Jan. 12, 1971 L. G. SROGI 3,555,505

AIR SPACE TRAFFIC SIMULATOR

Filed March 17, 1969

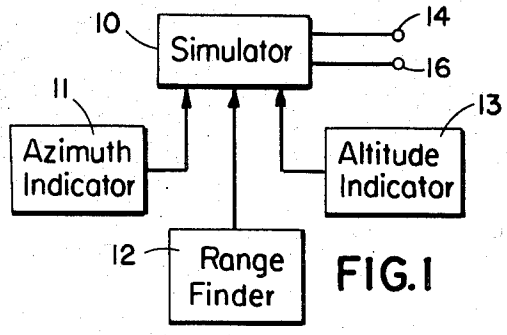


FIG.1

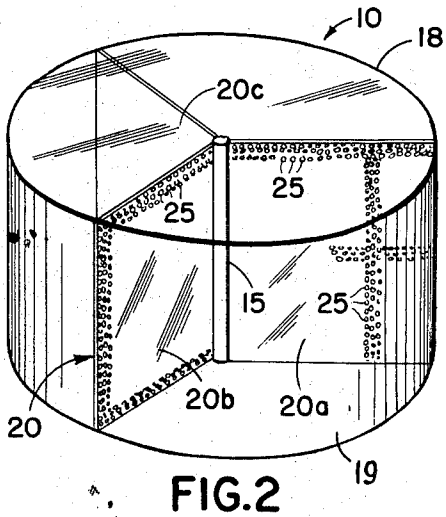


FIG.2

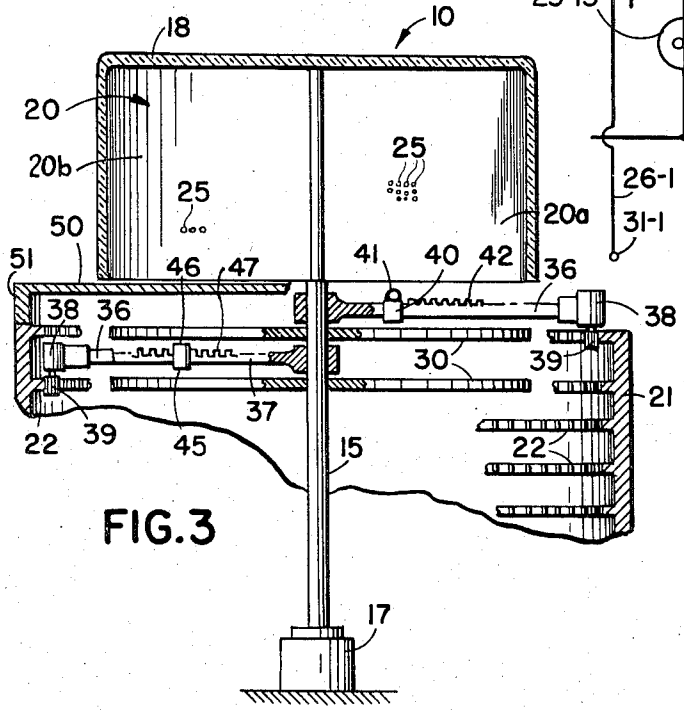


FIG.3

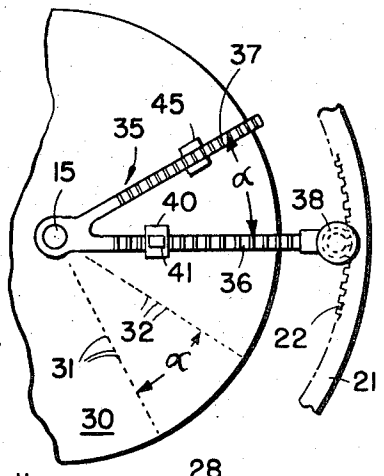


FIG.4

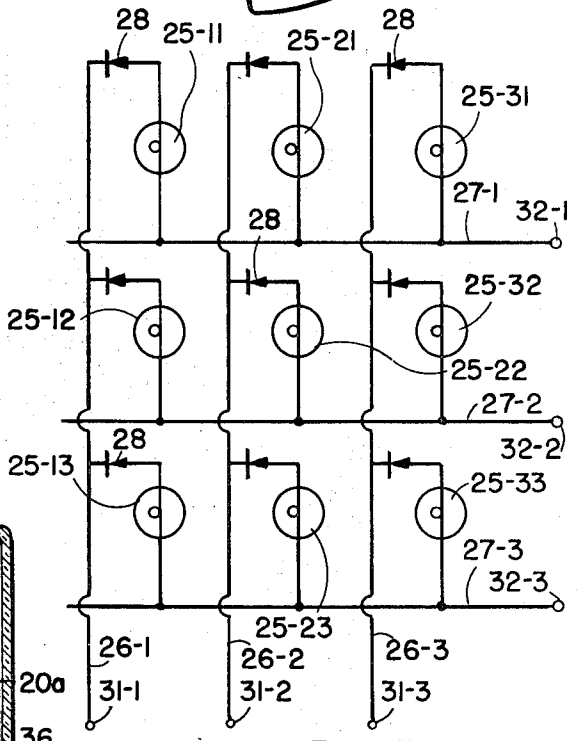


FIG.5

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AIR SPACE TRAFFIC SIMULATOR

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ABSTRACT OF THE DISCLOSURE

An air space traffic simulator has inputs applied from azimuth indicating means, range finding means and altitude indicating means. The simulator comprises a shaft rotatable by a driving motor and carrying at least one set of angularly spaced vanes fixed thereto and extending radially therefrom, a hollow cylindrical transparent enclosure preferably being provided for the vanes. Each vane carries a plurality of lamps arranged in rows and columns such that the height of each lamp represents a particular altitude of an aircraft relative to a reference plane and the radial position of each lamp represents a particular distance of the aircraft from a reference point. Disks are fixed to the shaft for rotation therewith, and each disk carries a first radial row of contacts with each contact, connected to first terminal of all the lamps in a corresponding column on a respective vane, and a second radial row of contacts with each contact connected to the second terminals of all the lamps in a corresponding row on the respective vane. A radially extending azimuth arm means is angularly adjustable about the axis of the shaft, and driving means are provided to adjust the azimuth arm means angularly in accordance with the azimuth of an aircraft to be monitored. The azimuth arm means carries a first contact member adjustable therealong and connected to one terminal of a source of potential, and carries a second contact member adjustable therealong and connected to the opposite terminal of the source of potential. Each contact member is engageable with the contacts of a respective one of the two radial rows. Each time the respective vane is rotated into alignment with the azimuth arm means, a respective lamp thereon is illuminated at a position corresponding to the distance and altitude of the monitored aircraft. Blocking diode means are associated with each lamp whereby only one lamp, at the intersection of a respective column and a respective row, can be illuminated at any one time.

BACKGROUND OF THE INVENTION

It is well known that air traffic congestion has become a major problem at airports located in metropolitan areas such as New York, Chicago, Washington and other areas. A great deal of effort has been and is being undertaken to provide an effective means of controlling air traffic in areas of intense concentration, such as the mentioned metropolitan airports. To date, none of these systems has been fully effective in providing the necessary information for effective control of the air traffic under congested or concentrated conditions.

