No. 2454503

THE UNITED STATES OF AMERICA

TO ALL TO WHOM THESE PRESENTS SHALL COME:

Whereas Carl J. Crane, of Dayton, Ohio,

PRESENTED TO THE Commissioner of Patents A PETITION PRAYING FOR THE GRANT OF LETTERS PATENT FOR AN ALLEGED NEW AND USEFUL IMPROVEMENT IN

AUTOMATIC AURAL-VISUAL SIGNAL TRANSMITTERS FOR AVIATION GROUND TRAINERS,

A DESCRIPTION OF WHICH INVENTION IS CONTAINED IN THE SPECIFICATION OF WHICH A COPY IS HEREUNTO ANNEXED AND MADE A PART HEREOF, AND COMPLIED WITH THE VARIOUS REQUIREMENTS OF LAW IN SUCH CASES MADE AND PROVIDED, AND

Whereas UPON DUE EXAMINATION MADE THE SAID CLAIMANT is ADJUDGED TO BE JUSTLY ENTITLED TO A PATENT UNDER THE LAW.

NOW THEREFORE THESE Letters Patent ARE TO GRANT UNTO THE SAID Carl J. Crane, his heirs OR ASSIGNS FOR THE TERM OF SEVENTEEN YEARS FROM THE DATE OF THIS GRANT

THE EXCLUSIVE RIGHT TO MAKE, USE AND VEND THE SAID INVENTION THROUGHOUT THE UNITED STATES AND THE TERRITORIES THEREOF. Provided, however, that the said invention may be manufactured and used by or for the Government for governmental purposes without the payment of royalty thereon.

In testimony whereof I have hereunto set my hand and caused the seal of the Patent Office to be affixed at the City of Washington this twenty-third day of November, in the year of our Lord one thousand nine hundred and forty-eight, and of the Independence of the United States of America the one hundred and seventy-third.

Attest:

Law Examiner.

Lawrence C. Kingsland
Commissioner of Patents.

AUTOMATIC AURAL-VISUAL SIGNAL TRANSMITTER FOR AVIATION GROUND TRAINERS

Filed March 30, 1940

8 Sheets-Sheet 8

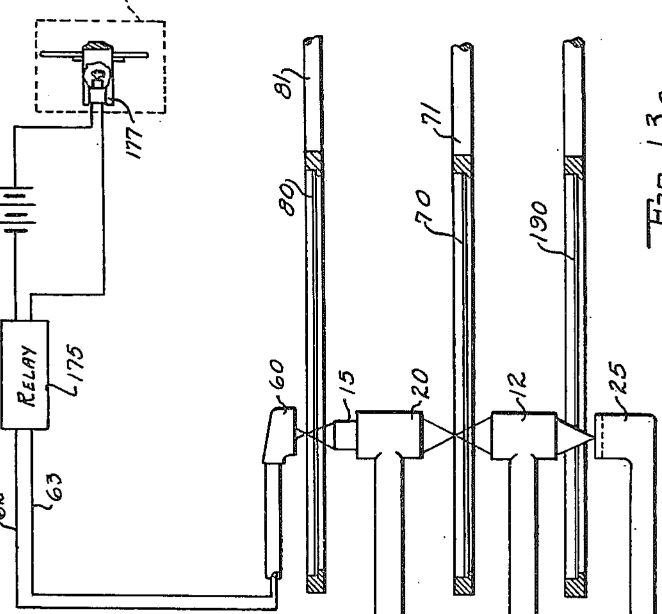

FIG. 13.

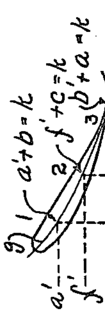

FIG. 13a.

