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350/314
[redacted]
XR 3,341,700

CROSS REFERENCE [redacted]

Sept. 12, 1967 D. M. FINCH 3,341,700

VANE CONTROLLED HEADLIGHTING SYSTEM

Filed Oct. 19, 1964 5 Sheets-Sheet 1

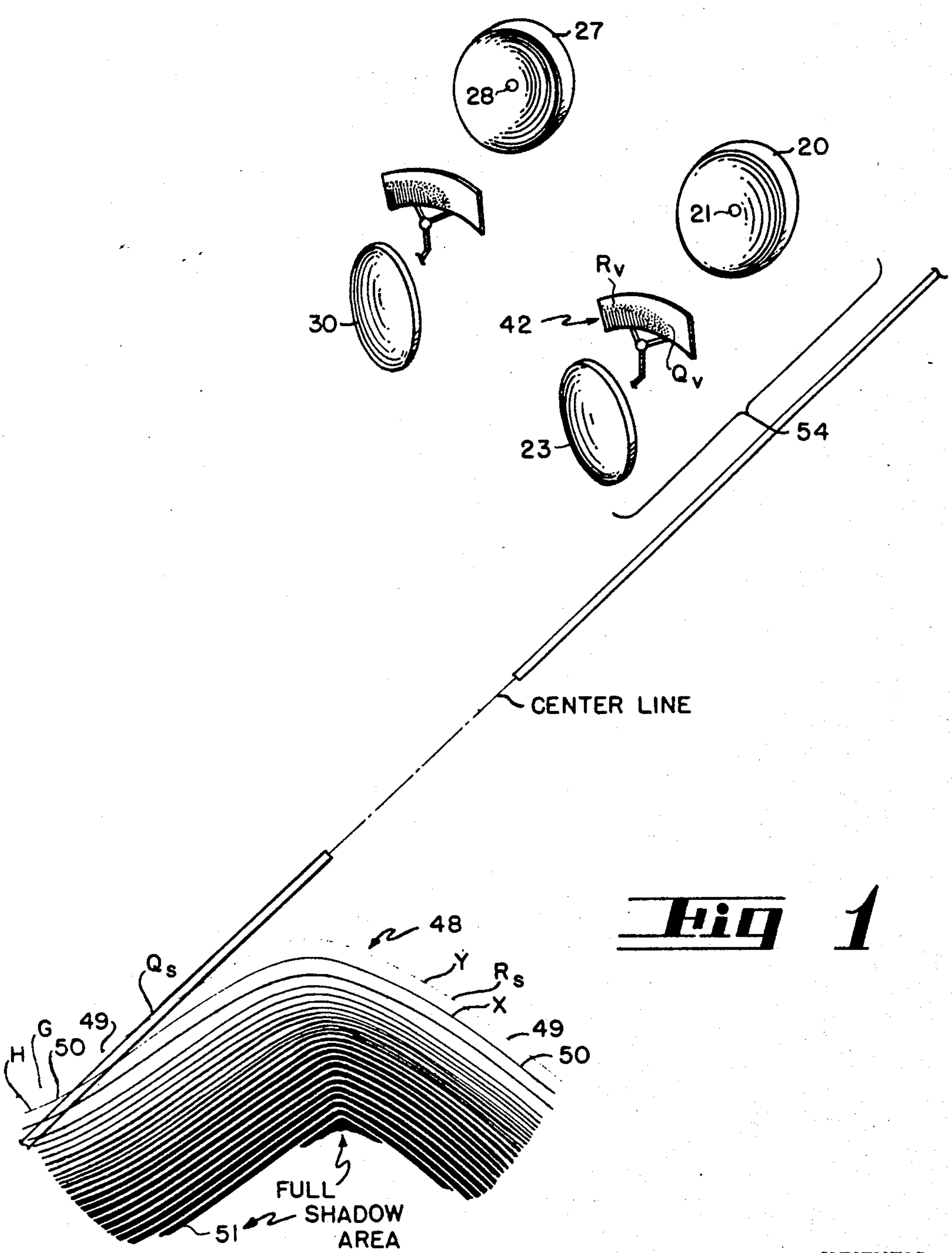

Fig 1

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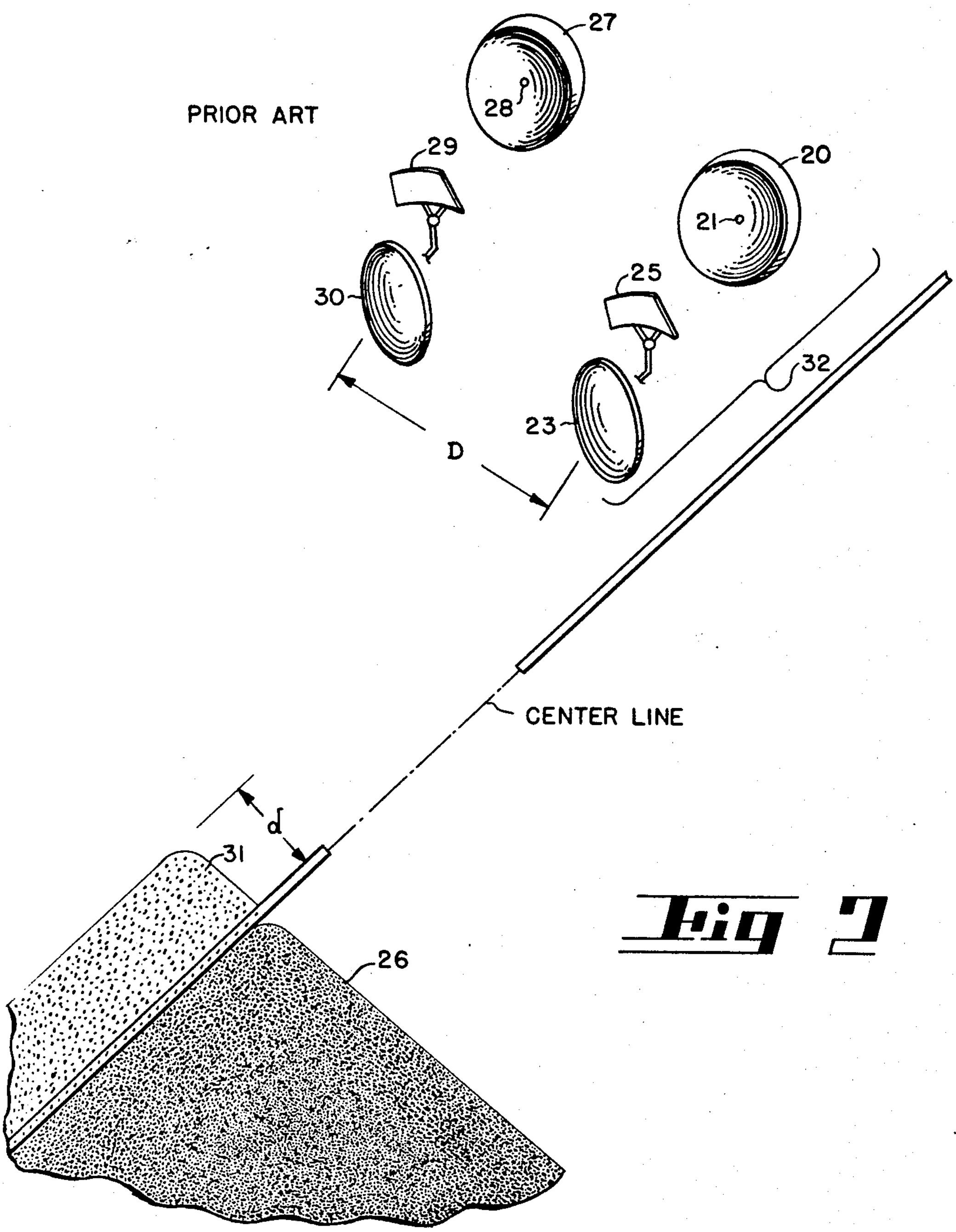