Despite the use of ground controlled approach paths, ground-based radar, and other equipment, the control of air traffic under congested conditions still presents a major problem. There is a definite need for a relatively simple and relatively inexpensive means for indicating the location in space, speed of approach, and location relative to other aircraft, of any given aircraft approaching a major airport.

SUMMARY OF THE INVENTION

This invention relates to means for monitoring an aircraft approaching an airport and, more particularly, to

a novel air space traffic simulator for indicating the position, in space, of an aircraft relative to a reference point, as well as providing an indication of the speed of the aircraft and its position, in space relative to other aircraft. The invention thus relates to an air space traffic simulator which provides a continuous indication of the position, in space, of any or all aircraft in flight within the air space adjacent a reference point, such as an airport, and including indications of the azimuth of each aircraft relative to a reference directional plane, i.e., 0° north and 180° south direction, the distance of the aircraft from the reference point and the altitude of the aircraft relative to a reference plane. Such a continuous indication which, of course, changes with time as the aircraft approaches the reference point, and also changes if the heading or azimuth of the aircraft changes, can be used further as an indication of the speed of the aircraft and its relation, in space, to other aircraft.

The traffic simulator includes an upright rotatable shaft which is driven by a drive motor, and several vanes are secured to this shaft for rotation therewith and to extend radially therefrom, the vanes preferably being rectangular. Preferably, a hollow cylinder of transparent material encloses the vanes, reducing air resistance to vane movement. One or more of these vanes support a plurality of lamps arranged in rows and columns such that the height of each lamp represents a particular altitude of an aircraft relative to a reference plane, and the radial position of each lamp represents a particular distance of the aircraft from the reference point. While a rectangular grid arrangement of the lamps is preferred, other arrangements may be used. Preferably, the lamps are so mounted in the respective vanes that they are visible from opposite sides of the vane.

Circular disks are secured to the shaft, in axially spaced relation, to rotate with the shaft. These disks are operatively associated with respective vanes. With respect to an associated vane, each disk has a first radial row of contacts radially aligned with its associated vane, and a second radial row of contacts. Each contact of one radial row is connected to first terminals of all the lamps in a corresponding column on the associated vane. Each contact of the other radial row is connected to the second terminals of all the lamps in a respective row of the associated vane.

