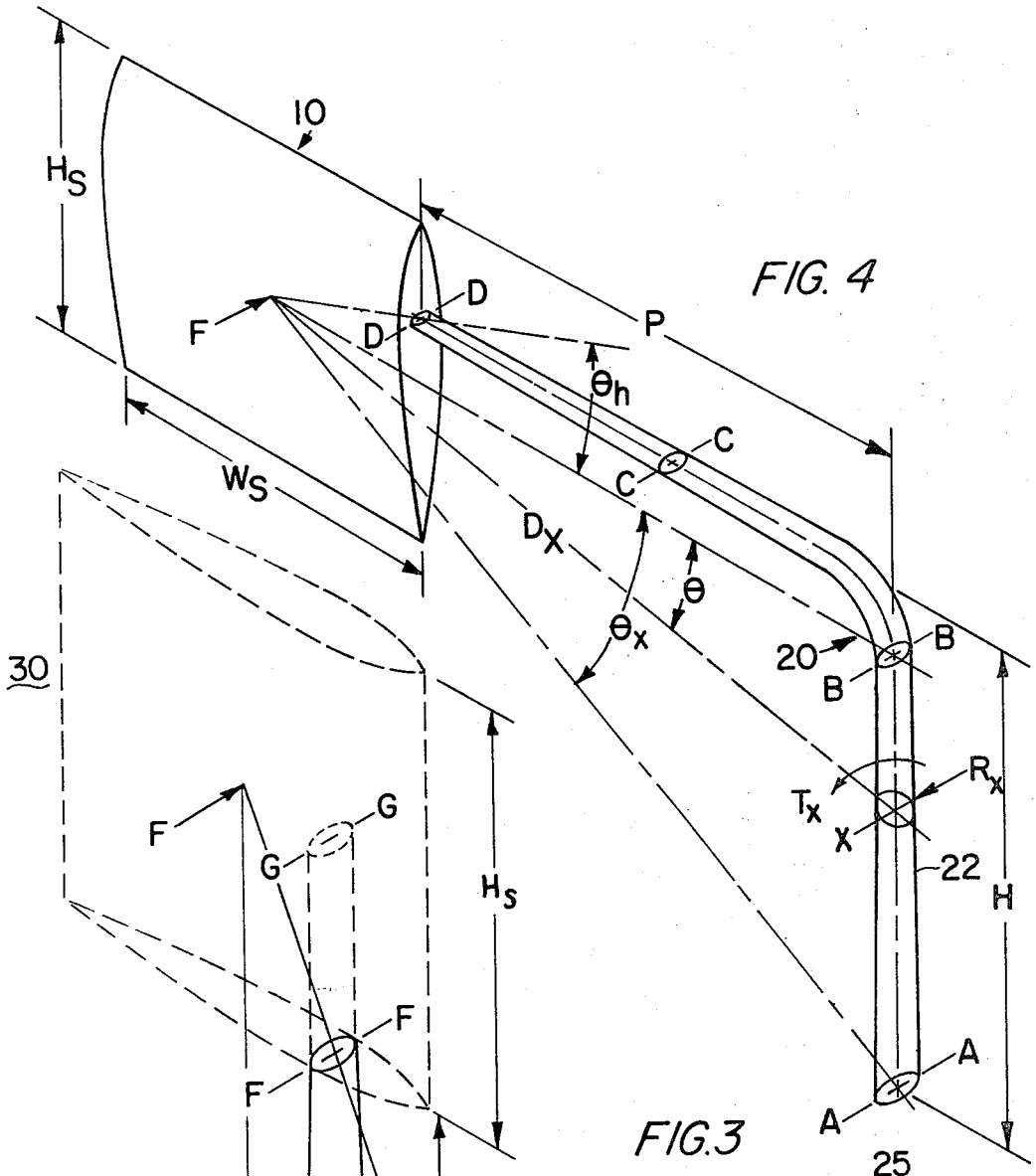


FIG. 4

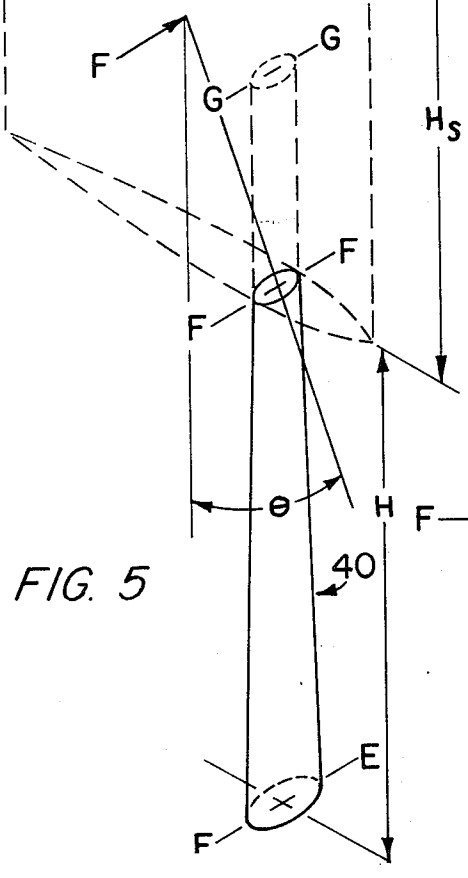


FIG. 5

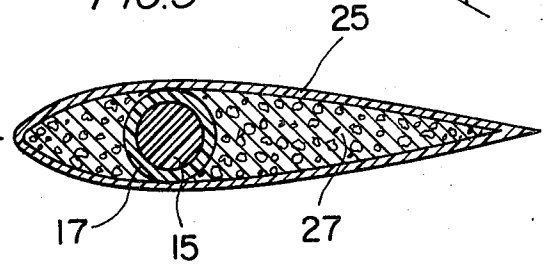