Fig 2

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VANE CONTROLLED HEADLIGHTING SYSTEM

Filed Oct. 19, 1964 5 Sheets-Sheet 3

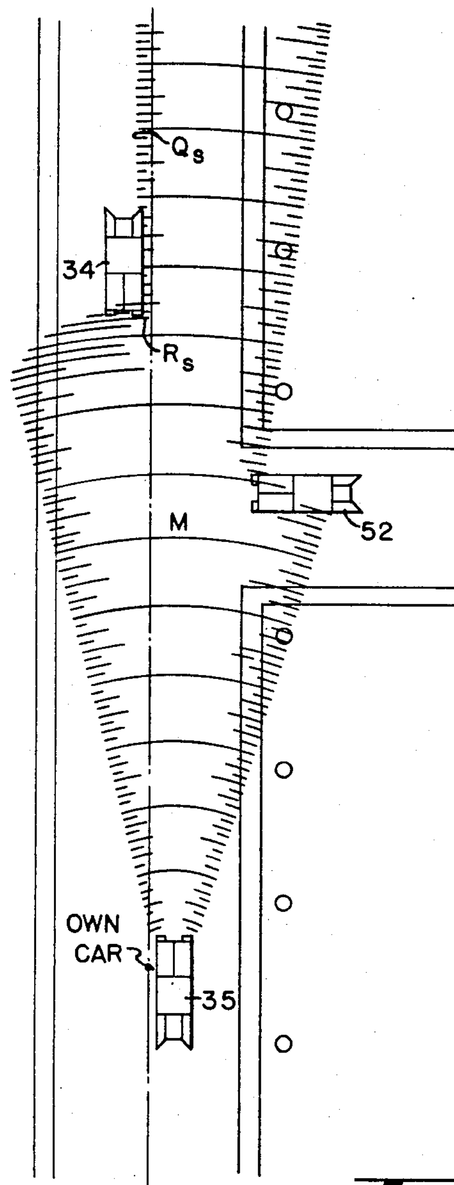

Fig 3

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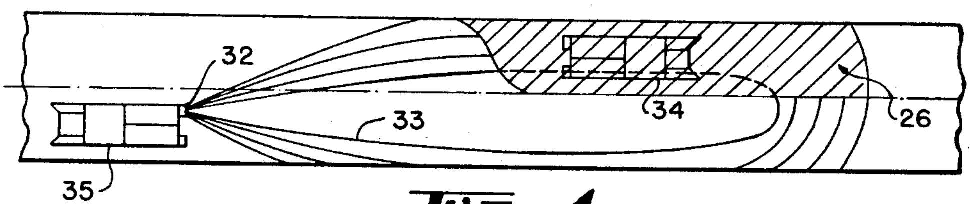