Azimuth arm means extend radially from the shaft and are angularly adjusted about the axis of the shaft. Each azimuth arm means has an associated driving means operable to adjust the azimuth arm means angularly in accordance with the azimuth of an aircraft whose position in space is to be indicated or monitored. Each azimuth arm means supports two shuttles or switch operators which are adjustable longitudinally of the arm means or radially relative to the shaft. Each shuttle has a respective drive means operable to adjust the same radially of the shaft, and one shuttle is thus adjusted radially of the shaft in accordance with the distance of the aircraft to be monitored from the reference point, with the other shuttle being adjusted radially of the shaft by its drive means in accordance with the altitude of the aircraft to be monitored. Each of the two shuttles carries a wiper contact associated with the contacts of a respective radial row of contacts on a circular disk, and the two wiper contacts are connected to respective opposite terminals of a source of electrical potential. Thus, one wiper contact will engage a respective contact in one radial row of contacts in accordance with the distance of the aircraft to be monitored, and the other wiper contact will engage a respective contact in the other radial row of contacts in accordance with the altitude of the aircraft to be monitored. The two wiper contacts are brought into engagement with their

associated contacts whenever the associated vane is angularly aligned with the respective azimuth arm means. At this instant, a single lamp on the associated vane is illuminated, giving the distance and altitude of the plane being monitored. The azimuth of the plane is indicated by the angular position of the azimuth arm means. By sufficiently rapid rotation of the shaft, there is provided a visual indication which appears to move as the plane changes distance, altitude, or azimuth heading.

As stated, the lamps on each vane are arranged preferably in a rectangular grid and, to assure that only one lamp at a time is energized, blocking diodes are associated with each lamp so as to prevent "backflow" of current through a lamp which is not intended to be illuminated.

In a preferred embodiment of the invention, there are three angularly spaced vanes secured to the shaft and each having the mentioned lamps thereon. The lamps in the first vane are illuminated selectively in the manner just described. The second vane is arranged to indicate the range and the azimuth bearing of an aircraft whose altitude is not known. For this purpose, the switching arrangement provides for all the lamps in a respective column of this second vane to be illuminated simultaneously whenever the vane has a predetermined angular orientation coordinated with the azimuth of the aircraft to be monitored. The vertically extending column of illuminated lamps on the second vane indicates the distance and azimuth bearing of an aircraft whose altitude is not shown.

The third vane is designed to indicate buildings, towers and other fixed objects in the line of approach of an aircraft being monitored. For this purpose, there is associated with a third vane a stationary circular disk carrying suitable contact arrangements which, as the third vane rotates, effect illumination of lamps on the third vane to indicate the overall contours of buildings and fixed objects located within the field of the apparatus.

As a feature of the invention, two such simulators may be provided, preferably in coaxial superposed relation. One of the simulators will then be used to indicate the position, in space, of any or all aircraft within the effective radar range of the airport over a relatively great distance and a relatively great height. The second simulator will be used for landing and take-off monitoring purposes by indicating the position, in space, of all those aircrafts in the vicinity of the airport with range and altitude displaced to a much larger scale for this purpose.

An object of the invention is to provide a facile, accurate, simple means of visually indicating the location, altitude, speed and relative position of aircraft approaching or near an airport or the like, to permit proper, adequate and effective control of the aircraft by traffic controllers.

Another object of the invention is to provide a novel and simple air space traffic simulator for indicating the position, in space, of an aircraft relative to a reference point and a reference plane.

A further object of the invention is to provide such an air space traffic simulator in which an illuminated lamp gives a visual impression of the altitude, distance, speed and approach path of an aircraft being monitored.

Another object of the invention is to provide such an aircraft space traffic simulator using illuminated lamps to give a visual impression of building and other fixed objects within the operating field of the apparatus.

A further object of the invention is to provide such an air space traffic simulator providing a visual indication of the range and azimuth bearing of an aircraft being monitored and whose altitude has not been determined.

Another object of the invention is to provide an air space traffic simulator in the form of an automated system for monitoring traffic of aircraft during flight, during takeoff and during landing.

A further object of the invention is to provide such an air space traffic simulator which may accommodate a large number of aircraft to be monitored and which permits more effective utilization of traffic controllers for their primary function as monitors.

Another object of the invention is to provide such an air space traffic simulator which is compatible with equipment presently in use.

A further object of the invention is to provide a space traffic simulator providing a visual three-dimensional indication of the position, range and relative velocity of a space vehicle and any other associated orbiting object or objects relative to the reference space vehicle.