FIG. 3

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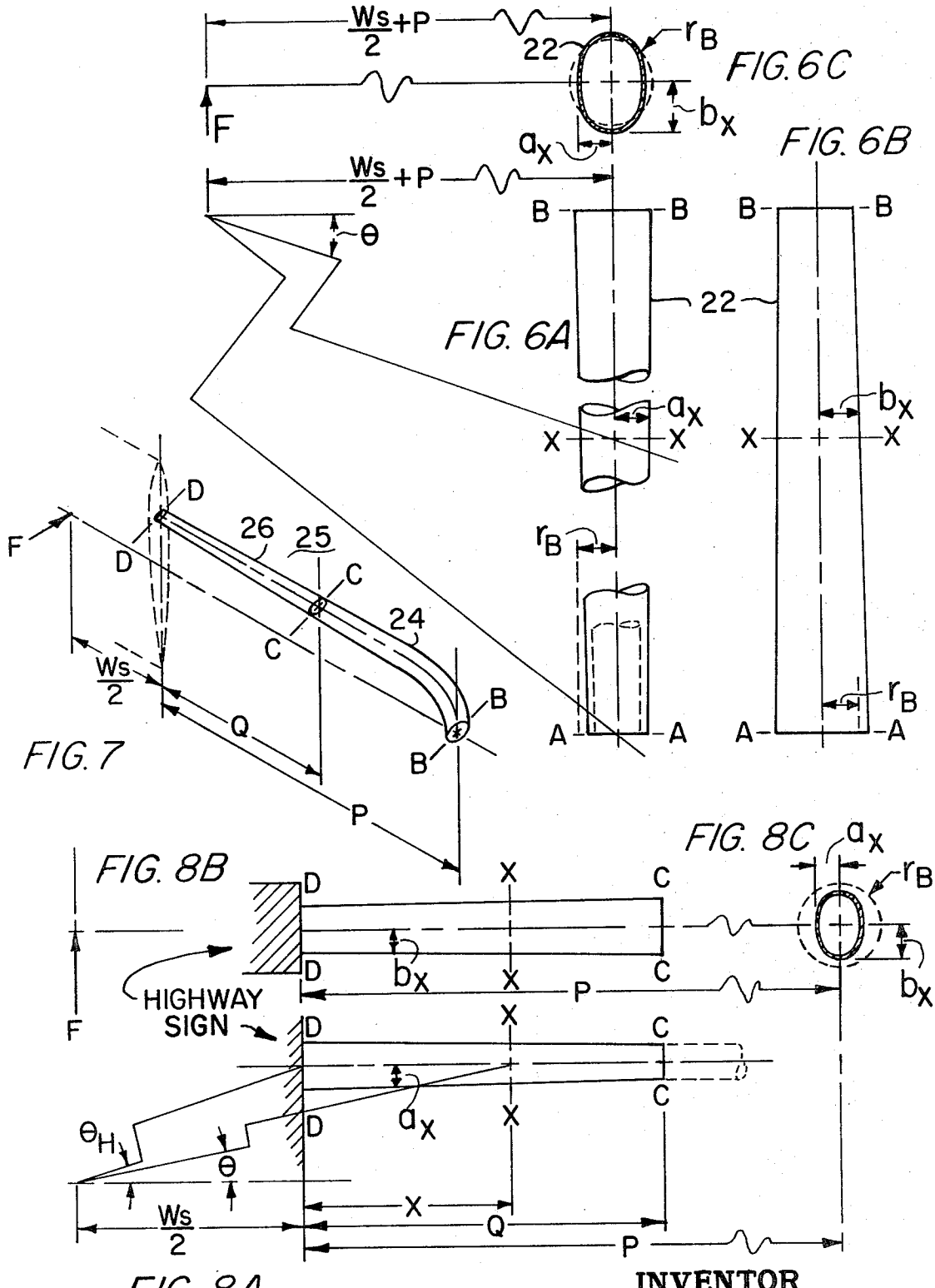