Fig 4

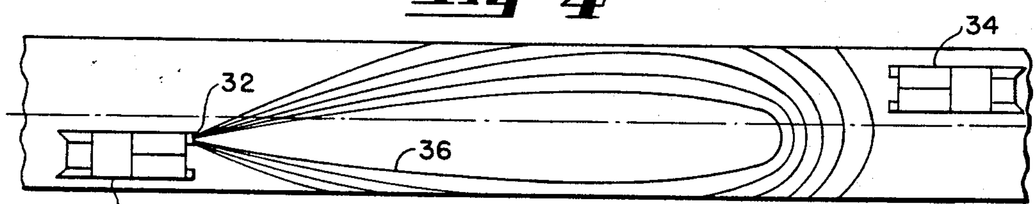

Fig 5

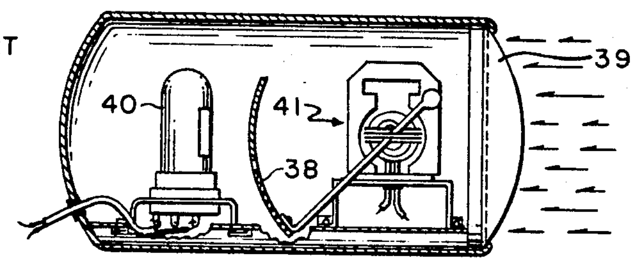

Fig 6

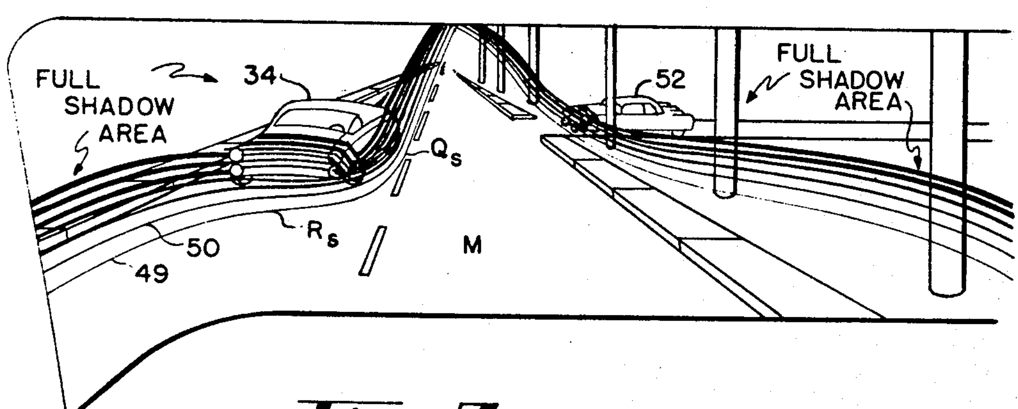

Fig 7

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VANE CONTROLLED HEADLIGHTING SYSTEM

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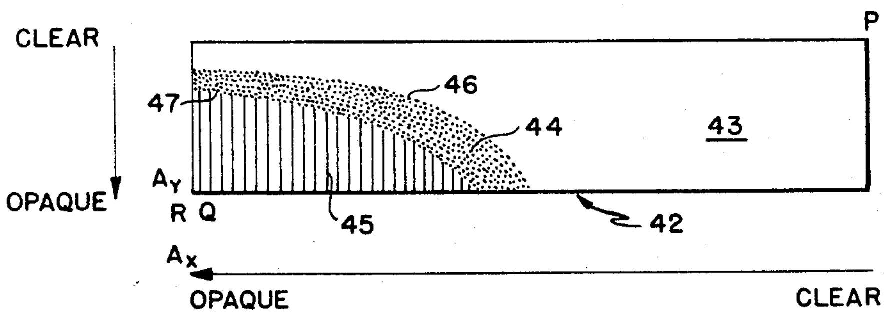