For an understanding of the principles of the invention, reference is made to the following description of a typical embodiment thereof as illustrated in the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings:

FIG. 1 is a block diagram of air space traffic simulating apparatus embodying the invention;

FIG. 2 is a perspective view of the upper portion of an air space traffic simulator embodying the invention;

FIG. 3 is a somewhat schematic axial sectional view, omitting duplicated parts, of an air space traffic simulator shown in FIG. 1;

FIG. 4 is a partial plan view of a circular disk and an azimuth arm means shown in FIG. 3; and

FIG. 5 is a partial schematic wiring diagram of the lamps on one vane, illustrating their arrangement in columns and rows and their energizing connections.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring first to FIG. 1, an air space traffic simulator embodying the invention is illustrated at **10** as supplied with inputs from an azimuth indicator **11**, a range finder **12** and an altitude indicator **13**. Traffic simulator **10** has an operating potential applied thereto from a source of electric potential connected across the terminals **14** and **16**. In accordance with the signals supplied thereto from components **11**, **12**, and **13**, simulator **10** provides, by means of points of light, the course of any or all aircraft within the operating field of the apparatus, and particularly indicating their altitude, distance and azimuth bearing relative to the airport and the relation of each aircraft to other aircraft in the air space being monitored.

Referring to FIGS. 2 and 3, simulator **10** includes a generally upright or vertical shaft **15** which is rotated by a driving motor indicated at **17** and connected to the shaft either directly or through the interposition of suitable reduction gearing. Several substantially rectangular flat plates or vanes **20**, shown as three in number for exemplary purposes, are secured in angularly spaced relation to shaft **15** adjacent the upper portion of the shaft, the vanes **20**, in the illustrated example, being disposed approximately 120° apart. The vanes, which are indicated at **20***a*, **20***b* and **20***c*, are fixed to rotate with shaft **15** when the latter is rotated at a preselected speed by its driving motor **17**. A hollow cylindrical transparent casing **18** encloses the rotating vanes **20** and the upper portion of shaft **15**, to minimize air drag loads on driving motor **17**. Vanes **20***a*, **20***b* and **20***c* preferably are formed of a suitable dielectric material, although this is not absolutely essential.

Each vane **20** has mounted thereon a plurality of light emission devices or lamps **25**, and preferably the lamps **25** are so mounted on each vane that they are visible, particularly when illuminated, from both sides of the vane. The light emission devices or lamps **25** preferably are arranged in a rectangular grid pattern at the intersections of vertical columns and radial or horizontal rows. The light emission devices or lamps may be fila-

ment-type lamps, gaseous discharge lamps, solid state lamps, etc., as necessary. While, in the specific embodiment of the invention illustrated in the drawings, the lamps are arrayed in a closely spaced matrix or grid comprising vertical columns and horizontal rows, it should be understood that other configurations of the lamps may be used. For the sake of simplicity, the light emission devices **25** will be hereinafter referred to solely as "lamps," and it will be understood that this term encompasses any type of light emission device.

During rotation of the vane assembly within the transparent casing **18**, each lamp occupies points in space whose locus is a circle whose center is the axis of the vertical shaft **15**. The radius of each circle corresponds to a specific distance from the point of reference, such as an airport, space port, aircraft carrier, etc. The elevation of each circle, or its vertical distance from base **19** of the simulator, corresponds to a specific altitude of the aircraft or space craft from a horizontal reference plane. Suitable electrical energization of the lamps **25** at any point in the plane of rotation produces a momentary spot of light, and the position of the spot of light or light point corresponds to the instantaneous position of the moving object, such as an aircraft or space craft, relative to the reference point. The light spot at this point appears to hang in space and, by suitable operation of the simulator, to move in space in relatively accurate simulation of the corresponding movement in space of the aircraft or space craft being monitored.

In a manner to be described more fully hereinafter, the lamps **25** are connected through suitable electrical circuitry to a source of electric potential in such a manner that energization of the lamps is under the control of the azimuth indicator **11**, range finder **12** and altitude indicator **13**. The elements **11**, **12** and **13** may comprise known existing equipment, such as radar, lasers, transponders, fixed position switches, or manually controlled switches which are controlled in accordance with information or signals received from suitable sources.

Referring more particularly to FIGS. 3 and 4, beneath simulator **10**, circular disks **30** are secured to shaft **15** to rotate therewith, these circular disks being disposed within a cylindrical outer casing **21**. For a purpose to be described, the inner surface of casing **21** is formed with a plurality of axially spaced internal annular gears or circular racks **22**. As disks **30** are fixed to shaft **15** in vertically or axially spaced relation therealong, these disks rotate as a unit with the assembly of vanes **20**. While the disks **30** are illustrated as arranged with a casing **21** beneath simulator **10**, it will be understood that, while this is a preferred location, the disks could be secured to a portion of shaft **15** projecting upwardly above simulator **10**.

