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MULTIZONE HIGH POWER LIGHT REFLECTOR

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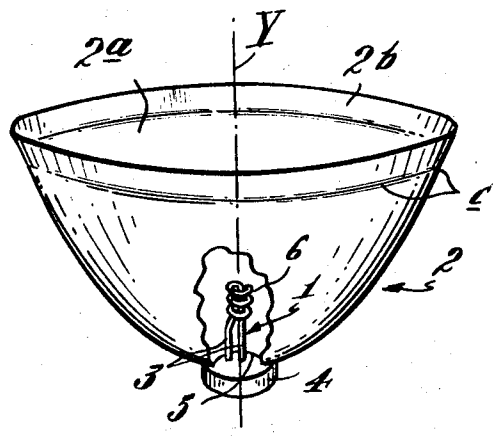


Fig. 1

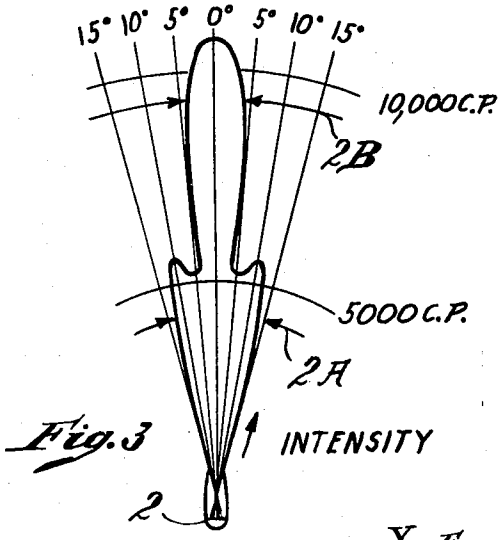


Fig. 3

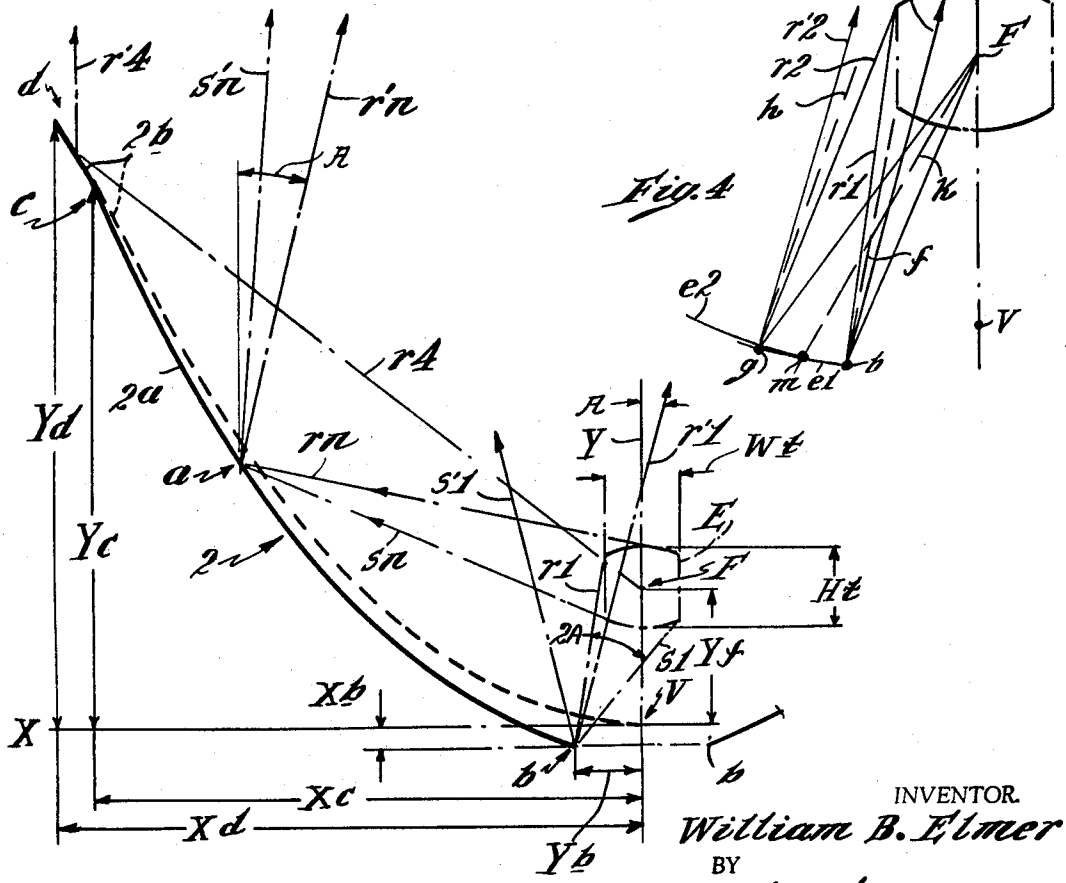


Fig. 4

Fig. 2

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MULTIZONE HIGH POWER LIGHT REFLECTOR

