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United States Patent [19]

Brown et al.

[11] **3,767,309**

[45] **Oct. 23, 1973**

[54] **VISUAL SURFACE GUIDANCE APPARATUS**

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[73] Assignee: **Lockheed Aircraft Corporation,** Burbank, Calif.

[22] Filed: **July 22, 1970**

[21] Appl. No.: **63,981**

Related U.S. Application Data

[62] Division of Ser. No. 703,589, Feb. 7, 1968, Pat. No. 3,599,143.

[52] **U.S. Cl.** **356/138,** 240/1.2, 240/46.59, 340/26, 350/317, 356/172

[51] **Int. Cl.** **G01b 11/26**

[58] **Field of Search** 350/317; 356/172, 356/138; 340/25, 26, 29; 240/1.2, 39, 46.59

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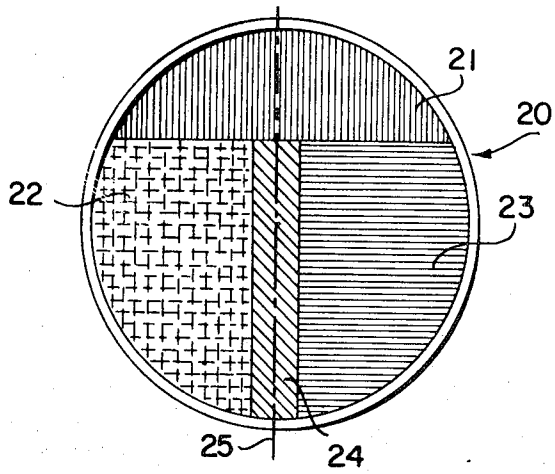
[57] **ABSTRACT**

Guidance apparatus providing lateral and longitudinal visual guidance information to the operator of an aircraft or other vehicle to facilitate vehicular surface maneuvering. A light projection apparatus and a filter provide several multi-color laterally disposed beam segments to provide course guidance and also provide a longitudinal guidance beam portion positioned either above or below the laterally disposed segments to be undershot or overshot by the line of vision of the vehicle operator.