FIG. 6C

FIG. 6B

FIG. 6A

FIG. 7

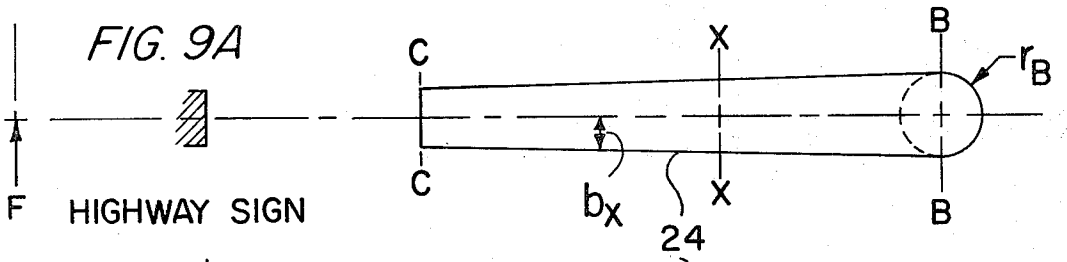
FIG. 8C

FIG. 8B

FIG. 8A

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FIG. 9A



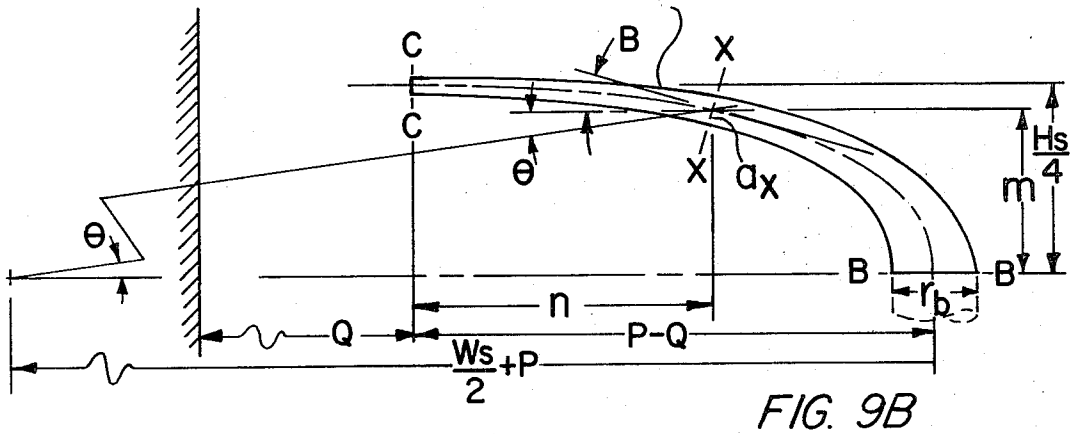


FIG. 9B

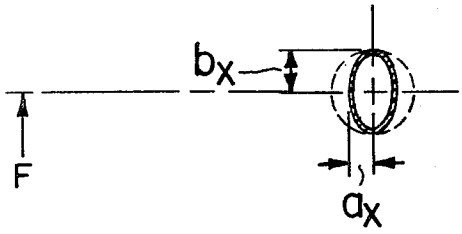


FIG. 10 C

FIG. 10 A

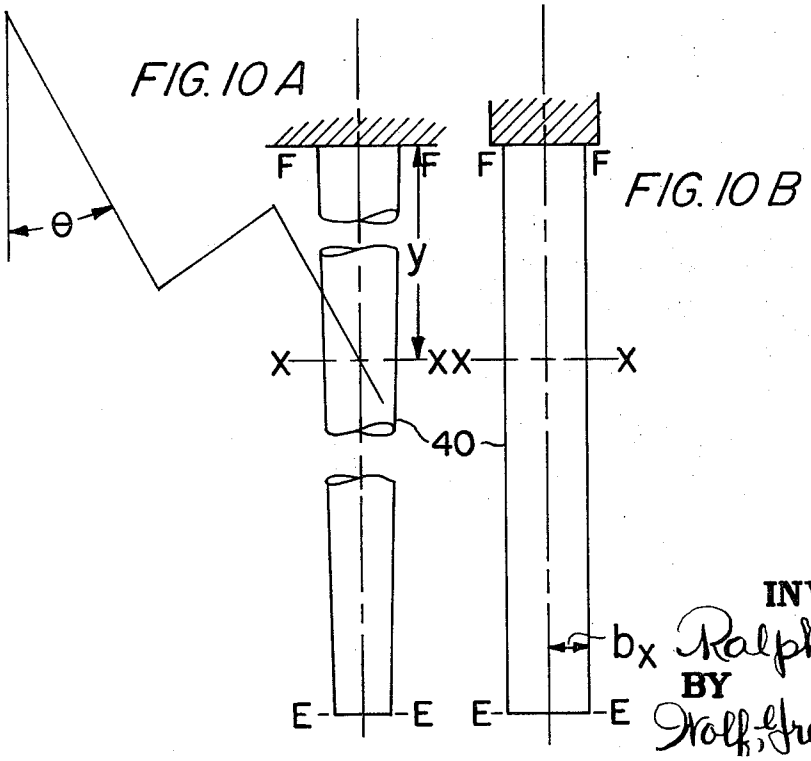


FIG. 10 B

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SIGN AND SUPPORT APPARATUS

This is a (continuation, of application Ser. No. 99,000, filed Dec. 17, 1970, now abandoned.

SUBJECT MATTER AND BACKGROUND OF THE INVENTION

The present invention relates, in general, to sign and sign support apparatus and, in particular, is concerned with a sign and sign support that is characterized by a relatively large strength-to-weight ratio and is preferably for use along a road or highway.

Existing signs, particularly those used along roadways, are generally constructed of flat plates which are reinforced with a frame or ribs to withstand wind forces. The signs are, in turn, supported in a fixed position by rigid supports. The supports are usually constructed from channel beams, I-beams or tubular pipes. These supports provide for fixed sign positioning by being rigidly reinforced into the ground or a similarly immovable object. Some of the disadvantages associated with existing sign and support members are: (1) they are heavy and bulky; (2) they are difficult to fabricate and assemble; and (3) when located along a highway they may cause substantial injury to passengers and damage to an impacting vehicle.

SUMMARY OF THE INVENTION

It is an important object of the present invention to provide an improved sign and support apparatus.

It is another object of the invention to provide a sign and sign support that is characterized by a relatively large strength-to-weight ratio.

Another object of the invention is to provide a safe sign and sign support for use along a roadway.

It is a further object of the invention to provide an aerodynamically-shaped sign that is normally restrained in a readable position and is released under high wind condition.

It is still a further object of the invention to provide a sign that can be restrained in more than one fixed readable position, thereby being capable of displaying different sign nomenclatures.

A further object of the invention is to provide a sign support structure that is relatively light in weight and has an optimized cross sectional configuration that provides for maximum strength.

Another object of the invention is to provide a sign support structure that is circular in a cross-section that passes through the force center of the sign and the support for each incremental section of the support.

Another object of the invention is to provide a support structure that shatters when hit by a vehicle thereby minimizing vehicle impact.

Still another object of the invention is to provide a sign and sign support apparatus that can be fabricated in many different configurations.

According to the invention, the sign is relatively light-weight, has an aerodynamic cross-sectional shape and is hingedly rotatable about a member which passes through the sign. The sign is normally prevented from rotating by a releasable restraining member. The restraining member holds a sign in a readable position under normal wind forces. When the wind exceeds a given pre-determined force value the sign is released by the restraining member and rotatably assumes a minimum force (drag) position. The support structure for the sign has an optimized strength-to-weight ratio. The cross-section through the support is circular in a plane that passes through the normal (perpendicular) force center on the sign and the support, for each incremental section of the support.

Numerous other objects and advantages of the invention will now become apparent upon a reading of the following specification in conjunction with the drawings in which:

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** shows a horizontally supported sign and sign support in accordance with the principles of this invention, partially cut away.

FIG. **2** shows a vertically supported sign according to the invention, partially cut away.

FIG. **3** is a cross-sectional view through the sign shown in FIG. **1** along line **3—3.**

FIG. **4** is a diagrammatic representation for a horizontal support, according to the invention, indicating pertinent dimensional and analytic parameters.

FIG. **5** is a diagrammatic representation of a vertical support, according to the invention, indicating pertinent dimensional and analytic parameters.

FIGS. **6A**, and **6B**, and **6C** are diagrammatic representations showing the vertical component of the horizontal support of FIG. **4** in front, side and cross-sectional top views and associated parameters.

FIG. **7** is a perspective representation showing the horizontal component of the horizontal support of FIG. **4** and associated parameters.

FIGS. **8A**, **8B** and **8C** are diagrammatic representations, showing the horizontal segment of the horizontal component of FIG. **7** in front, top, and cross-sectional side views and associated parameters.

FIGS. **9A** and **9B** are diagrammatic representations showing the transitional segment of the horizontal component of FIG. **7** in side and top views and associated parameters.