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ABSTRACT OF THE DISCLOSURE

An airport beacon for projecting a narrow (10°) vertical beam portion of high intensity (10,000 c.p.) and a concentric wider (30°) beam portion of lower intensity (5,000 c.p.) unitary with the first. The beacon comprises a compound reflector of light from a source with volume, rather than a point source. The reflector is a surface of revolution with two concentric portions generated from two coaxial curves. The curve further from the light source is a parabola with its focus at the light source and reflects the narrow, high intensity beam portion. The curve nearer the light source is the locus of increments reflecting light in the wider beam but within a definite angle.

This invention relates to a light reflector for projecting a light beam in two or more zones with different intensities, and wherein a beacon is reflected from a light source of substantial size with respect to the reflector.

There is a need at airports for a vertical beacon which casts a relatively wide beam of given candlepower and also a relatively narrow beam of substantially higher power. Such beacons may comprise a high power flash tube mounted in a reflector. Prior reflectors have been paraboloids or distorted paraboloids. By paraboloid is meant the surface of revolution of a parabola. A paraboloid reflects light from a flash tube located with its focal point generally parallel to the principal axis of the paraboloid in a rather narrow beam. The beam may be widened by distorting the paraboloid, e.g. by effectively warping the reflecting surface from true paraboloid form toward or away from the central axis. A distorted paraboloid surface reflects light in a diverging beacon which, however, has reduced power adjacent the axis where increased power is required. Similarly a paraboloid reflector with a flash tube located off the focal point projects a beam with a low intensity zone around its axis. Since a flash tube drawing suitable power, for example 30 watt-seconds, cannot be a point source, but must be of substantial extent along the principal axis of the reflector, an out of focus problem is inherent in prior reflectors.

One object of the present invention is to provide a beacon with a single reflector projecting light both in a narrow beam parallel to the central axis of the reflector and also in a wider beam concentric with the narrow beam. A further object is to provide such a reflector which reduces the electrical power requirements while retaining the candlepower of the beacon.

According to the invention a high power beacon comprises a concave reflector having a central axis, a light source, and means to mount said light source in said reflector on said axis, said light source having an envelope extending a substantial distance along said axis so as to radiate light from substantially spaced light points to reflecting increments on said reflector, said reflector comprising a surface of revolution about said central axis of at least two curves extending outwardly of said axis including a first curve comprising the locus of increments reflecting light within a narrow beam substantially parallel to said central axis, and a second curve comprising the locus of increments reflecting light in a wider beam concentric with the first said beam.

For purpose of illustration a typical embodiment of the invention is shown in the accompanying drawing in which:

FIG .1 is an isometric view of a beacon comprising a light source and a reflector according to the invention;

FIG. 2 is a geometric diagram of the beacon of FIG. 1;

FIG. 3 is a plot of light intensity versus angular deviation of light from the beacon of FIG. 1; and

FIG. 4 is an enlarged portion of FIG. 2.

As shown in FIG. 1 a beacon comprises a flash tube **1** mounted in a reflector **2**. The flash tube is a gaseous discharge lamp comprised of a length of quartz tubing having two legs **3** mounted on a base **4**, the legs extending through an opening **5** in the reflector to a coiled tubing portion **6** in which light emission is concentrated. The tubing is typically filled with a rare gas such as Xenon.

The reflector comprises two surfaces of revolution **2***a* and **2***b* connected at a circular junction *c*. These surfaces may be spun or drawn from a single sheet of aluminum 1/16 inch thick, for example. The inner surfaces of the reflector are then highly polished.

The two reflector surfaces **2***a* and **2***b* are generated by the revolution of two corresponding curves shown in FIG. 2. The surface **2***a* reflects light from the flash tube **1** (envelope E in FIG. 2) in a relatively broad beam whose maximum angle A of divergence from the Y axis is predetermined. The other surface **2***b* reflects light in a relatively narrow beam with a predetermined angle B of divergence from the Y axis. The intensity of the combined beams from surfaces **2***a* and **2***b* is plotted versus light intensity in FIG. 3. FIG. 3 also illustrates schematically the general shape of the combined beams within the maximum angles of divergence A and B.