3 Claims, 10 Drawing Figures



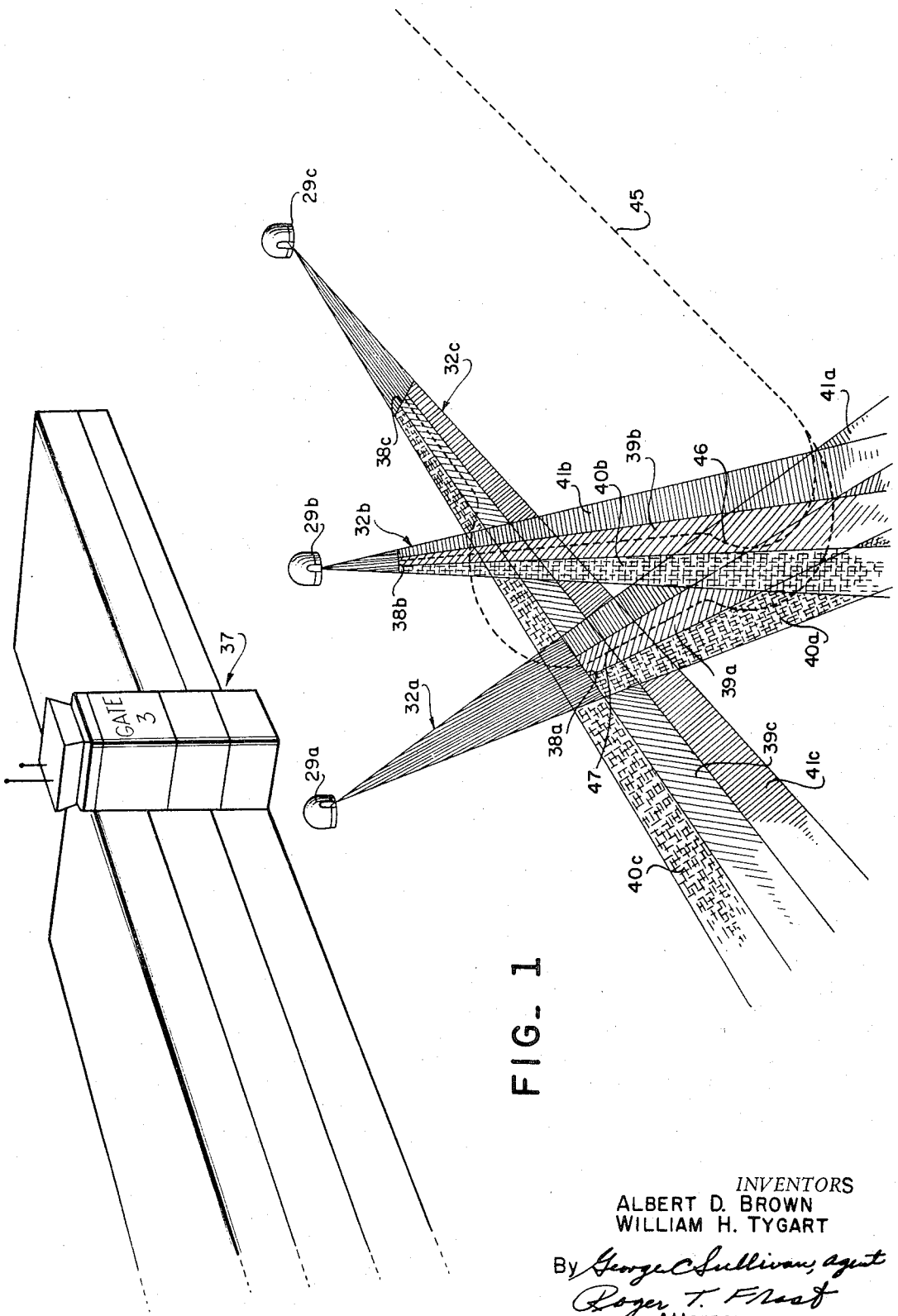


FIG. 1

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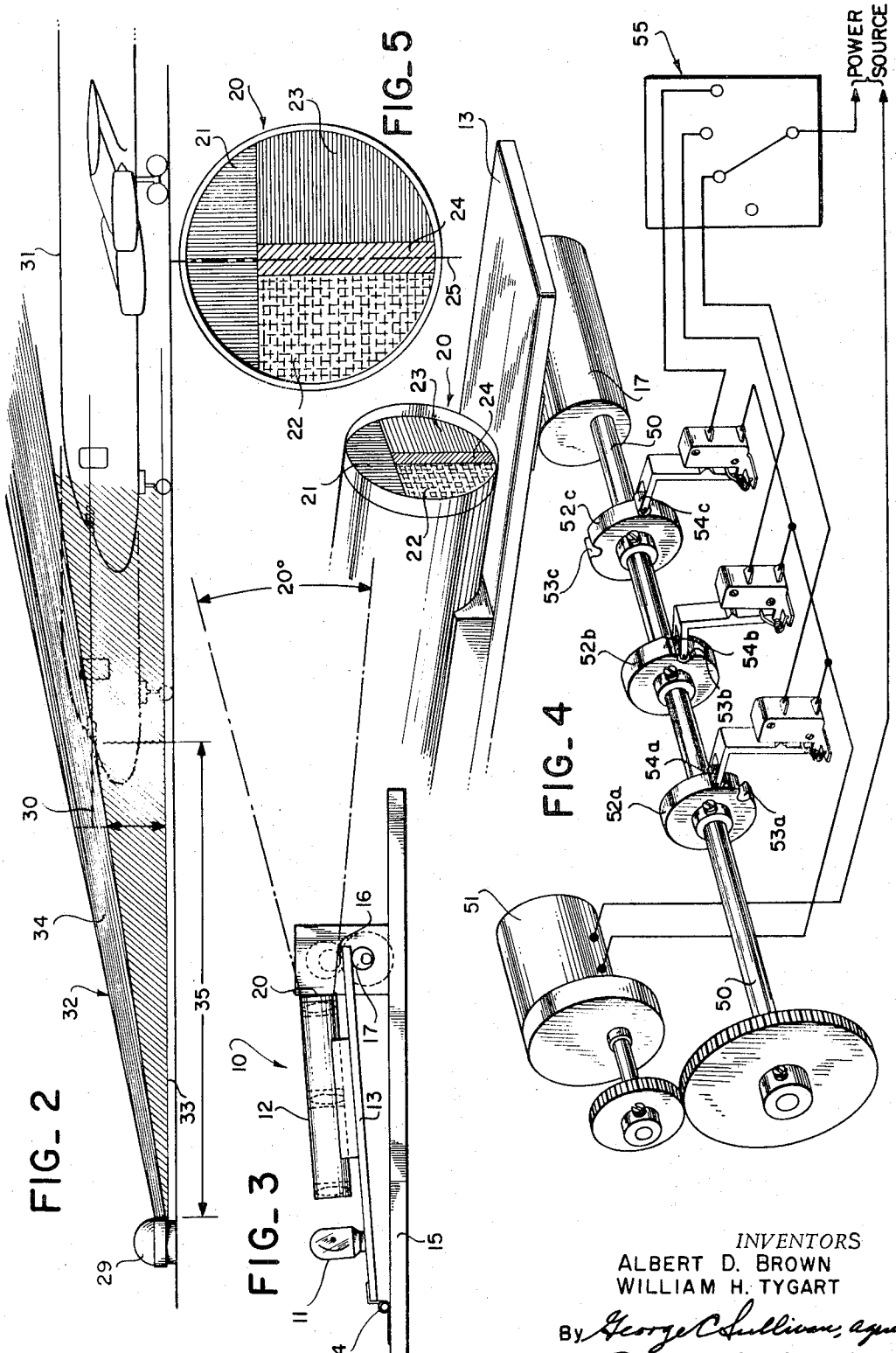