Fig 8

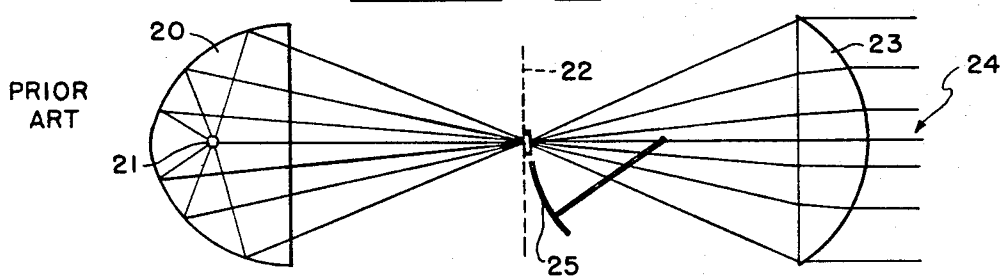

Fig 9

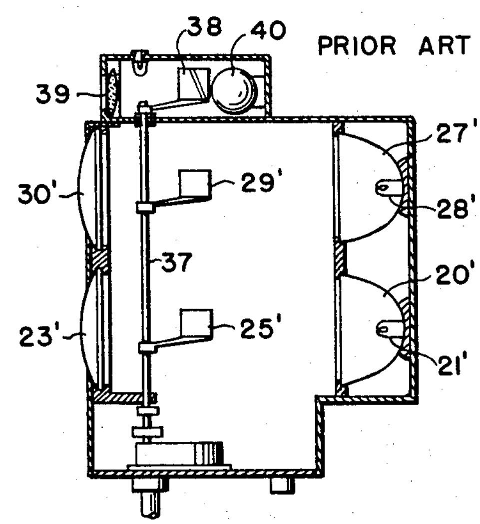

Fig 10

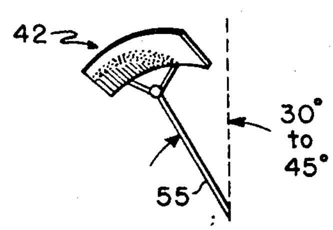

Fig 11

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3,341,700
Patented Sept. 12, 1967

3,341,700

VANE CONTROLLED HEADLIGHTING SYSTEM

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Filed Oct. 19, 1964, Ser. No. 404,742
4 Claims. (Cl. 240—7.1)

ABSTRACT OF THE DISCLOSURE

Two head lamps project down the road beam patterns each having a light area and a shadow. The shadows blend without sharp transitional boundaries. Each head lamp comprises an elliptical reflector, a light source at the inner focal point of the reflector and a lens having its focus at the second focal point of the reflector, thereby to define an image region. A graded density filter is located in light intercepting position in each image region. The filters have fully light transmissive portions and light intercepting portions and portions of intermediate transmissivities, and the last-mentioned portions are so positioned that the shadows blend.

The present invention is an improvement in vane type headlighting systems of the type which, although not limited thereto, generally includes elliptical reflector optics.

The statement of the objects of the invention and the problems which it solves is prefaced by a brief discussion of elliptical reflector optics and the like and vane type systems so that the environment in which such problems arose may be clearly understood.

The first vane system including elliptical-reflector type head lamps was invented by Evan P. Bone. It is shown and described in United States Patent 1,389,291, issued Aug. 30, 1921. The Bone system, as described in this patent, and improvements to the Bone system extending over a period of thirty years were directed to these objectives: the production of a fuller pattern of long range light for a car equipped with the system; and reduction of glare directed toward oncoming cars without sacrificing light or visibility in the lane of the first-mentioned car, i.e. a Bone system-equipped car in which an observer is riding. Now making reference to FIG. 2 (the upper part of which is isometric and the lower part of which is in plane) the Bone system employs a pair of head lights, which are installed on the front of an automobile. Each Bone head light (FIGS. 2 and 9) comprises an optical projector. This projector consists of a sealed beam ellipsoidal reflector, such as **20**, provided with a single filament **21** placed at the rear focus of the reflector, whereby an image of the filament appears at a plane **22**. Plane **22** is the plane of the forward focus of the reflector and the plane of the rear focal point of an aplanatic lens **23** disposed in front of plane **22**. It will be understood that the aplanatic projection lens forms a narrow beam **24** (FIG. 9) of approximately parallel rays and employs the projected filament image as a source. In accordance with the teachings of Bone, and as shown in the patents of Bone and/or associated workers, which patents are listed below, a movable vane **25** is mounted to move in light-intercepting fashion through plane **22**. This vane, being at the focal point of the projection lens **23**, causes a sharp shadow **26** to be projected along the road when the vane moves into the filament image on plane **22**.

As shown in FIG. 2 the principal elements of the left hand head light (as seen by an observer in an equipped car) are referred to by the numerals **20, 21, 25** and **23**. The corresponding elements of the right hand head lamp are referred to by the numerals **27, 26, 29** and **30**. The shadow produced by the left hand head light is referred to by the numeral **26**. As seen from the driver's seat of an equipped car as the point of observation, the shadow **26, 31** produced by the right hand head lamp, while overlapping shadow **26** for the most part, will extend to the right, across the center line, and into the driver's lane, by an amount *d*. The quantity *d* is proportioned to the spacing D between the two head lamps, the aiming point for each head lamp, and the distance from the head lamps to the down-road point at which the registration is checked.

A light pattern about four times as wide as it is high is sought to be produced by Bone head lamps. This is a considerably fuller beam pattern than is provided by standard head lamps during high beam operation, and this pattern provides needed illumination above the level of the head lamps. Concomitant increase in candle power accomplishes a substantial improvement in seeing distance. The Bone system, involving an ellipsoidal reflector and a vane, therefore produces longer range visibility and a greatly improved light pattern. Increase of range of visibility and reduction of glare are simultaneously achieved.