FIGS. **10A** and **10B** and **10C** are diagrammatic representations showing the vertical support of FIG. **5** in front, side and cross-sectional top views and associated parameters.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

FIGS. **1** and **2** show two separate embodiments for the sign and sign support apparatus. FIG. **1** shows a horizontally hinged sign **10** supported by member **20.** FIG. **2** shows a vertically hinged sign **30** supported by member **40.** Members **20** and **40** may both be rigidly supported within the grounds or a similarly immovable object. The sign and the support members include a light weight inner core material, such as a foamed plastic, covered by a relatively thin skin material of higher strength such as fiberglass, and are constructed to have a relatively large strength-to-weight ratio. The support structure is discussed in more detail in association with FIGS. **4** through **10.**

SIGN

FIG. **1** shows a perspective view of the sign **10** having width W_s and height H_s and sign support member **20.** The member **20** may be constructed in accordance with the principles of the invention or other support members including conventional ones may be used with sign **10.**

FIG. 3 is a cross-sectional view through the sign of FIG. 1 taken along line 3—3. The cross-section is in the shape of an aerodynamic air foil. The sign includes a light-weight core material 27, such as a foamed or cellular plastic, surrounded by a thin skin 25 of fiberglas, for example. The sign 10 is supported so that the center of gravity of the cross-sectional air foil coincides with the center line of internal portion 15 of support 20. In FIG. 1 this center of gravity line passes through the sign one-quarter of the way down from the top edge, as shown. The internal portion of the sign 10 includes a torque tube 17 for facilitating the easy rotation of sign 10 about support 15. Tube 17 is provided, as shown, touching skin 25 on its inner surface, in order to transmit stresses from the sign surface loads to the support.

The wind forces upon the sign 10 may be resolved into a normal force F applied at a sign force center which for the embodiment of FIG. 1 is at approximately the mid-point of sign 10. Sign 10 is able to rotate about portion 15 of member 20 except when restrained by restraining members 11.

The sign and support shown in FIG. 1 may be provided with two restraining member 11, only one of which is clearly illustrated in FIG. 1. Restraining member 11 includes a cylindrical arm 13 which forms a part of sign 10 and extends outwardly from sign 10 about member 20. Each arm 13 has a pair of oppositely positioned holes for accommodating a shear pin 12, or the like. Member 20 would also be provided with a hole that would align with the holes in the arm 13 to allow pin 12 to insert therethrough and hold sign 10 in a normally restrained position relative to support member 20. A second restraining member including a shear pin could also be provided on the left side of sign 10, as viewed in FIG. 1.

When the wind increases to a value where the force F exceeds a predetermined value, the load upon the pins 12 will cause them to sheer and the sign will rotate to a streamlined position as indicated in FIG. 3. In this position the drag upon the sign and the support is reduced to a minimum. In order to restrain the sign to a fixed position again pin 12 is replaced. This operation is significantly less time consuming and less costly than having to replace the entire structure destroyed by an excess wind force.

In addition, if the particular sign is located adjacent to a roadway and a vehicle hits the sign it will yield more than a rigid sign and will cause less damage to the impacting motor vehicle.

A further advantage of the present invention is realized by referring to FIG. 2 where a vertically hinged sign is shown. With the arrangement of FIG. 2 the sign 30 may be restrained in one of two readable positions. Sign 30 has an aerodynamic shape and includes a sleeve 34 which may be circular in cross-section. Sign 30 rotates about internal support portion 32 which is usually integrally formed with the remaining exposed portion of support 40, except when secured by restraining members 31.

As in FIG. 1, the sign and support shown in FIG. 2 may be provided with two restraining members 31 similar to those shown in FIG. 1. Restraining member 31 includes a cylindrical arm 33 which forms an integral part of sign 30 and extends outwardly from sign 30 about support member 40. Each arm 33 has a pair of oppositely positioned holes for accommodating a shear pin 35. Member 40 also is provided with a hole that aligns with the holes in the arm 33 to thereby allow pin 35 to insert through both the member 40 and arm 33, and hold the sign 30 in a normally restrained position relative to support member 40.

When it is desired to restrain the sign in a new position the pins 35 may be extracted or screwed out in the event screw threads are used. The sign may then be rotated to a second position and new shear pins inserted to restrain it in that position. In either position, however, when an excessive wind force occurs the pins 35 shear and the sign 30 assumes a minimum force position, as previously discussed with reference to FIGS. 1 and 3.

With the arrangement of FIG. 2 the sign can have different legends written on both sides. One side of the sign, for example, could be provided with standard roadside nomenclature, while the other side could display emergency or military symbols.

SUPPORT STRUCTURE

FIGS. 4 and 5 show two separate embodiments of the sign support structure. The support structure is similar in construction to the sign and includes a light-weight core material such as a cellular or foamed plastic surrounded by a stronger, thin-walled jacket such as fiberglass. The support for the horizontally hinged sign of FIG. 2, is shown in FIG. 4 along with associated support parameters. The wind forces on the sign can be resolved into a force F normal to the sign at the midpoint thereof.

The support system may be divided into two components. The vertical component extends from Section A—A to Section B—B. Section B—B lies in a horizontal plane with respect to gravity with the vector defining force F, and is the fundamental section to which all other support sections are related. The horizontal component extends from section B—B to section D—D.

The stress imposed by the force F upon any section of the support can be resolved into a torque T_x and reaction load R_x. The reaction load, R_x is equal to the normal wind force F at all support sections. The torque T_x is equal to the product of force F and distance D_x which is a function of the angle θ. The angle θ is, in turn, determined in part by the sign size W_s and H_s, support overhang, P, and support height H. The limiting angles of θ as shown in FIG. 4 are θ_v and θ_h. These angles may be determined as follows:

$$\theta_v = \text{Arctan } (H - H_s/4)/(W_s/2 + P), \text{ and} \quad (1)$$

$$\theta_h = \text{Arctan } (H_s/4)/(W_s/2). \quad (2)$$

It has been found that the optimum strength for a sign of the type described requires a support with a cross-section that is circular in a plane that passes through the force F and any point along the centerline of the support. Since force F is perpendicular to the plane containing the centerline of the support, any plane through force center F is also perpendicular to the plane containing the centerline of the support, any plane through force center F is also perpendicular to the plane containing the centerline of the support. The only circular cross-section thus defined which also lies in a horizontal plane is section B—B. All other cross-sections thus defined as circular in a plane that passes

through the force F are elliptical in any other plane perpendicular to the plane containing the centerline of the support. (For convenience reference will be made herein to horizontal planes or cross-sections intending to specific aforesaid perpendicular or vertical planes or cross-sections. Further force center of F means the point of the force vector F on the sign at which all perpendicular forces may be resolved into a single component). The dimensions of the elliptical cross-section are determined by the horizontal projection of an inclined circle whose major axis equals the circle radius and minor axis is a cosine function of the angle θ. In FIG. **4**, the sections A—A and D—D are both elliptical in shape when horizontally projected and vertically projected, respectively.