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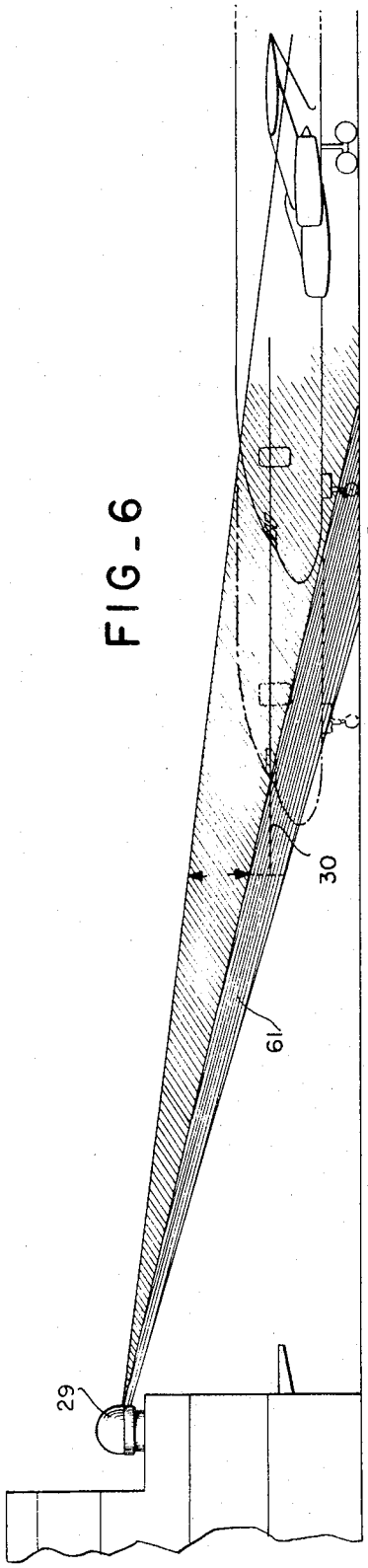