Disks **30** are operatively associated with respective vanes **20**. In the embodiment of the invention illustrated in the drawings, each disk **30** has, on a surface thereof, a radially extending row of first electrical contacts **31**, which row is radially aligned with the respective vane **20**, such as a vane **20***a*, or located in the same radial and axial plane as the respective vane **20***a*. At an angular spacing α from the row of first contacts **31**, each disk is formed with a radially extending row of second contacts **32**. The number of first contacts **31** in each radial row is equal to the number of vertical columns of lamps **25** on the associated vane **20***a*, and the number of second contacts **32** in each radial row is equal to the number of rows of lamps **25** on the respective vane **20***a*. In addition, each contact **31** is connected to a respective "column" conductor, such as **26–1**, **26–2** and **26–3** shown in FIG. 5. In a like manner, each contact **32** is connected to a respective "row" conductor, such as the row conductors **27–1**, **27–2** and **27–3** of FIG. 5. Such connections may be made, for example, by bringing the connections into shaft **15**, the latter thus being a tubular shaft, and bringing the connections out of shaft **15** at the appropriate locations within simulator **10**. With this arrangement, it will be appreciated that, when a particular contact **31** is connected to one side of the source of potential indicated by the terminals **14** and **16**, with a particular contact **32** being connected to the other side of this source, a lamp connected to the associated column conductor **26** and the associated row conductor **27** will be energized to indicate a particular distance and a particular altitude of an aircraft or the like being monitored. If desired, transparent casing **18** may be marked, on its upper circular surface, with a plurality of concentric circles each corresponding to a respective distance of the monitored aircraft from the reference point, and may be marked, on its cylindrical surface, with a plurality of vertically or axially spaced circles each indicating a respective altitude of the monitored aircraft with respect to the reference plane.

Respective azimuth arm means **35** are operatively associated with each disk **30**, and these arm means are mounted on shaft **15** but are rotatable or angularly adjustable relative to shaft **15** about the axis of the latter, while being fixed against axial displacement along shaft **15**. Each azimuth arm means **35** comprises an azimuth arm **36** and an altitude arm **37**, and arms **36** and **37** have an angular spacing equal to the aforementioned angle α. The radially outer end of each arm **36** mounts a suitable drive device or motor **38** driving a pinion or gear **39** meshing with a respective rack or internal ring gear **22** on external casing **21**. The arrangement of the arms **36** and **37** of the azimuth arm means **35** is more clearly illustrated in FIG. 4, which also illustrates the two angles α which are equal to each other. Through operation of motors **38**, azimuth arm means **35** may be rotated about the axis of shaft **15** through 360°, to any azimuthal position, such as a position corresponding to the bearing or azimuth of an aircraft being monitored. Such positioning is effected under the control of the azimuth indicator **11**, which may be a radar providing a directional radar signal and through a suitable electronic circuit. As azimuth controls of this type are well known, per se, they have not been shown in detail in the drawings.

Arm **36** has mounted thereon, for longitudinal or radial adjustment therealong, a shuttle **40**, which may be termed a switch operator and which, in the particular embodiment of the invention shown in the drawing, carries the wiper contact cooperable with the first contacts **31** of the associated disk **30**. Shuttle **40** is connected to one terminal of the source of electric potential such as, for example, the terminal **14** of FIG. 1. Shuttle **40** is moved along arm **36** by an electric motor or the like **41** and, for this purpose, arm **36** may be formed with a rack or the like, as indicated at **42**. The radial position of shuttle **40** is controlled, through motor **41**, by a signal from the range finder **12** which is converted, by suitable electronic circuitry, into a control signal for motor **41**. Shuttle **40** is thus adjusted radially of arm **36** in accordance with the distance or range of the aircraft to be monitored.

Correspondingly, a shuttle or switch operator **45** is mounted on arm **37** for longitudinal or radial adjustment therealong. In the particular embodiment of the invention illustrated in the drawings, this shuttle **45** carries a wiper contact engageable with contacts **32** when the wiper contact on shuttle **40** is engaged with contacts **31**. Shuttle **45** is moved radially by a motor **46** and, for this purpose, arm **45** may be formed with a rack, as indicated at **47**. The shuttle **45** may be termed an altitude shuttle, whereas the shuttle **40** may be termed a range shuttle. Shuttle **45** is adjusted radially along arm **37** in accordance with altitude signals from transponders or the like, as provided by the altitude indicator **13** of FIG. 1, to conform to the altitude of the aircraft relative to the ground or other horizontal reference plane. Shuttle **45** is electrically connected to the other terminal, such as the terminal **16**, of the source of electric potential. Thus, when the wiper of shuttle **40** is engaged with a respective contact **31**, the wiper of shuttle **45** is engaged with a respective contact **32**, and this completes an energizing circuit

for a lamp **25** which is located, on vane **20***a*, for example, at the intersection of a particular row and a particular column, this intersection representing the range or distance of the aircraft and its altitude relative to the reference plane. In addition, the azimuth or bearing of the aircraft is also indicated, as will be described more fully hereinafter. Thus, the constantly rotated vanes produce an apparently continuous light spot which moves in accordance with the movement of the aircraft being monitored and at a speed corresponding to the speed of such aircraft. The flight of the aircraft, or its approach or take-off, is thus simulated by the simulator **10**.