The change in the torque T_x due to the change in the torque arm D_x can be compensated for by either a direct proportional change in the thickness, t, of the stressed skin of the support or a change in the radius of the coplanar, circular cross-section, which varies as the square root of the changing torque arm (D_x). The coplanar radius is the radius measured at right angles to the vertical plane of the sign and support.

A vertically hinged sign is shown in FIG. **5** along with associated support parameters. The normal force on the sign can be resolved into a force F normal to the sign at the midpoint thereof. The structural concept of the vertical support is similar to that of the horizontal support. The reference section G—G of the support is in a horizontal plane that passes through the force point F, is circular, and is contained within the sign **30.** No exposed portion of the support is circular in a horizontal cross-section. All cross-sections on an axis other than that through section G—G are circular in a plane that passes through the force point of F and are elliptical in a horizontal cross-section. Cross-section E—E and F—F are both elliptical in FIG. **5** in horizontal planes.

For a better understanding of the concepts of the invention specific examples are considered below. In these examples both variations in skin thickness and coplanar radius are considered.

HORIZONTAL SUPPORT

Verticle Component

Referring to FIG. **4**, there is shown the horizontal support member **20** and associated dimensional parameters. The configuration of the vertical component **22** between sections A—A and B—B is based upon the initially chosen dimensions of section B—B; the torque T_b, skin thickness t_b and cross-sectional radius r_b. Throughout this specification the subscripts *a,b,c* and *d* refer to their respective cross-sections A—A, B—B, C—C and D—D while subscript x refers to other cross-sections. FIGS. **6A**, **6B** and **6C** show front, side and top cross-sectional views of the vertical component **22** for a constant skin thickness configuration. A vertically hinged support is considered hereafter constructed according to the invention and using a constant coplanar radius.

Assuming a vertical, straight support center line for component **22** the torque load T_x, for any section X—X is a function of the angle θ to the particular section from the force center:

$$T_x = T_b \sec \theta \tag{3}$$

The secant (sec θ) varies from a value of **1** at zero degrees (section B—B) to values greater than **1** for larger angles. From the above equation it can be seen that the torque does increase as θ increases and as the torque arm D_x increases.

As previously stated, the change in torque with changes in torque arm between section A—A and B—B can be compensated for by varying the coplanar radius, r_b of the particular cross-section. If the skin thickness remains constant, then the equations for t_x and r_x at any section X—X are:

$$t_x = t_b = \text{constant, and}$$
$$r_x = r_b \quad \sqrt{\sec \theta} \tag{4}$$

Because the radius varies as the square root of the torque, equation (4) shows both the θ and square root relationships.

If, in the alternative, the coplanar radius r_b remains constant then the equations for r_x and t_x are:

$$r_x = r_b = \text{constant, and}$$
$$t_x = t_b \sec \theta, \tag{5}$$

since the skin thickness varies as a direct function of the torque.

By varying both skin thickness and circular coplanar radius for different segments or components of the support, it is apparent that an unlimited number of support combinations exists.

Up to now only coplanar (with F) dimensions have been considered. The horizontal projected cross-sections are now considered. The horizontal or perpendicular to the centerline cross sections are elliptical, except for section B—B. If the skin thickness remains constant then $t_x = t_b$. The elliptical cross-section, however, is defined by major and minor axis dimensions, b_x and a_x, respectively. The elliptical cross-section axis, b_x, is perpendicular to the plane of the sign and support and equals the radius of the circular cross-section, r_x, which is an angular function of the basic radius r_b, so that:

$$b_x = r_x = r_b \quad \sqrt{\sec \theta} \tag{6}$$

The elliptical cross-sectional minor axis, a_x, in the plane of the sign and support is an angular function of the circular coplanar radius r_x which is, in turn, an angular function of the basic radius r_b, so that:

$$a_x = r_x \cos \theta$$
$$= r_b \quad \sqrt{\sec \theta} \cos \theta$$
$$= r_b \quad \sqrt{\cos \theta} \tag{7}$$

For the case where the skin thickness varies and the coplanar radius, r_x remains constant, or $r_x = r_b$, then the equations for a_x, b_x and t_x for any section X—X are:

$$a_x = r_x \cos \theta = r_b \cos \theta, \tag{8}$$

$$b_x = r_x = r_b, \text{ and} \tag{9}$$

$$t_x = t_b \sec \theta \tag{10}$$

Referring to FIGS. 6A, 6B and 6C there are shown three views of the vertical component of the support between sections A—A and B—B, for the constant skin thickness application. The top cross-sectional view taken at section X—X is elliptical and has a major axis b_x, and a minor axis a_x. The major axis b_x is slightly greater than the basic radius r_b whereas the minor axis a_x is slightly less. The reasons for the configuration of FIG. 6C will become apparent after considering equations (6) and (7) above. The axis b_x increases because the sec θ is greater than one and its square root is also. The axis a_x, however decreases because the cos θ is less than one as is its square root. The front and side views show the tapered configurations.

HORIZONTAL COMPONENT

The horizontal component **25** of the horizontal support **20** is shown in FIG. **7** along with associated dimensional parameters. The horizontal component **25** includes a horizontal segment **26,** because sections C—C and D—D, and a transitional segment **24** between sections B—B and C—C. The horizontal and transitional segments are considered in conjunction with FIGS. **8** and **9,** respectively.

HORIZONTAL SEGMENT

Horizontal segment **26** can be analyzed in a similar manner to vertical segment **22** by referring to FIGS. **8**A, **8**B and **8**C. All vertical cross-sections between and including sections C—C and D—D are elliptical. The torque load T_x, with relation to section B—B is a function of the angle θ and certain sign/support parameters trigonometrically arrived at:

$$T_x = \frac{[T_b W_s/2 + X]}{[W_s/2 + P]} \sec \theta,$$

or

$$T_x = T_b K \sec \theta \tag{11}$$

shere K is less than **1,** W_s equals the sign width, X equals the distance from the edge of the sign to the section X—X, (the distance x obviously varies with the position of section X—X and thus both K and θ are functions of x), P equals the distance from the edge of the sign to the section B—B and $K = (W_s + 2_x) / (W_s + 2P)$. It is noted that equation (11) above is similar to equation (3) for the vertical component except for the factor K which is less than one because X is always less than P.