FIG_6

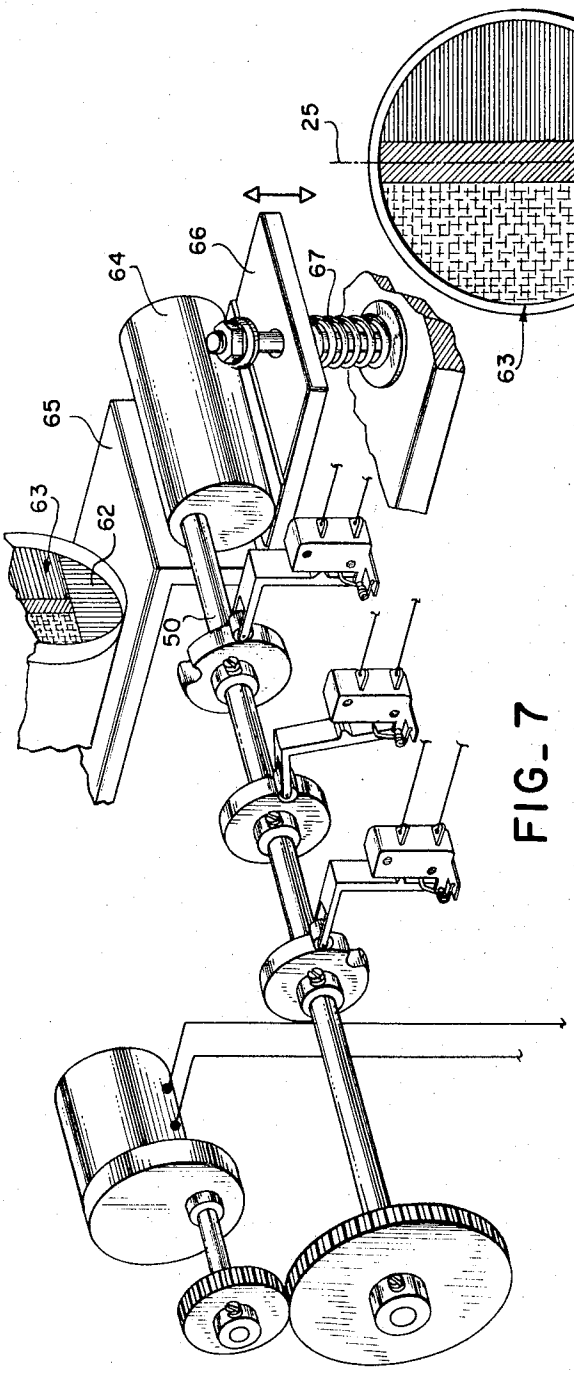

FIG_7

FIG_8

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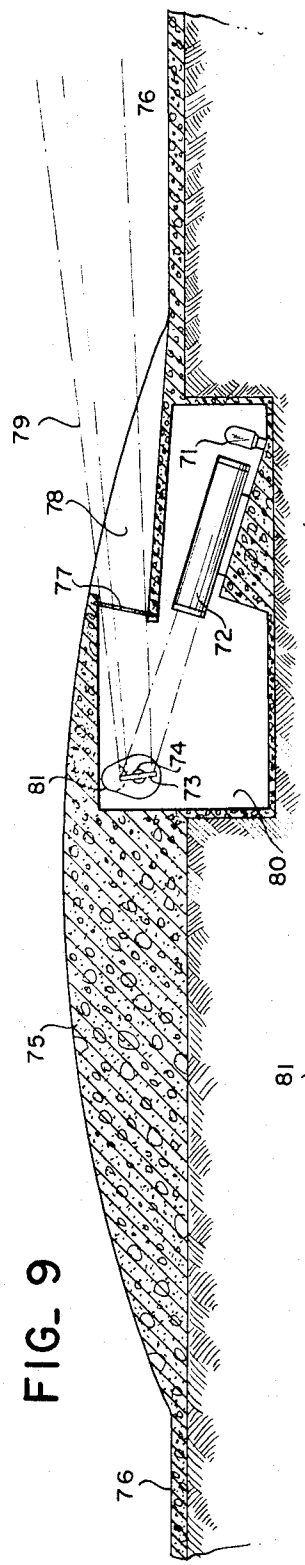