Attention is now invited to several disadvantages and limitations of the Bone type system. It has not been found feasible under all conditions to make the two shadows **26, 31** and **26** register or coincide and to eliminate the margin **31**. Second, there is a sharp transition between high intensity and to low intensity light at the edges of the shadow as seen by the driver and the occupants of the equipped car. This sharp transition is objectionable to some drivers. Third, due to the fact that it is not economically practical to use a color corrected lens chromatic abberation is present. Such aberration can produce spurious red or blue rays at the edge of the shadow. Finally, the prior art vane and optics have no provisions for meeting current legal requirements.

In order that the full impact of these disadvantages may be better understood, the discussion now proceeds to the dynamics of the vane.

As shown in FIG. 5, each lamp **32** normally projects a long range, high intensity light beam **36** down the road. When an oncoming car **34** (shown in FIG. 4) comes within range each of the equipped car's head lights continues to project a high intensity beam down the right side of the road, but the opaque light intercepting vane **25** in the lamp **32**, for example, projects its image as a protective nonglare shadow **26** on the left side of the road, modifying the beam distribution as shown by **33** (FIG. 4). The oncoming driver sees very dim, relatively glare-free head lamps. It will be understood that two approximately coordinated shadows are cast, one shadow for each head light.

The vane **25** (FIG. 2) is placed in the focal area of reflector **20** whenever another car **34** (FIG. 4) approaches. This may be accomplished manually as by a foot switch or automatically as by a phototube control circuit. The present discussion postulates that the operation is binary and not continuous. The vane alters the pattern of the light (FIG. 4) so that a long range light pattern **33** and safe visibility are maintained in the line of the equipped car and so that the shadow assures protection against glare for oncoming drivers. The result is that the headlighting in one's own lane is equivalent to or greater than that of the conventional high beam, even when the equipped car is passing an oncoming vehicle. However, glare directed against oncoming drivers is only a fraction of the glare experienced with standard down or low beams. As the approaching vehicles finish passing each other the FIG. 5 conditions are restored.

The present invention is an improvement in vane headlighting of the type which utilizes ellipsoidal reflectors.

While the invention is described as including an ellipsoidal reflector the invention is applicable to systems in which the reflector is in form a slightly modified ellipse or is non-conical. Additionally, the location of the focal planes is not critical. The reflector element may be moved away from the plane of the focal point of the lens.

Since the present invention is of utility in binary systems, either manual or automatic, and in automatic tracking systems, a few definitions are now in order.

First, a distinction is made between a two-state or binary system and a continuously operable or tracking system. A binary system has two discrete states of operation designated "high beam" and "low beam." The conventional automobile headlighting system of today is a binary system. A binary system may be either automatic or manual, i.e. either controlled by a phototube (or equivalent) or foot-switched (or hand-switched). A tracking system is automatic and continuously follows an oncoming car in a manner which simulates the tracking motion of the human eye.

Conventional headlighting of today does not employ vanes. Separate filaments are conventionally provided for the high beam and low beam modes of operation. It is now in order to draw a distinction between such conventional headlighting systems and vane type systems. A basic continuous vane type system and improvements thereto are shown in the following United States patents:

2,562,258—Bone, Headlighting System, July 31, 1951
2,753,487—Bone, Headlight Control System, July 3, 1956
2,917,663—Engelmann, Synchronizing and Compensating Circuit for Headlight Control System, Dec. 15, 1959
2,917,666—Engelmann and Foster, Momentary Electrical Override for Headlight Control System, Dec. 15, 1959
2,941,117—Dugle, Mechanically Steerable and Electronically Automatic Headlighting System, June 14, 1960
2,941,118—Engelmann, Vane Actuating Circuitry for Headlighting System, June 14, 1960
3,132,252—Engelmann, Photosensitive Automatic Headlight Control System, May 5, 1964

An illustration of an early binary vane type system is the above-mentioned United States Patent 1,389,291 to Bone, issued Aug. 30, 1921.

In a continuously automatic system the shadows **26** and **26**, **31** (FIGS. 2 and 4) are projected down the road when an oncoming car comes within pick-up distance. When the system is continuous and automatic this shadow casting is automatically accomplished, so that the shadows just cover the oncoming car at all times. As the oncoming car approaches closer and closer, the generally overlapping shadows are automatically moved to the left, as viewed from the equipped car. As the cars pass the shadows are entirely removed from the road. The motions of the shadows are continuous in an automatic tracking system. In a binary system, however, the shadows are intially cast by reason of a manual order given by the vehicle operator. The shadows remain cast until the passing of the two cars is accomplished. whereupon the shadows are removed manually as by foot switching or the like. If the binary system is automatic this is accomplished by the control of a phototube or the like.