In the event that the altitude of the aircraft to be monitored is unknown, all of the lamps in a respective column of vane **20***b*, of each set of vanes, are energized in parallel with each other so to provide a vertically extending row of illuminated lamps at a position corresponding to the range or distance of the aircraft from the reference point. Separate disks **30** are electrically connected to the lamps on the vane **20***b*, so that electrical contact between the wiper on a range shuttle **40** and a set of first contacts such as the contacts **31** will illuminate all of the lamps in a particular column on vane **20***b*. For this purpose, the shuttle, such as **40**, cooperable with a disk **30** associated with the vane **20***b* may be connected to one terminal, such as the terminal **14**, of the source of electric potential, and all of the row conductors **27** on the vane **20***b* can be connected in parallel to the other terminals, such as the terminal **16**, of the source. The illuminated column of lamps **25** on a vane **20***b* indicates that the aircraft being monitored may be located, with respect to the horizontal reference plane, at any altitude within the range of simulator **10**.

In order to provide a complete air space simulation, it is desirable to provide a simulation of the position, contour and height of stationary ground-based objects, such as other airports, radio and television antenna towers, tall buildings, hills, and other flight barriers which may be in the path of an approaching aircraft to be monitored and constitute a flight barrier. For this purpose, there is used a vane **20***c* of each set of vanes, which has lamps **25** arranged thereon in a special or singular pattern corresponding to the width and height of these stationary objects and their range location. For this purpose, a stationary disk **50** is mounted immediately beneath the vanes **20**, as by being formed with an annular rim **51** resting on the external casing **21**. Electrical contact wipers, brushes, or the equivalent are mounted on the lower edge of vane **20***c*, and these wipers, brushes or the like contact electrical contacts or the like mounted on stationary disk **50** to complete electrical energizing circuits for particular lamps simulating one or more of the ground-based objects. The circumferential length of each ground-based object establishes the circumferential length of each specific respective contact on stationary disk **50**. The illuminated lamps reproduce, in facsimile form, the position, approximate shape and height of each of the ground-based objects.

FIG. 5 illustrates a portion of the lamp grid for a vane, such as the vane **20***a*. From this figure, it will be noted that each lamp **25** has one terminal connected to a column conductor **26** and its other terminal connected to a row conductor **27**. When the contact **31–2** of column conductor **26–2** is engaged by the wiper of shuttle **40** simultaneously with engagement of the contact **32–2** of row conductor **27–2** by the wiper of shuttle **45**, a direct energizing circuit is completed through lamp **25–22**. However, in the usual case, other lamps connected to column conductor **26–2** and to row conductor **32–2** are illuminated through other current flow paths. For example, current can flow from row conductor **27–2** through lamp **25–32**, lamp **25–31** and lamp **25–21** to column conductor **26–2**.

To avoid this possibility, and to assure that one particular lamp is energized in particular radial positions of shuttles **40** and **45**, each lamp **25** has connected, in series therewith, a polarizing or blocking diode **28**. All of the diodes are so polarized that current flow through the associated lamp only from a row conductor **27** and to a column conductor **26**. Thus, upon applying of a potential between contact **31–2** and contact **32–2**, current flows from contact **32–2** through conductor **27–2**, lamp **25–22**, the associated diode **28**, column conductor **26–2** to contact **31–2**. This is the only lamp energizing circuit effective under such conditions, and there are no possible branch circuits for illuminating other lamps. The provision of these blocking or polarizing diodes **28** is an important feature of the invention.

In the operation of the device, the azimuth arm **35** is first adjusted to the bearing or azimuth of an aircraft to be monitored, and this may be effected either manually or through the operation of the azimuth indicator **11**. The motor **17** is then energized to rotate the vane assembly through the shaft **15** and, each time the vane **20***a* is radially aligned with the arm **36** of the azimuth arm means **35**, a single particular lamp **25** on the vane **20***a* will be lit. With sufficiently rapid rotation of the vane assembly, there will appear to be a continuous spot of light which will appear to travel over the vane **20***a* in a simulation of the path of travel of the aircraft which is being monitored and at a speed corresponding to the speed of the aircraft. At the same time, there will appear on the vane **20***c*, during each cycle, a simulation of ground-based objects which may be in the path of the aircraft, either during flight, during take-off or during landing. In the event the altitude of the aircraft to be monitored is unknown, there will appear, on the vane **20***b*, a movement of a vertical column of lights corresponding to the travel of the aircraft but not indicating its change in altitude although its azimuth will still be indicated by the azimuth arm means. Should the bearing of the aircraft change, the azimuth arm means will likewise be angularly adjusted under the control of azimuth indicator **11**, so that a continuous simulation of the bearing or azimuth of the aircraft is always present.