FIG_9

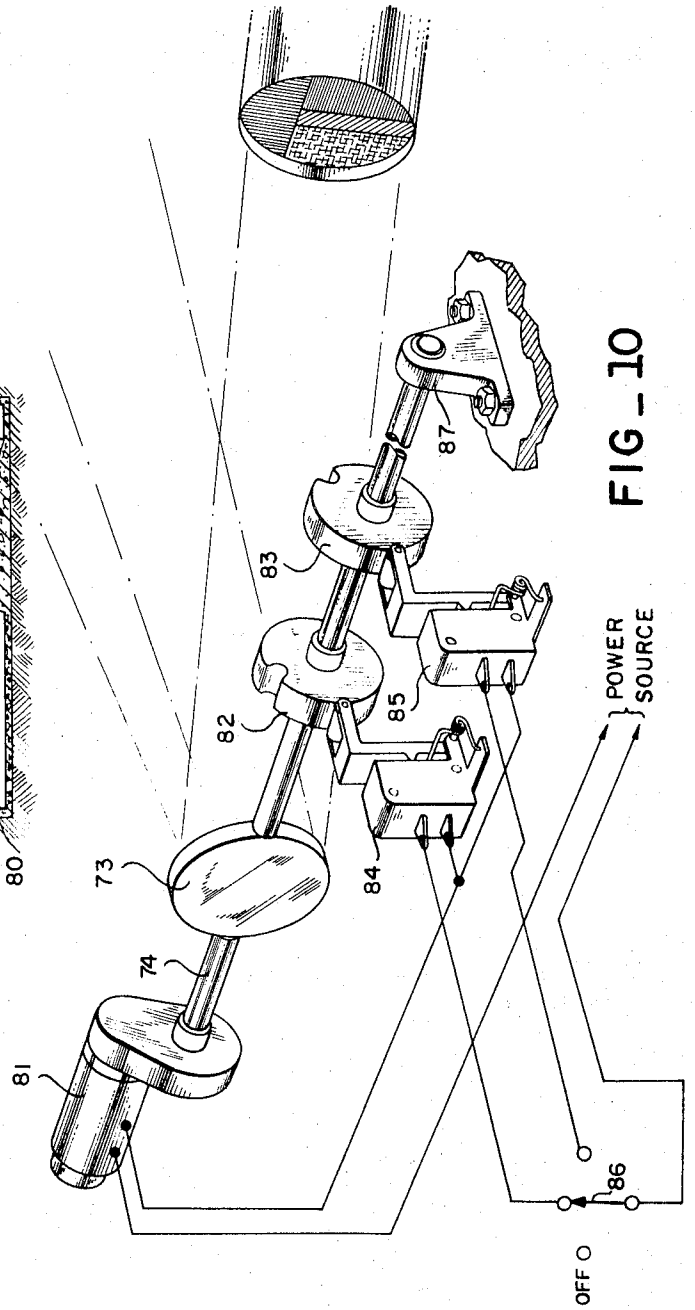

FIG_10

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VISUAL SURFACE GUIDANCE APPARATUS

This is a division of application Ser. No. 703,589, filed Feb. 7, 1968, and issued on Aug. 10, 1971 as U.S. Pat. No. 3,599,143.

This invention relates in general to visual guidance apparatus and in particular to visual guidance apparatus useful for directing the maneuvering and positioning of surface vehicles.

In the maneuvering of certain types of surface vehicles the need frequently arises for some guidance technique which enables the vehicle operator to position the vehicle accurately without endangering persons or property in the vicinity of the vehicle and also without relying on the subjective judgments of an observer who is watching the maneuvering process and is attempting to communicate with the operator by hand signals with a similar technique. This problem is acutely exemplified by nearly every large airport wherein large aircraft, particularly transport aircraft, must move from a taxiway to a designated gate or parking area to permit unloading and loading of passengers or cargo. Typically, such a maneuver involves taxiing a large aircraft along one or more taxiways, turning the aircraft at an appropriate point to reach the proper gate, and then stopping the aircraft within a few inches of a desired location so that an appropriate passenger or cargo loading device can be positioned.

These maneuvers are accomplished at the present time by following lines painted on the taxiway, edge lights along the sides of the taxiway, and finally, the hand signals of a ground attendant at the parking or stopping location. At the same time, the pilot must be careful to keep the aircraft accurately positioned within the desired taxiing and stopping limits to minimize the danger of collision with other vehicles and/or the terminal building. While attending to all of the foregoing the pilot, who sits many feet forward of the turning axis of the aircraft, must know exactly when to commence a turn maneuver so that the aircraft wheels, as well as the outwardly extending wings, stay within desired travel limits. Under the best conditions this is a difficult and exacting task, and under the adverse conditions of nighttime, a rain-darkened runway, and/or a momentary lapse of attention on the part of the ground attendant, the hazards normally present become greatly compounded and the risk of a collision with another aircraft or some other object becomes a very real probability. This risk is particularly acute during the turnout phase of parking an aircraft adjacent the terminal building, where delayed initiation of the turn can cause damaging contact between the outboard wing tip and the terminal structure.

Accordingly, it is an object of this invention to provide an improved visual guidance apparatus.

It is another object of this invention to provide visual guidance apparatus for use with surface maneuverable vehicles.

It is still another object of this invention to provide visual guidance apparatus which provides lateral guidance information to the operator of a vehicle.

It is a further object of this invention to provide visual guidance apparatus which provides both lateral and longitudinal guidance information to the operator of the vehicle.

It is another object of this invention to provide visual guidance apparatus which provides longitudinal guidance information without requiring surface hoses, treadles, or other structures responsive to the presence of a vehicle.

It is yet another object of this invention to provide visual guidance apparatus which is relatively uncomplicated, yet which enables a pilot to taxi an aircraft along a certain path to a predetermined location.

Still another object of this invention is to provide visual guidance apparatus which frees the vehicle operator from dependence on the judgment of an observer who must watch the progress of the vehicle and communicate such progress to the operator.

Stated generally, the present invention includes a directional guidance apparatus having an optical system for projecting a beam of illumination along a path of travel to be followed by the pilot of an aircraft. The optical system includes a filter having a first portion for furnishing lateral guidance information and a second portion for longitudinal or stopping information. The first filter portion has a number of segments of distinct colors aligned so that the pilot sees a certain color if he is traveling on the proper course and sees certain other colors if he deviates laterally in either direction from this course. The second filter portion furnishes a beam segment which, in combination with the angular position of the beam relative to the line of sight of the pilot, provides a clearly discernible visual indication when a predetermined distance from the optical system has been reached. More than one guidance apparatus may be used in combination to provide guidance along zigzag courses, and the invention includes an angular adjustment apparatus for varying the included angle between the illumination beam and the surface being traveled.