For constant skin thickness applications $t_x = t_b$. The elliptical, vertical cross-section may again be defined by major and minor axis dimensions, b_x and a_x, respectively. The elliptical cross-section axis b_x is perpendicular to the plane of the sign and support and equals the radius of the circular cross-section r_x, which is an angular function of the basic radius r_b and certain dimensional parameters:

$$b_x = r_x = r_b \, K \sec \theta \tag{12}$$

It is noted that equation (12) is similar to equation (6) for the vertical component except for K.

The elliptical cross-section minor axis a_x, in the plane of the sign and support is an angular function of the circular complanar radius r_x:

$$a_x = r_x \sin \theta$$

$$a_x = r_b \sqrt{K \sec \theta} \sin \theta \tag{13}$$

Equation (13) is similar to equation (7) for the vertical component except for K and a different trigonometer's relationship.

For the case where the skin thickness varies and the coplanar radius r_x remains constant, or $r_x = r_b$, then the equations for a_x, b_x and t_x for any section X—X are:

$$a_x = r_x \sin \theta = r_b \sin \theta \tag{14}$$

$$b_x = r_x = r_b, \text{ and} \tag{15}$$

$$t_x = t_b \sec \theta \tag{16}$$

Referring to FIG. **8**C in particular the horizontal segment **26** is constructed with a constant skin thickness which is elliptical and has a major axis b_x and minor axis a_x. The major axis b_x is slightly less than the basic radius r_b whereas the minor axis a_x is less than axis b_x. These dimensions are smaller than for the vertical component **22,** in part, due to the shorter average torque arm for the horizontal segment **26.** The reasons for the configuration of FIG. **8**C should become apparent after considering equations (12) and (13) above. From equation (12) the axis b_x varies as a function of $\sqrt{\sec \theta}$ and K. K is controlling to cause b_x to be smaller than r_b. Equation (13) indicated that a_x which also varies as the sin θ is even smaller than b_x because the sin θ is always less than one.

TRANSITIONAL SEGMENT

Transitional segment **24** can be analyzed by referring to FIGS. **9**A and **9**B, which also show associated dimensional parameters. In view **9**A, the center line for the transitional segment **24** has been selected illustratively as a quarter of an ellipse, between sections B—B and C—C. Section X—X is normal to the center line of the segment and varies between a horizontal and vertical cross-section between sections B—B and C—C respectively.

From the dimensions in FIGS. **9**A and **9**B it is possible to define the trigonometric relationships for the angles θ and B. The angle θ is an angle measured from the horizontal to a plane that passes through the normal force F and a point on the center line of the support at the particular section X—X. The angle B is an angle measured from the horizontal to a plane that is tangent to the elliptically shaped center line at section X—X. The torque load T_x, with relation to section B-B is a function of the angle θ and certain sign/support parameters trigonometrically arrived at:

$$T_x = T_b \, K_1 \sec \theta \tag{17}$$

where $K_1 = (W_s/2 + Q + n) / (W_s/2 + P)$ and is equal to or less than one, W_s equals sign width, Q equals the distance from the edge of the sign to section C—C, n equals the distance from section C—C to section X—X, and P equals the distance from the edge of the sign to section B—B. The distances m and n shown in FIG. **9** vary as the position of section X—X changes and thus both K, O and B are functions of m and n.

For constant skin thickness applications $t_x = t_b$. The elliptical cross-sections normal to the center line of segment **24** may again be defined by major and minor axis dimensions, b_x and a_x, respectively. The elliptical cross-section axis b_x is perpendicular to the plane of the sign and support and equals the radius of the circular cross-section r_x, which is an angular function of the basic radius r_b and certain dimensional parameters:

$$b_x = r_x = r_b \quad \sqrt{K_1 \sec \theta} \tag{18}$$

The value of K_1 is the same as that calculated for equation (17).

The elliptical cross-sectional minor axis a_x in the plane of the sign and support is an angular function of the circular coplanar radius r_x:

$$a_x = r_x \sin (\theta + B)$$
$$a_x = r_b \quad \sqrt{K_1 \sec \theta} \sin (\theta + B) \tag{19}$$

For the case where the skin thickness varies and the coplanar radius r_x remains constant, or $r_x = r_b$, then the equations for a_x, b_x and t_x for any section X—X are:

$$a_x = r_x \sin (\theta + B) = r_b \sin (\theta + B) \tag{20}$$

$$b_x = r_x = r_b, \text{ and} \tag{21}$$

$$t_x = t_b \sec \theta \tag{22}$$

Referring to FIGS. **9**A, and **9**B the transitional segment **24** is constructed with a constant skin thickness. From the top view of FIG. **9** it is seen that the major axis b_x varies from a value of r_b at section B—B to a slightly smaller value at section C—C. The minor axis varies from a value of r_b at section B—B to a smaller value than b_x at section C—C. Equations (18) and (19) indicate these relationships. In these equations K_1 is less than one because $Q + n$ is less than P. (See equation (17)). In equation (18) b_x is less than r_b because K_1 is less than one. In equation (19) a_x is less than b_x and r_b because K_1 is less than one and sin $(\theta + B)$ is also less than one.

EXAMPLE - HORIZONTAL SEGMENT

Referring to FIG. **4** and Table **1** below, variations in a_x, b_x and t_x are shown, calculated for varying skin thickness t, and varying coplanar radius b, respectively. The values shown are non-dimensional and relate to section B—B as the basic cross-section.

TABLE I

ELLIPTICAL CROSS-SECTION VARIANCES

Section	Station	Constant Skin Thickness			Constant Coplanar Radius		
		axis a	axis b	skin thickness t	axis a	axis b	skin thickness t
A-A	0	0.90	1.11	1	0.81	1	1.23
	5	0.93	1.07	1	0.87	1	1.15
	10	0.95	1.06	1	0.90	1	1.11
	15	0.98	1.02	1	0.96	1	1.04
	20	1.00	1.01	1	0.99	1	1.01
B-B	25	r=1	r=1	1	r=1	r=1	1
	30	0.193	0.96	1	0.207	1	0.93
	35	0.130	0.93	1	0.153	1	0.85
C-C	40	0.087	0.72	1	0.12	1	0.34
	45	0.094	0.59	1	0.16	1	0.25
D-D	50	0.172	0.42	1	0.24	1	0.17

The values in Table I were arrived at by using the following dimensions: H_s equal to 10 feet; W_s equal to 20 feet; H equal to 27.5 feet; P equal to 25 feet; and Q equal to 10 feet. The sections were taken at five foot intervals (stations).