While, in the embodiment of the invention which has been specifically illustrated in the drawings, the contacts **31** and **32** have been indicated as being on the same surface of the disk **30**, it will be appreciated that one set of contacts could extend radially along one surface of the disk and the other set of contacts could extend radially along the opposite surface of the disk, in alignment with the radial row of the first contacts. In such case, the two wipers on the shuttles **40** and **45** would be disposed adjacent respective opposite side of the disk.

The purpose of the disks **30** is properly to support the electrical contacts such as **31** and **32** in proper angular relation with the associated vanes, **20***a* or **20***b*. Thus, each disk **30** could be replaced by an appropriate number of radial arms for supporting the contacts, and these arms could be tubular so that the connections to the contacts could extend through the tubular arms. If two vanes **20***a* are mounted on shaft **15** and spaced 180° apart, each disk **30** would carry diametrically aligned radial rows of contacts **31** and **32**, each radial row being associated with a respective one of the two vanes.

The electrical connections between each individual lamp and its corresponding contact **31** or **32** must not interfere with the operation of the contact wiper **40** or **45** and the arms **36** or **37**. The arrangement shown in FIG. 3 meets this requirement by providing the underside of the disk **30** to carry the conductors connected to the contacts **31** and **32**, while the upper surface provides for arm and wiper operation. However, other arrangements are possible.

Thus, instead of the disk, a tubular arm could be used and the electric conductors could pass from the shaft **15** through the center of this arm to the contacts, which can be in the form of rings electrically isolated from each other on the outer surface of the tubular arm. The tubular

arm could be formed from a suitable non-conducting or dielectric material, while the contact ring would comprise suitable electrically conductive material.

A V-shaped double arm could be used, one arm being for range while the other arm being for altitude, and with the two arms being separated by the angle α. Alternatively, a single arm could be used with the shuttle arms **36** and **37** above and below the tubular arm. The contact rings would then have to be separated into an upper semi-circle and a lower semi-circle connected, respectively, to the range terminals and to the altitude terminals of the lamp.

In the event two vanes **20***b* are used, positioned 180° apart, a second extending row of contacts **31** would be required at an angle spacing of 180° from the first row. As the terrain display is affected by the stationary set of contacts mounted on disk **50**, additional vanes **20***c* do not require additional contacts. As each disk **20***c* sweeps over the stationary contacts, the lamps that are illuminated are phased with the ground-based object, and therefore effectively produce a display representing, in facsimile form, that object as to position, height, width and length. For terrain and obstacle indication, the contacts on disk **50** are arranged depending on the position of the objects or the like in question and, as a result, are scatter and not in any particular geometrical pattern.

The lamps on the vanes **20***a* and **20***b* could be arranged in concentric circles in radially extending rows, rather than in a rectangular grid pattern. Radar or laser could be used for range indication, and suitable means for determining the angular position relative to a specific plane of reference established by a first space vehicle. A particular pattern of lamps would depend on the application for the particular purpose of the apparatus. The rectangular grid of lamps does not provide an exact simulation of position of the aircraft in the field of the apparatus, or in the field of the radar or range measuring device. For example, an aircraft five miles away from the radar unit but also five miles high would be directly over the radar unit. A more precise representation would array the lamps in horizontal rows and in vertical arcs centered from the reference airport based upon its altitude above sea level. However, the rectangular grid of lamps provides a display that, although somewhat imprecise, is the simplest and easiest to scan and interpret with respect to the traffic controller.

In the case of a large scale representation of array for landing, approach and taking-off display, the rectangular grid is still acceptable. For space flight simulation, such as a vehicle orbiting about the earth or otherwise in space, monitoring the approach of another space vehicle plus assorted debris possibly in the vicinity of both vehicles, a different array of lamps in the vanes would be utilized. The first orbiting vehicle would be the reference point and its spatial position would be the center of the vertical axis of the vane.