Other objects and advantages of the present invention as well as a more detailed description thereof are apparent from the attached drawing in which:

FIG. 1 shows an isometric view of an airport gate equipped according to an embodiment of the present invention and including three visual guidance devices;

FIG. 2 is an elevation view showing the operation of the longitudinal guidance portion of an embodiment of the present invention;

FIG. 3 shows a schematic representation of an optical system according to an embodiment of the invention;

FIG. 4 shows in greater detail the elevation changing mechanism for the optical system of FIG. 3;

FIG. 5 shows in detail an embodiment of an optical filter of the invention;

FIG. 6 shows an elevation view of another embodiment of the present invention and particularly illustrating the longitudinal guidance features thereof;

FIG. 7 shows in detail the elevation changing mechanism of the embodiment depicted in FIG. 6;

FIG. 8 shows in detail the color filter used in the embodiment of FIG. 6;

FIG. 9 shows still another embodiment of the present invention utilizing a folded optical system; and

FIG. 10 schematically depicts the details of the reflector positioning mechanism of FIG. 9.

Turning initially to FIGS. 3 and 5, there is shown generally at 10 an optical system including a source of illumination 11 and a lens system 12 mounted on a platform 13. The platform 13 is pivotally attached at 14 to a base 15 and is supported at the other end 16 by a cam 17 described in greater detail below.

The optical system includes a filter 20 having an arc portion 21 colored red, a left segment 22 colored am-

ber, a right segment 23 colored blue, and a middle 24 colored green. Normally, the filter 20 is designed with the middle segment 24 being bisected by filter vertical center line axis 25 and with filter segments 22 and 23 being symmetrical with respect to this center line axis, although as explained later it may be desirable to deviate from this general rule in certain applications.

FIGS. 1 and 2 show the apparatus as described above in use at an exemplary airport loading gate. The optical system 10 is contained in a suitable housing 29 at some predetermined vertical distance below the eye level 30 of a pilot in aircraft 31. The aforementioned predetermined vertical distance, the dimension of red arc portion 21 along filter axis 25, and the angular inclination of the light beam 32 with respect to the surface 33 being traveled are selected to cause the pilot's line of sight to pass into the red portion 34 of light beam 32 when the aircraft has reached a predetermined desired location as indicated in FIG. 2 by phantom lines. At this time, the pilot knows that his craft is at some specific longitudinal distance 35 relative to the housing 29 and that he must either stop or execute some other maneuver such as a turn.

An exemplary practical application of the embodiment thus far described is apparent from FIG. 1. An aircraft loading gate 37 typically must serve a number of different aircraft types which are required to assume a variety of alignments with respect to the gate, because of the unique location of the loading door or doors on each type of aircraft. Moreover, a particular gate such as gate 37 typically can be approached along more than one taxi path under the direction of the ground traffic controller or the choice of the pilot. Accordingly, three separate guidance beam projecting devices as described above are located in respective housings 29*a*, 29*b*, and 29*c* to produce corresponding beams 32*a*, 32*b*, and 32*c*. Each of these beams, in addition to having the red stop portion with the predetermined pilot's line of sight intersection noted at 38*a*, 38*b*, and 38*c*, also contains a green middle segment 39*a*, 39*b*, and 39*c* aligned to indicate the desired path of travel, and correspondingly designated amber left beam portions 40*a*, 40*b*, and 40*c* and blue right beam portions 41*a*, 41*b*, and 41*c*.

The arrangement of FIG. 1 is used as follows with one particular type of aircraft, for example the DC-9. An aircraft of this type approaches the terminal along a path indicated by dotted line 45 until the light beam 32*b* first is seen by the pilot. At this time he commences the turn maneuver which causes the aircraft to follow dotted line 46 and which, is properly executed, causes the aircraft to proceed down green beam portion 39*b*. Any impermissible lateral deviation from the approach path 46 causes the aircraft and the pilot's line of vision to enter the amber beam portion 40*b* or the blue beam portion 41*b*, whereupon the pilot knows that he is off course and must steer his aircraft in the proper direction to return to the desired course. The pilot continues taxiing along approach path 46 until his line of vision first intersects the red beam portion at location 38*b*, thereby indicating that the aircraft is properly positioned relative to the terminal gate 37.

A different approach path may be required for other larger types of aircraft such as the DC-8 and the Boeing 727. For such aircraft, beams 32*a* and 32*c* are used; the aircraft approaches along path 45 and turns onto beam 32*a* as indicated by approach path 47. This path is followed until the pilot's line of sight moves into the red portion of beam 32*a* as indicated at line 38*a*. At this time, the pilot turns the aircraft onto beam 32*c* and then follows the dotted line path along the green portion 39*c* of that beam until the red portion again is reached at line 38*c*, whereupon the pilot stops the aircraft at its final destination. Although applicable regulations or other consideration may make it desirable or necessary to supplement the guidance techniques as described herein with a ground attendant having the usual paddles, lighted wands, or other visual aids for final close position of the aircraft, actual tests of the present invention have indicated that this should not be necessary with a properly installed system according to the present invention.