The curves from which the surfaces **2***a* and **2***b* are generated are geometrically defined with respect to a focal point F at the center of an imaginary envelope E which outlines the volume occupied by the coiled tubing **6** of the flash tube **1**. In FIG. 2 the location and dimensions of the reflector curves **2***a* and **2***b* and the flash tubes envelope E are shown with reference to a horizontal axis X and a vertical axis Y. The curves and flash tube are concentric with the vertical axis Y. The curve **2***a* extends from a point *b* at the edge of the opening **5** to the junction *c* with curve **2***b*, and is constructed in a known manner, as will be explained in detail. The curve **2***b* is a portion of a parabola having its focus at the point F and extends from the junction *c* to the rim *d* of the reflector. An imaginary extension of the parabola **2***b* is shown by a broken line extending from the junction *c* to a parabolic vertex V at the intersection of the X and Y axes. The parabola is defined by the distance Y*f* between the vertex V and the focus F in the equation $x^2=4(Yf)\,y$, between the limits Y*c* and Y*d*, which are respectively the heights of the junction *c* and the outer rim *d* of the reflector. The light beam reflected from the surface **2***b* will be confined within a maximum angle B determined by the size of the envelope E relative to the distance Y*c* of the surface **2***b* from the parabolic vertex V. The intensity of the beam is determined by the radial extent (X*d* minus X*c*) of the surface.

The curve which generates the portion **2***a* of the reflector between the paraboloid **2***b* and the opening **5** is constructed with regard to the envelope E, the width (2Y*b*) of the reflector opening **5** between points *b*, *b*, and the maximum angle A at which the relatively broad beam from surface **2***b* diverges from the central axis Y of the reflector. The construction is as follows with reference to FIG. 2.

Lines parallel to the Y axis are drawn on either side of the Y axis at half the opening width distance Y*b*. The

angle 2A between the lines *r*1 and *s*1 is then fitted to the outline of the envelope E and adjusted until the vertex of the angle is on each of the above defined parallel lines. This may be accomplished by forming the angle 2A on a transparent sheet, superimposing the sheet on the envelope and keeping the lines *r*1 and *s*1 tangent to the envelope E as the vertex of the angle 2A is swung into superposition on the parallel lines. Points *b* at the edge of the opening 5 are thereby located with respect to the focus F at the center of the flash tube. Also the inclination of lines *r*1 and *s*1 is determined with respect to the Y axis. A line *r'*1 is then drawn through one point *b* at the angle A with respect to the Y axis. A very short line *e*1 drawn normal to the bisector *f* of the angle between *r*1 and *r'*1 represents a reflecting increment on the curve 2*b*. The increment is so inclined that, if line *r'*1 is regarded as a ray of light from a point on the flash tube envelope E, then line *r'*1 represents a ray reflected at the desired maximum angle A, with respect to the Y axis. A ray along the line *s*1 must be reflected on a line *s'*1 lying at an angle equal and opposite to the angle A. Any other rays from the flash tube envelope E will also be reflected at less than the desired maximum angle A, since they must lie between the rays *r*1 and *s*1.

After drawing the line *e*1, construction of the curve 2*a* proceeds, as shown in FIG. 4, by selecting an arbitrary point *g* on the line *e*1 at a distance from point *b* selected as the approximate desired increment length. Lines F*b* and F*g* are then drawn from the focus F and the angle between them is bisected by a line *k* which intercepts line *e*1 at a point *m* thereby limiting the length of line *e*1. A further line *r*2 is drawn through point *g* tangent to the outer part of the envelope E; a line *r'*2 is drawn through point *g* at the angle A to the Y axis; and the angle between lines *r*2 and *r'*2 is bisected by a line *h*. A second incremental line *e*2 is then drawn through point *m* at right angles to the bisector *h*. The point at which the second line *e*2 intersects a third incremental line is determined in the same way as was point *m*, and further incremental lines are located as the curve is constructed to the junction *c* with the parabolic curve 2*b*. After such incremental construction the curve 2*a* is easily smoothed to form a continuous curve.

As construction of the curve proceeds outwardly from point *b*, rays such as *rn* and *sn* tangent to the envelope subtend angles progressively smaller than the angle 2A, and the ray *s'n*, which is the reflection of the ray *sn* tangent to an inward point of the flash tube envelope E, approaches and passes beyond parallelism with the central axis Y. Thus it is the rays *r'*1, *r'*2 . . . *r'n* . . . which are reflections from rays *r*1, etc., tangent to outer points of the envelope which are held at the maximum angle A.

Solely by way of example, typical values of the dimensions in FIG. 2 are given as follows:

A=14°
B=4°
H*t*=0.9 inch
W*t*=0.9 inch
X*b*=0.75 inch
X*c*=5.75 inches
X*d*=6.5 inches
Y*b*=0.18 inch
Y*c*=5.4 inches
Y*d*=6.95 inches
Y*f*=1.56 inches

The flash tube coil 6 may be considered a solid of revolution of the envelope E with height H*t* parallel to the Y axis and width W*t* parallel to the X axis.