While the present invention is described as incorporated in a binary system, it is reiterated that the invention is useful both in binary and continuously operable or tracking systems. The background of the invention and the pertinent prior art and the problems raised by the prior art having been pointed out, the discussion now proceeds to the objects of the invention.

A primary object of the invention is to provide, in a vane type headlighting system, a variable density (i.e. variable transmittance) vane, so proportioned that the beam pattern cast by vane controlled head lamps is made legally acceptable.

Another object of the invention is to provide in a vane controlled head lamp system, vanes of such character and construction that the disadvantages heretofore occasioned by improper registration do not arise.

It is of course an object of the invention to eliminate the sharp transition which heretofore characterized the shadow edges.

A related object of the invention is to eliminate the objectionable chromatic aberration which accompanies said transition.

Another related object of the invention is to shape the left, right and/or upper portions of the beam by controlling the intensity, using the variable transmittance vane to accomplish this shaping.

The importance of the object directed to improved registration is demonstrated by various attempts made to solve the probelm, i.e. the elimination of margin **31** (FIG. 2). One proposal is shown in FIG. 3 of Dugle Patent 2,941,117, reproduced here as FIG. 10. In the Dugle proposal the head lamps are vertically stacked. That is, one group of head lamp elements as illustrated in FIG. 2 is placed above another group of such head lamp elements. Accordingly the reference numerals of FIG. 10 are primed to indicate that the FIG. 10 elements are generally similar to the FIG. 2 elements.

The head lamp vanes **29'** and **25'** are carried by the same shaft **37** on which a direction finder vane **38** (presently described) is mounted. Vanes **25'** and **29'** are azimuthally positioned in synchronism. Light from an oncoming car passes through lens **39** to phototube **40** and causes vane **38** automatically to be positioned in accordance with the teachings of Bone Patent 2,753,487. The direction finder vane and the lamp vanes are positioned by a photoelectrically controlled electronic circuit. The pertinent aspect of FIG. 10 is the fact that the superposition or stacking of the head lights represents an attempt to solve the registration problem. This approach is completely outside of the practice and trends in automobile construction and styling. The advantage of the present system over the FIG. 10 solution resides in part in its compatibility with automobile construction and the more current trends in styling.

The parenthetical discussion of FIG. 10, necessary to a complete understanding of the objects of the invention, calls for a brief discussion of FIG. 6. FIG. 6 shows a Bone-type direction finder including a lens **39**, a phototube **40**, and a vane **38** azimuthally positioned by a motor **41** automatically in accordance with the relative bearing of an oncoming car. The continuous type Bone system comprised a direction finder including photoelectric means such as **40**, for detecting the presence of an oncoming vehicle. The direction finder vane was positioned in azimuth to measure the direction of approach of the oncoming vehicle. The head lamp vanes were coordinated with the direction finder vane in such a way as to cast the overlapping shadows or non-glare areas. Since in the prior art system of FIGS. 6 and 10 one lamp was superimposed on the other the undesired margin **31** of FIG. 2 was effectively eliminated, but as previously indicated the solution has practical drawbacks.

Another effort to solve the registration problem consists in the geometric shaping of the right hand lamp vane in such a way as to make the shadow which it casts correspond to the shadow **26** (FIG. 2), thus effectively eliminating margin **31**. The disadvantage of this solution resides in the fact that it is completely satisfactory only in operating on relatively flat terrain and under that condition of car loading for which vane alignment was established.

An additional object of the invention is to provide an arrangement such that the shadow approaches its FIG. 1 position by a motion downwardly and to the right, as viewed from an equipped car.

For a better understanding of the present invention, together with other and further objects, advantages and capabilities thereof, reference is made to the following description of the appended drawings, in which there is illustrated a preferred form of improved headlighting system in accordance with the invention. In the drawings:

FIG. 1 is a pictorial illustration (the upper part being isometric, the lower part being in plan), generally schematic, showing means and methods in accordance with the present invention and featuring a graded density (variable transmittance) filter for projecting a protective shadow pattern down the road;

FIG. 2 is a pictorial view (the upper part being isometric, the lower part being in plan), generally schematic, showing how overlapping shadows were formed in accordance with the prior art vane practice;

FIG. 3 is a schematic top plan view showing the relative positions of the equipped car and two other cars under the FIG. 7 circumstances, together with a projected outline of the light intensity pattern of the equipped car;

FIGS. 4 and 5 are schematic outline drawings showing in plan the conditions which exist when an oncoming car is within the protective shadow (FIG. 4), and the conditions which exist when an oncoming car is too remote to be picked up and protected by the shadow (FIG. 5), respectively;

FIG. 6 is a top plan view of a prior art direction finder;

FIG. 7 is a pictorial view as taken from the front seat of an equipped automobile, showing an oncoming automobile, an automobile approaching from the right, and the light intensity characteristics of the shadow projected down the road by the equipped car;

FIG. 8 is a plan or face view of a graded density filter in accordance with the invention as seen by an observer looking into the headlamp from the front;

FIG. 9 is an outline drawing of the basic optics in a typical elliptical headlighting system in which the improved filter of the present invention may be installed; and

FIG. 10 is a cross-sectional view of a prior art head lamp and direction finder as incorporated in a continuous type system, showing an environment in which head lamp vanes in accordance with the invention may be used;

FIG. 11 is a view of the mounted vane construction as viewed by an observer in an oncoming car. The vane is arranged so that the shadow moves downwardly to the right as seen from an equipped car (on a diagonal 30° to 45° from the horizontal) as the vane approaches its FIG. 1 static position.