The relative dimensions of the various portions of filter 20 are dictated by such factors as the available distance between the location of the optical system 10 and the stopping or turning location denoted by the intersection of the red beam with the pilot's line of vision, the desired width of the middle beam 24, and other factors. By way of example only and without intent to limit, good results have been obtained with a system having a maximum overall beam width of 20°, a middle or guidance beam produced by middle filter segment 24 of about 1° in width, both as seen in plan view, and a stop beam produced by arc portion 21 of about 4° high at the center. Of course, the filter 20 is not limited in overall shape to the circular configuration depicted but could as well be rectangular or another appropriate shape. Moreover, the lateral guidance pattern could intentionally be asymmetrical with respect to axis 25 if such a pattern were desired for a particular application.

Since the longitudinal distance from the optical system to the intersection of the pilot's line of sight and the red stop beam is determined not only by the configuration of the beam but also by the vertical height of the pilot's eyes relative to the location of the optical system on or adjacent to the surface of travel 33, some allowance must be made for the fact that the seating location of the pilot, measured vertically with respect to this surface of travel, varies appreciably between different types of aircraft. For the applications with which the apparatus of this invention has been used to the present time, a 10° range of angular variation of the light beam 32 relative to the surface of travel has proved to be sufficient. This is accomplished as shown in FIGS. 3 and 4 by rotating cam 17 to move the platform 13 around its pivot connection 14.

FIG. 4 shows the cam 17 connected to a shaft 50 driven for rotation by a motor 51. A number of cams 52*a*, 52*b*, 52*c* are secured to the shaft, with each of these cams having a corresponding detent 53*a*, 53*b*, and 53*c*. Each cam has an associated cam follower 54*a*, 54*b*, 54*c* comprising the actuating lever of a switch chosen to be open-circuit when the cam follower rests in the respective detent 53 and to be closed-circuit at other times. The switches associated with the respective cam followers are connected in parallel with a selector switch 55, the cam follower switches, the selector switch, and the motor 51 being connected in series to a suitable power source.

The angular positions of the cams 52*a*, 52*b*, 52*c* on the shaft 50 are determined at the installation of the apparatus so that the choice of a particular position of selector switch 55, corresponding to the desired stopping or turning location of a particular aircraft type, causes

the cam follower associated with that selector switch position to enter the corresponding one of the detents 53*a*, 53*b*, or 53*c* and stop the motor 51 at a position of cam 17 which provides the proper elevation of platform 13. Of course, any number of cams 52 along with corresponding cam followers and switches can be provided on the shaft 50, this being determined by the different requirements of longitudinal guidance distances and/or the different aircraft types with which the apparatus is to be used. The selector switch 55 can conveniently be located adjacent the terminal gate 37 and this switch can be provided with a second terminal deck connected to provide power to the illumination source 11 for each of the operative positions of the platform elevating mechanism.

For many applications of the present invention it may be inconvenient or impractical to have the optical system contained in a housing 29 situated adjacent the level of the surface traveled as shown in FIG. 2. For example, in locations having an appreciable amount of snowfall such positioning of the apparatus would require a heating unit or some other expedient to keep the apparatus free of snow and ice, and the apparatus would be constantly exposed to the danger of being struck by a snowplow. To remedy this, the optical system 10 may be contained in a housing 29 elevated a suitable distance above the pilot's line of sight 30 as depicted in FIG. 6. It can be seen that the pilot's line of sight in this embodiment runs into the red stopping beam 61 from above, rather than from below as in the FIG. 2 embodiment. This difference is provided by the filter shown in FIG. 8, wherein the red stop beam is produced by an arc portion 62 situated at the lower side of the filter 63. The filter 63 is similar in all other aspects to the filter 20 of FIG. 5.

FIG. 7 shows a modified version of the platform elevation mechanism shown in FIG. 4 whereby a variable angle of depression is obtained for the platform on which the optical system is mounted. An extension member 66 is provided extending outwardly from platform 65, this extension member being biased upwardly by a spring 67 against the cam 64 connected to the shaft 50. Rotation of the cam 64 causes the angle of depression of the platform 65 to be varied in opposition to the upward force of the spring 67.