As indicated in FIG. 3 a beacon of the dimensions given above can produce a central beam of 10,000 candlepower and a wider beam of 5,000 candlepower using a power supply delivering less than 15 watts per second to the flash tube. Previous reflectors of the distorted paraboloid type, or with an off focus location of the flash tube, required a power supply delivering more than 30 watts per second. Not only does the present reflector meet the beam width and candlepower specifications required at airports with twice the efficiency, and hence one half the operating cost, but also it requires a power supply one half the size and hence substantially less in original cost.

It should be understood that the present disclosure is for the purpose of illustration only and that this invention includes all modifications and equivalents which fall within the scope of the appended claims.

I claim:

1. A high power beacon for simultaneously projecting light of a given intensity within a relatively wide angle (A) beam and also in a relatively narrow angle (B) beam with a greater intensity, comprising a concave reflector (2) having having a central axis (Y), a light source (6) and means (4) to mount said light source through an opening (5) in said reflector on said axis, said light source having an envelope (E) extending a substantial distance (H*t* and W*t*) along and transversely of said axis so as to radiate light from substantially spaced light points to reflecting increments on said reflector, said reflector comprising a surface of revolution about said central axis of at least two curves extending outwardly of said axis including

a parabolic curve (2*b*) having its vertex (V) at the intersection of said central axis (Y) with an axis (X) normal thereto, the geometrical center of said envelope (E) being located a predetermined distance (Y*f*) from said vertex (V) and said parabolic curve being defined with respect to said axes by the equation $X^2=4(Yf)\ y$ and joining a second curve (2*a*) at a junction (*c*) sufficiently remote from said envolep to confine rays reflected from the surface generated by said parabolic curve (2*b*) within said relatively narrow angle (B),

and said second curve extending from the edge (*b*) of said opening (5) to said junction (*c*), said envelope (E) subtending an angle (2A) at said edge (*b*) substantially twice said relatively wide angle (A), and said second curve comprising a series of light reflecting increments (*e*1, etc.) inclined normally to the bisector of the angle between a line (*r'*1, etc.) inclined at said relatively wide angle (A) and a line (*r*1, etc.) tangent to said envelope (E) at a point located outwardly of the reflector.

2. A high power beacon comprising a concave reflector having a central axis, a light source, and means to mount said light source in said reflector on said axis, said light source having an envelope extending a substantial distance along said axis so as to radiate light from substantially spaced light points to reflecting increments on said reflector, said reflector surface being substantially continuous, said reflector comprising a surface of complete revolution about said central axis of at least two curves extending outwardly of said axis including a first curve comprising the locus of increments reflecting light within a narrow beam portion substantially parallel to said central axis, and a second curve comprising the locus of increments reflecting light in a wider beam portion unitary with the first beam portion and concentric with the first said beam, said increments being disposed to produce said two beams with no gaps therebetween, and said two curves defining two concentric portions of said surface of revolution.

3. A beacon according to claim 2 wherein said second curve comprises the locus of reflecting increments so inclined with respect to said central axis as to reflect rays incident from light points disposed most outwardly from the reflector within a constant angle with respect to said central axis.

4. A beacon according to claim 2 wherein said first curve comprises a parabola, said light source being located at the focal point of said parabola.

5. A beacon according to claim 3 wherein said first curve comprises a parabola, said light source being located at the focal point of said parabola.

6. The beacon according to claim 2 wherein the concentric surface position further from said light source has a focal point at the center of said light source envelope.

7. A high power beacon comprising a concave reflector having a central axis, a light source, and means to mount said light source in said reflector on said axis: said source comprising light radiating points occupying a volume with a cross section intersecting said central axis and extending a substantial distance along and radially of said axis, said points being disposed generally symmetrically about a focus; said reflector surface being substantially continuous, said reflector comprising a surface of complete revolution about said central axis of at least two curves extending outwardly of said axis including a first curve comprising the locus of increments reflecting light from said light radiating points within a narrow beam portion substantially parallel to said central axis, and a second curve comprising the locus of increments reflecting light from said points in a wider beam portion unitary with the first beam portion and concentric with the first said beam, said increments being disposed to produce said two beams with no gaps therebetween, and said two curves defining two concentric portions of said surface of revolution.

8. A beacon according to claim 7 wherein said second curve reflects light within a predetermined angle with respect to said central axis, said curve comprising a series of reflecting increments inclined normally to the bisector of the angle between a line disposed at said predetermined angle and a line tangent to said volume of light reflecting points at a point located outwardly of the reflector.

9. A beacon according to claim 8 wherein said reflector has an opening centered on said central axis, and spaced from said volume such that with respect to each point of the edge of said opening said volume subtends an angle substantially twice said predetermined angle.

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