The basic size of section B—B, to which all other sections are sized, is based on the load imposed by an 80 MPH wind and a margin of safety of 1.5. A correlation of skin thickness t, with cross-sectional radius r, for section B—B is shown in Table II.

TABLE II

Skin Thickness t (inches)	Radius B—B r (inches)
0.050	11.32
0.100	8.02
0.150	6.53
0.200	5.66

The above values were arrived at by assuming a force F, of 3,830 lbs. and a fiberglass working stress of 60×10^3 psi. Although this working stress was assumed, other material may be used having working stresses of $120–150 \times 10^3$ psi. The reduction of skin thickness of the basic cross-section is directly related to an increase in working stress. The smaller thickness, larger radius structure is preferred for vehicle impact conditions.

In another embodiment of the invention the support structure was constructed using different variations in different segments of the support. The vertical component **22** used the constant skin thickness variation while the horizontal component **25** used the constant coplanar radius variation. The constant skin thickness vertical component provides for a ten percent increase in the major axis b, at section A—A instead of a 20 percent increase in skin thickness t, at the same section. The thinner skin will also yield more easily when impacted by a vehicle. At the same cross-section A—A the reduction in the minor elliptical axis a_x was only ten percent (see table I).

One reason for using a constant coplanar radius for the horizontal component was that a larger cross-section was attained at section D—D where the support mated with the sign. Also, for most of the horizontal component the minor axis a, is relatively uniform (see table I). With the major axis constant, a relatively uni-

form elliptical cross-section resulted. This fascilitated fabrication without a significant weight penalty.

In still another embodiment of the invention, the horizontal segment **26** used a constant skin thickness while the transitional segment **24** uses step laminations to provide the thickness variation.

The horizontal and vertical components may also be fabricated separately and joined together at section B—B, for example. A circular coupling sleeve could be used to provide the structural connection.

VERTICAL SUPPORT

Referring to FIG. **5,** there is shown the vertical hingeline support **40** and associated dimensional parameters. The configuration of the support between sections E—E and F—F is based upon the initially chosen dimensions of section G—G which is in a horizontal plane with force F. The vertical hingeline support is similar to the vertical component of the horizontal hingeline support in that all horizontal cross-sections of the support are elliptical. For optimum strength, however, the reference section G—G is circular and all other sections between E—E and F—F are circular in a plane that passes through the force center of force F, at the midpoint of the sign. In FIG. **10** the vertical support is shown as having a constant coplanar radius. Note that in FIG. **5** the angle θ is measured from the vertical whereas it was previously measured from the horizontal in FIG. **4.**

Although all sections between E—E and F—F are based upon section G—G, the internal portion **32** of the support need not be based upon section G—G. The entire portion **32,** may for ease of fabricaton be cylindrical and circular in all horizontal planes so as to be compatible with the torque tube of the sign.

Assuming a vertical, straight support center line, the torque load T_x, for any section X—X is a function of the angle θ to the particular section:

$$T_x = T_g \sec \theta, \text{ and}$$

$$r_x = r_g \quad \sqrt{\sec \theta}$$

(23)

As previously stated, the change in torque with changes in torque arm between sections E—E and F—F can be compensated for by either varying the skin thickness t, of the support or by varying the coplanar radius r_b of it. If the skin thickness remains constant then the equations for a_x, b_x and t_x as they relate to section G—G are:

$$a_x = r_x \sin \theta = r_g \quad \sqrt{\sec \theta} \sin \theta$$

(24)

$$b_x = r_x = r_g \quad \sqrt{\sec \theta} \text{ and}$$

(25)

$$t_x = t_g$$

(26)

For the case where the skin thickness, t, varies and the coplanar radius (r_x) remains constant, then the equations for a_x, b_x and t_x for any section X—X are:

$$a_x = r_x \sin \theta = r_g \sin \theta$$

(27)

$$b_x = r_x = r_g, \text{ and}$$

(28)

$$t_x = t_g \sec \theta$$

(29)

The distance y shown in FIG. **10** varies with the position of section X—X and thus θ is a function of y.

Referring to FIGS. **10A, 10B** and **10C** there are shown separate views of the vertical support **40,** for the constant coplanar radius application. The top cross-sectional view of FIG. **10C** taken at section X—X is elliptical and has a major axis b_x equal to r_g and a minor axis a_x which is a smaller one than b_x. The skin thickness at section X—X is larger than that at section G—G. The side views of FIG. **10B** shows the constant coplanar radius whereas the front view of FIG. **10A** shows the tapered a_x dimension. Equation (27) indicates that a_x becomes smaller as θ decreases, while equations (28) shows the constant r_g relationship. Equation 29 shows that t_x increases with increases in the angle θ.

EXAMPLE - VERTICAL SUPPORT

Referring to FIG. **5** and Table **111** below, variations in a_x, b_x and t_x are shown, calculated for varying skin thickness t, and varying coplanar radius b, respectively. The value shown are non-dimensional and relate to section G—G as the basic cross-section.

TABLE III

		ELLIPTICAL CROSS-SECTION VARIANCES					
		Constant Skin Thickness			Constant Coplanar Radius		
Section	Station	axis a	axis b	skin t	axis a	axis b	skin t
G—G	−5	r = 1	r = 1	1	r = 1	r = 1	1
F—F	0	0.840	1.19	1	0.707	1	1.414
	2	0.763	1.31	1	0.581	1	1.720
	4	0.694	1.44	1	0.485	1	2.060
	6	0.645	1.55	1	0.413	1	2.420
	8	0.595	1.68	1	0.357	1	2.800
	10	0.562	1.78	1	0.316	1	3.160
E—E	12	0.532	1.88	1	0.282	1	3.540

The values expressed in Table III were arrived at by using the following dimensions: H_s equal to 10 feet; W_s equal to 10 feet; and H equal to 12 feet. The sections were taken at 2 foot intervals (stations).