Attention is now invited generally to FIGS. 1, 3, 7 and 8 for a description of the improvements made in accordance with the invention, and specifically to FIG. 1. The upper part of FIG. 1 is an isometric or perspective view showing a pair of head lamps incorporating improved vane constructions provided by this invention. The elements **20**, **21**, **23**, **27**, **28** and **30** of FIG. 1 are alike in construction and function to the elements to which have been assigned corresponding reference numerals in FIG. 2. That is, elements **20** and **27** are elliptical reflectors, elements **21** and **28** are filaments, and elements **23** and **30** are aplanatic lenses. The reference numeral **54** collectively designates the elements of the equipped car's left head lamp.

It has previously been indicated that the utility of the present invention is not limited to purely elliptical reflectors or to the precise arrangement of focal planes here shown.

From a point of observation in the driver's seat of the equipped car, elements **23** and **30** are the most forwardly located elements (i.e. the occupant of the equipped car is behind elements **20** and **27**, FIG. 1). The equipped car is to the right of the center line and the shadow is generally to the left of the center line, as seen from such point of observation (i.e. the driver's seat of the equipped car).

The FIG. 1 arrangement in accordance with the invention differs from the prior art FIG. 2 system primarily in the incorporation of a variable density filter as shown generally in FIG. 1 and in detail in FIG. 8. For purposes of explanation, filter **42** is shown in FIG. 8 as comprising a clear area **43**, a variable-density area **44**, and an opaque area **45**, with abrupt transitions **46** and **47** between the various areas. These transitions are imaginary and are utilized only as an expedient for clear description. In practice, as a point on area **43** is displaced in the directions A_x and A_y as indicated in FIG. 8, the light transmittance gradually decreases and there is a gradual blend between areas designated by the reference numerals **43** and **44**. Similarly, the density at a point in area **44** gradually increases as it is displaced in the directions A_x and A_y of FIG. 8. Likewise, the area **44** gradually and imperceptably blends into the area **45**. The entire area **45** is opaque for all practical purposes. Generalizing, the approach from point P to point Q is generally characterized by a change from approximately 100% transparency to approximately 0% transparency. The degree of transmittance at any point in the filter **42** is the ratio of the light intensity desired at the corresponding point in the head lamp pattern to the maximum candle power intensity which the head light can produce at that point. Therefore, given either the presently ordained and legally accepted light intensity pattern or any desired light intensity pattern, the transmittance characteristics of the vane can readily be determined by the simple use of the arithmetic of ratio and proportion.

In a preferred mode of making the vane **42**, a metal coating can be evaporated onto a suitable high temperature resisting substrate such as glass or quartz. Means and methods for designing graded filters are per se well known.

Reference is now made to the single shadow **48** (FIG. 1) which is effectively cast by a system according to the present invention and incorporating a graded density filter. In order to aid the explanation it is stated grossly that the region R_s of the shadow **48** corresponds to the region R_v of the vane **42**. The region Q_s of the shadow corresponds to region Q_v of the vane (still making reference to FIG. 1). The lines **49**, **50**, etc. in FIG. 1 represent a variation in light intensity in the field due to the variation in the intensity in the filter in region **44** and may be thought of crudely as corresponding to lines of constant transmittance in the filter. That is to say, point X on line **50**, slightly displaced away from a point Y on line **49**, has a lesser light intensity than point Y. Similarly, a point G on line **49** has a greater light intensity than a slightly displaced point H on line **50**. In other words, there is no sharp frontal shadow edge but there is a gradual change from light to shadow; nor is there any sharp side edge, but again there is a gradual decrement from light to shadow. There being no sharp transitions and edges there are no radical discontinuities to register. When the gradually darkening regions or borders of one shadow are superimposed on the gradually darkening borders or regions of another shadow, those regions blend together so smoothly and continuously as not to present any serious registration problem, with its concomitant disadvantages and limitations. The lines **49** and **50** etc. (counting away from the edges and toward the main body of the shadow) therefore represent a gradual approach to darkness, full shadow being achieved at the inner line **51**, which has a gross correspondence to line **47** of the vane (FIG. 8).