The embodiment shown in FIGS. 9 and 10 provides a ground-mounted guidance system which may be used where no adequate support structure is available for the elevated embodiment of FIG. 6 and which minimizes the problems of physical damage arising from the embodiment depicted in FIG. 2. As shown in FIG. 9, a folded optical system is employed incuding a lamp 71, a fixed-position optical system 72 including appropriate lenses and a filter as described above, and a reflector such as a mirror 73 affixed to an angular adjustment mechanism such as the rotatable shaft 74. This apparatus is covered by a housing 75 having a relatively low profile with respect to the ground or other surface 76 to enable the housing to be run over or struck by vehicles with a minimum likelihood of resulting damage either to the housing or to the vehicle. A suitable window 77 is provided in a housing recess 78 to enable the guidance beam 79 emanating from the optical assembly 72 and reflected from the mirror 73 to be projected along the desired path.

Folding of the optical system in the manner shown in FIG. 9 permits the underground portion of the apparatus to be received in a relatively shallow recess 80, thereby simplifying the installation and minimizing water drainage problems associated with subterranean assemblies. At the same time the folded optical system permits the use of a housing 75 having a low profile and therefore a substantially reduced exposure to damage from surface vehicles.

FIG. 10 shows an exemplary mirror position control apparatus for use with the embodiment of FIG. 9. The mirror 73 is secured to the mirror shaft 74 and this shaft is connected to a suitable source of rotary motion such as a gearhead motor 81. An appropriate number of control cams 82 and 83 along with associated switches 84 and 85 are provided connecting the motor 81 to a source of power through a selector switch 86 in a manner described with reference to FIG. 4. The shaft 74 is mounted for rotation in a suitable bearing 87.

Positioning of the selector switch 86 causes the motor 81 and the shaft 74 to rotate until the particular prepositioned control cam associated with the selected cam-operated switch causes the switch to open. At that time the shaft 74 and the mirror 73 secured thereto are appropriately positioned to cause reflection of the beam emanating from the optical assembly 72 at the proper elevation for the guidance beam 79.

As an alternative to the angular adjusting mechanisms disclosed in the foregoing embodiments, the same result can be obtained by providing at each location a plurality of guidance devices each of which is fixedly adjusted to produce a guidance beam at a different desired angle corresponding to the several angles preset into the angular adjusting mechanisms. A switch corresponding to selector switch 55 supplies electrical power only to the guidance device having the correct angle for a particular aircraft.

It should be emphasized that the particular colors mentioned herein for left beam, middle beam, right beam, and stop beam portions are not critical to the invention and any color arrangement can be used which effectively conveys the desired information to the pilot. Although in some instances the arc portions 21 or 62, respectively, of the filter need not extend across the entire breadth of the filter as seen in a direction transverse to the filter vertical center line axis 25, the depicted filter configurations are preferred for most aircraft ground navigation and docking applications.

It will be appreciated, of course, that the apparatus and techniques disclosed herein are not limited to use at airports or in aircraft ground maneuvering, but can as well be adopted to provide movement instructions for the operators of other ground vehicles. For example, the present apparatus can be used on marine waterways to indicate the location of a desired channel or docking location as well as the direction of any lateral deviation from this channel. The stop portion of the beam as applied to water navigation could be used to indicate that a change in channel direction was required. The light beam could be flashed in a predetermined code for a particular unit in order to identify a specific channel marker or docking location.

It should be understood of course that the foregoing relates only to preferred embodiments of the invention and that numerous modifications or alterations may be made therein without departing from the spirit and the scope of the invention as set forth in the appended claims.

What is claimed is:

1. An optical filter for use in a directional guidance apparatus having an optical system for projecting a beam of illumination in a predetermined direction along an illumination axis defining a desired path of travel, comprising:

a first filter portion including a plurality of optically distinguishable filter segments each having a dimension extending along the filter in a direction parallel with an axis of the filter located substantially perpendicular to the illumination axis;

said filter segments being serially disposed in a direction perpendicular to said filter axis, said dimension of at least one of said filter segments extending in said parallel direction on both sides of said filter axis to a location intermediate of the filter; and

a second filter portion optically distinguishable from each of said filter segments and extending in said parallel direction relative to the filter axis from said intermediate location toward an extremity of the filter.

2. A filter as in claim 1 wherein said one filter segment is of a color to denote a desired course of travel.

3. A filter as in claim 1 wherein said second filter portion extends along said intermediate location for substantially the entire breadth of the filter as measured in a direction perpendicular to said filter axis and extends in said direction parallel to said filter axis substantially to an extremity of the filter.

* * * * *

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,767,309 Dated October 23, 1973

Inventor(s) Albert D. Brown, et al.

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, in the heading, item [75] second inventor "William R. Tygart" should read -- William H. Tygart --.

Signed and sealed this 7th day of May 1974.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents

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