The basic size of section G-G, to which all other sections were related is based on the load imposed by an 80 MPH wind and a margin of safety of 1.5. The correlation of skin thickness t, with cross-sectional radius r, for section G-G is shown in Table IV.

Skin Thickness t (inches)	Radius G—G r (inches)
0.010	4.76

-Continued

Skin Thickness t (inches)	Radius G—G r (inches)
0.030	2.75
0.050	2.13
0.070	1.80

The above values were arrived at by assuming a force F, of 2,850 lbs. and a fiberglass working stress of 60×10^3 psi. The variations in skin thickness are inversely proportional to the radius at section G—G.

In another embodiment of the invention similar to that shown in FIG. **10** the top half of support **40** was constructed with a constant coplanar radius while the bottom half was constructed with a constant skin thickness. With such an arrangement the constant skin thickness on the bottom is provided for impact situations.

From the foregoing analysis of the concepts for the present invention and from the different illustrative embodiments shown, it should be apparent to one skilled in the art that various modifications of and departures from the concepts shown may be made, all of which are contemplated as falling within the spirit and scope of the present invention.

What is claimed is:

1. A sign structure comprising;

a sign having within its outer edges a force center line which is directed substantially perpendicularly to the face of said sign,

a support member having one end maintained stationary and including means for attaching the other end to said sign,

said support member including a substantially vertical section that is formed having a circular cross section in all planes that pass through the force center line of said sign and respective points along the length of said section,

said sign having an air foil shape and including means for receiving said attaching means of said support member,

said means for receiving being disposed off-center of said sign and spaced from said force center line.

2. A sign structure as defined in claim **1** comprising means for restraining said sign in a normal, readable position when normal forces are applied to said sign and for releasing said sign from said restrained position when said forces exceed a predetermined value, said sign including a fixed sleeve having a portion of said support structure contained therein.

3. A sign structure as defined in claim **1** wherein said restraining means includes a securing member located at one side of said sign and including means for at least temporarily engaging said sign.

4. A sign structure as defined in claim **3** wherein said securing member includes a cylindrical collar attached to said sign and having a hole therethrough, said supporting means includes a hole aligned with said hole in said collar, and a shear pin adapted to fit through said holes.

5. A sign support as defined in claim **1** wherein said support member includes a relatively thin outer jacket and a relatively light weight inner core material.

6. A sign support as defined in claim **5** wherein the thickness of said outer jacket remains constant and the radius of said circular cross-section varies as a function of the distance between said force center line and respective portions along said support member.

7. A sign support as defined in claim **5** wherein the circular cross-section remains constant and the thickness of said outer jacket varies as a function of the distance between said force center line and respective portions along said support member.

8. A sign structure as set forth in claim **7** wherein the radius of each of said circular cross sections is determined by the formula.

$r_x = r_b \sec \theta$

where r_x = radius in any of said cross sections

r_b = radius of said one circular cross section which lies in a plane horizontal with respect to gravity and through the force center F,

θ = the angle from the force center F defined by the plane containing said one circular cross section defined by r_b and the plane containing the cross section defined in r_x.

9. A sign structure as set forth in claim **7** wherein the skin thickness of each of said circular cross-sections is determined by the formula: $t_x = t_b \sec \theta$

where

t_x = skin thickness in any of said cross sections,

t_b = skin thickness of said one circular cross-section which lies in a horizontal plane with respect to gravity, and through force center F,

θ = angle from the force center F defined by the plane containing said one circular cross-section defined by r_b and the plane containing cross section defined by r_x.

10. A structure of claim **1** wherein said substantially vertical section has a progressively larger cross-sectional area from the top to the bottom thereof.

11. A sign structure including a sign defining within its outer edges a force center line (F) which is directed substantially perpendicularly to the face of said sign, a support for said sign including horizontal and vertical members with said horizontal member having one end connected to said sign and the other to said vertical member, said vertical member having a circular cross section in all planes intersecting the force center and respective points along the vertical member for all angles of said plane that intersect said vertical member, said sign having an air foil shape and including means for receiving said attaching means of said support member, said means for receiving being disposed off-center of said sign and spaced from said force center line.

12. A sign structure as set forth in claim **11** wherein all planes passing through said vertical support horizontal to gravity define on said bearing support an elliptical shape except for those also passing through said force center line F.

13. A sign structure as set forth in claim **12** wherein all of said planes passing through said force center line F define circular cross sections on said vertical support.

14. A sign structure including a sign defining within its outer edges a force center line (F) which is directed substantially perpendicularly to the face of said sign, a support for said sign including a vertical member having one end connected to said sign, said vertical member having a circular cross section in all planes intersecting the force center line (F) and respective points along said vertical member for all angles of said plane intersecting said vertical member, said sign having an

air foil shape and including means for receiving said attaching means of said support member, said means for receiving being disposed off-center of said sign and spaced from said force center line.

15. A sign structure as set forth in claim **14** wherein all horizontal planes passing through said vertical support define an elliptical cross-sectional shape.

16. A sign structure as set forth in claim **14** wherein all of said planes passing through said force center line F define circular cross-sections on said vertical support.

17. A sign structure as set forth in claim **14** wherein the radius of each of said circular cross-sections is determined by the formula

$r_x = r_g \quad \sec \theta$

where

r_x = radius of any of said cross-sections,

r_g = radius of said one circular cross-section which lies in a plane horizontal with respect to gravity and through force center F, and

θ = the angle from the force center F defined by a vertical plane and the plane containing the cross-section defined by r_x.

18. A sign structure as set forth in claim **14** wherein the skin thickness of said circular cross-section is determined by the formula

$t_x = t_g \sec \theta$

where

t_x = skin thickness of said cross-sections,

t_g = skin thickness of said one circular crosssection which lies in a plane horizontal with respect to gravity and through force center F, and

θ = the angle from the force center F defined by a vertical plane and the plane containing the cross-section defined by r_x.

* * * * *

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,828,455 Dated August 13, 1974

Inventor(s) Ralph L. Bentley

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

On the cover sheet the illustrative figure should appear as shown on the attached sheet.

Signed and sealed this 3rd day of June 1975.

(SEAL)
Attest:

RUTH C. MASON
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents
and Trademarks

UNITED STATES PATENT OFFICE

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