What is claimed is:

1. An air space traffic simulator, for indicating the position, in space, of an aircraft or the like relative to a reference point, comprising, in combination, a vane assembly rotatable about a substantially vertical axis and including plural vanes extending radially of the axis of rotation and along the axis, and arranged in sets each including at least one vane; driving means operable to rotate said vane assembly about said substantially vertical axis; a plurality of lamps mounted on each vane along intersecting first and second coordinates in a manner such that the height of each lamp, above a reference base, represents a particular altitude of an aircraft relative to a reference plane, and the radial position of each lamp, relative to said substantially vertical axis, represents a particular distance of the aircraft from the reference point; a source of electric potential; first switch support means rotatable with said vane assembly, and supporting a radially extending row of first switch means, angularly aligned with a respective vane, with each first switch means being operable to connect first terminals of lamps along a respective first coordinate to one terminal of said source, and a radially extending row of second switch means each operable to connect second terminals of lamps along a respective second coordinate to the other terminal of said source; azimuth arm means extending radially of said carrier and angularly adjustable about said substantially vertical axis; second driving means operable to adjust said azimuth arm means angularly in accordance with the azimuth of an aircraft whose position in space is to be monitored; a first switch operator adjustable longitudinally of said azimuth arm means and controlling said first switch means in accordance with its radial position relative to said substantially vertical axis; third driving means operable to adjust said first switch operator radially in accordance with the distance of the aircraft from said reference point; a second switch operator adjustable longitudinally of said azimuth arm means and controlling said second switch means in accordance with its radial position relative to said substantially vertical axis; and fourth driving means operable to adjust said second switch operator radially in accordance with the altitude of the aircraft relative to said reference plane; whereby, each time said respective vane is angularly coincident with said azimuth arm means, a respective lamp on said respective vane will be illuminated at a position on the vane corresponding to the distance and altitude of the aircraft whose position is being monitored.

2. An air space traffic simulator, as claimed in claim **1**, in which said substantially vertical axis is the axis of a substantially vertical rotatably mounted shaft, said vanes being secured to extend radially of said shaft and axially along said shaft; said switch support means being secured to rotate with said shaft.

3. An air space traffic simulator, as claimed in claim **2**, in which said first and second switch means comprise first and second contacts, respectively, arranged in first and second radial rows; conductors connecting each first contact to the first terminals of lamps along respective first coordinates, and conductors connecting each second contact to the second terminals of lamps along respective second coordinates; said first and second switch operators comprising first and second shuttles, respectively, each carrying a wiper contact; the wiper contact of said first switch operator being engageable with said first contacts and connected to one terminal of said source, and the wiper contact of said second shuttle being engageable with said second contacts and connected to the other terminal of said source.

4. An air space traffic simulator, as claimed in claim **1**, in which said lamps are arranged, on each vane, in a rectangular grid constituted by vertical columns and horizontal radial rows of lamps, said columns constituting said first coordinates and said rows constituting said second coordinates.

5. An air space traffic simulator, as claimed in claim **4**, in which each of said sets of vanes includes at least two vanes; one vane constituting said respective vane aligned with said radially extending row of said first switch means; said switch support means supporting a radially extending row of third switch means operatively associated with a second vane which is angularly spaced from said respective vane, each of said third switch means being operable to connect all of the lamps in a respective column of said second vane simultaneously across said source of electric potential; whereby, when the altitude of an aircraft to be monitored is not known, the distance of the aircraft relative to said reference point will be indicated by a column of illuminated lamps on said second vane.

6. An air space traffic simulator, as claimed in claim **5**, in which each set of vanes includes three vanes at equal angular spacing from each other, and including said respective vane, said second vane and a third vane; second

switch support means fixed against rotation with said carrier and supporting radially extending rows of fourth switch means cooperable with the lamps on said third vane; switch operating means on said third vane cooperable with said fourth switch means to connect lamps on said third panel for illumination in a pattern indicating the contours of land-based objects within the operating field of the simulator.

7. An air space traffic simulator, as claimed in claim **3**, in which said switch support means comprises disks fixed to rotate with said shaft; each of said first and second switch means being supported on a surface of a disk.

8. An air space traffic simulator, as claimed in claim **7**, in which the first and second radially extending rows of contacts connected to the lamps of said respective vane are supported on the same surface of the associated disk; the radially extending row of first contacts being aligned with the respective vane and the radially extending row of second contacts being spaced angularly from the radially extending row of first contacts at a predetermined angle; said azimuth arm means comprising a pair of radially extending arms spaced angularly by said predetermined angle.

9. An air space traffic simulator, as claimed in claim **4**, including a plurality of polarizing diodes each connected in series with a respective lamp; said diodes being polarized in a direction such as to permit current flow through said lamps only in a direction from said second contacts to said first contacts.

10. An air space traffic simulator, as claimed in claim **1**, including a hollow cylindrical casing of transparent material enclosing said vane assembly and having at least one circular end wall; concentric circular distance gradations on said end wall; and axially spaced circular altitude gradations on the cylindrical surface of said casing.

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