FIG. 3 and FIG. 7 represent substantially the same condition using head lamps on car **35** of the type shown in FIG. 1. Considering for the moment only the left hand side of the picture, that is, the left lane and the oncoming car **34**, FIG. 3 shows a single curve on the roadway which would correspond to line **49** in FIGS. 1 and 7. Consequently the region R_s of FIG. 1 would appear in front of the oncoming car **34** in FIG. 3 and again in FIG. 7 while the region Q_s of FIG. 1 will appear alongside oncoming car **34** in FIG. 3 and again in FIG. 7. FIGS. 3 and 7 also show a car **52** to the right of the roadway, stopped at the intersection of a side street with the roadway. FIG. 7 indicates that the pattern of the head lamp on the right hand side of the road has been altered in a manner similar to the alteration on the left hand side. Such an alteration can be readily accomplished by the introduction of additional areas such as **44** and **45** of FIG. 8 but in the lower right hand corner of the vane rather than the lower left hand corner. An alternate means by which the distribution on the right hand side of the road can be changed would be the introduction of a second filter which would be used solely for the purpose of protecting cars in the position of car **52**. Such a second filter need not be introduced precisely in the plane **22** as shown in FIG. 9, but may be introduced either slightly forward or slightly behind that plane, there being a lack of chromatic aberration in either case as discussed below.

It will be apparent from the foregoing description that, by reason of the use of a graded density filter to grade the transmittance characteristics of the shadow borders, the resulting beam pattern can be made to assume the shape indicated by M in FIGS. 3 and 7, the pattern being the area enclosed by line **49**. The sharp edges of shadows are eliminated, the heretofore noticeable non-register of the shadows cast by the right and left hand lamps is rendered negligible and chromatic aberration is eliminated. The reason for the elimination of chromatic aberration is the absence of sharp transitions.

For purposes of illustration the vanes discussed herein are positioned in azimuth. In binary systems the head lamp vanes would be angularly positioned in what could be called the "flash" or "open road" position (corresponding to "high beam") for normal conditions of operation, with no oncoming car in sight. When an oncoming car is picked up or approaches under circumstances normally calling for "dimming" of head lamps then the vanes are angularly positioned in the "search" position (corresponding to "low beam"). For a definition of what is meant by the expressions "flash" and "search" reference is made to the United States patent of Richard H. Engelmann, No. 3,132,252, issued May 5, 1964. Suffice it for the present to say that "search" generally corresponds to "dim" and "flash" generally corresponds to "bright" operation of head lamps. The "search" and "flash" overrides in said Engelmann patent and other patents referred to therein are both manual and binary, although they are included in continuous systems. Therefore various electronic systems for positioning the vanes are well known to those skilled in the art as is further evidenced by the expired Bone patent referred to above, No. 1,389,291.

It has been the practice to move the shadow from left to right, as seen from an equipped car, as the shadow approaches the position illustrated in FIG. 1. Another improvement provided in accordance with the invention, directed to the purpose of assuring compliance with legal requirements, comprises means for introducing into the motion of the vane a vertical component. That is, the axis **55** of the vane, FIG. 11, is tilted at an angle to the vertical. The FIG. 11 view of the vane and its axis of rotation **55** are taken from approximately the same point of observation as FIG. 1. Since the vane as shown in FIG. 11 moves at an angle to the horizontal (i.e., upwardly and to the right), as the vane moves into intercepting position the shadow moves, as viewed by an observer in an oncoming car, downwardly and to the left as it assumes the position illustrated in FIG. 1. The angle of inclination of shadow motion to the horizontal is preferred to be in the range from 30 to 45 degrees.

The diagonal motion of the shadow allows the driver to have full road vision for an increased percentage of time and makes it feasible to adjust the open position (corresponding to "flash" or "high beam") to compensate for loading of the vehicle. Additionally such a motion affords design flexibility.

While there has been shown and described what is at present considered to be the preferred embodiment of the present invention, various modifications and changes will occur to those skilled in the art, and it is intended in the appended claims to secure the invention with a proper range of equivalents.

Having described my invention, I claim:

1. The combination of a first head lamp for projecting a beam pattern having a light area and a first shadow,

a second head lamp for projecting a beam pattern having a light area and a second shadow,

the first head lamp comprising a first reflector and a first light source and a first lens relatively positioned to define a first image region which receives all light from the first source which is reflected by the first reflector, and the second head lamp comprising a second reflector and a second light source and a second lens relatively positioned to define a second image region which receives all light from the second source which is reflected by the second reflector, and graded density filters individually located in light intercepting position in said image regions, said filters having fully light transmissive portions and light intercepting portions and portions of intermediate transmissivities relatively so positioned that the shadows blend without sharp transitional boundaries.

2. A head lamp for projecting a beam pattern having a light area and a shadow and a gradual transition between the light area and the shadow comprising, in combination:

an elliptical reflector having inner and outer focal points,

a light source located in the region of said inner focal point,

a lens having a focus in the region of said outer focal point,

said reflector and light source and lens being relatively positioned to define an image region, substantially at said outer focal point, which receives all light from the source which is reflected by the reflector, and

a graded density filter located in light intercepting position in said image region.

3. A head lamp in accordance with claim **2**, in which the graded density filter has fully light transmissive portions and light intercepting portions and portions of intermediate transmissivities, and

means for introducing the light-intercepting portions of said filter into said image region whereat the light intercepting portions introduce said shadow into said pattern.

4. A head lamp in accordance with claim **3** in which the last-mentioned means first introduces the fully light transmissive portions and then the portions of intermediate transmissivities and finally the light intercepting portions of the filter into said image region.

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