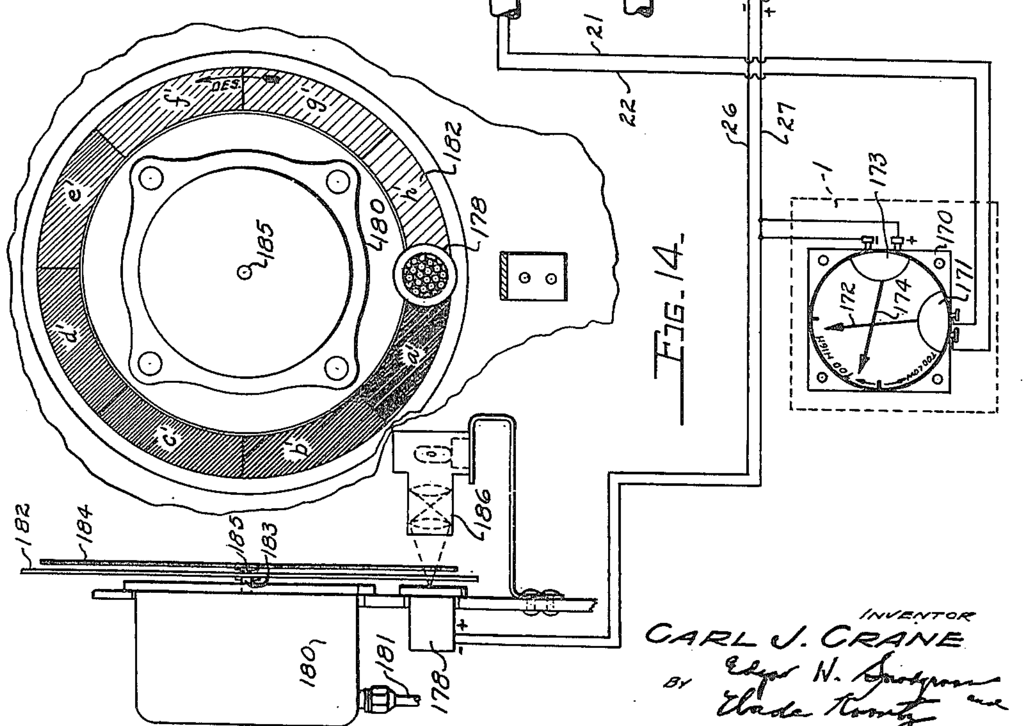

FIG. 14.

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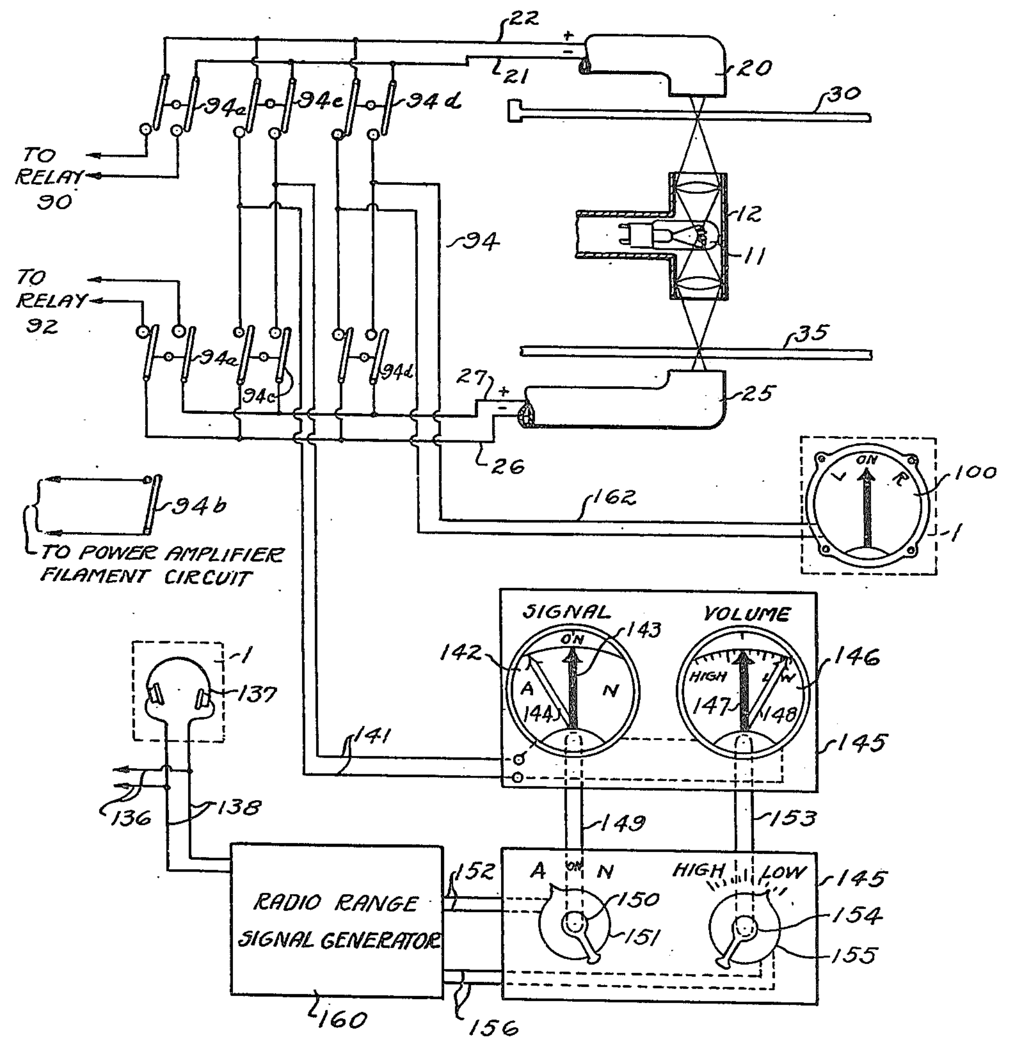
FIG. 12.



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AUTOMATIC AURAL-VISUAL SIGNAL TRANSMITTER FOR AVIATION GROUND TRAINERS

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FIG. 15.

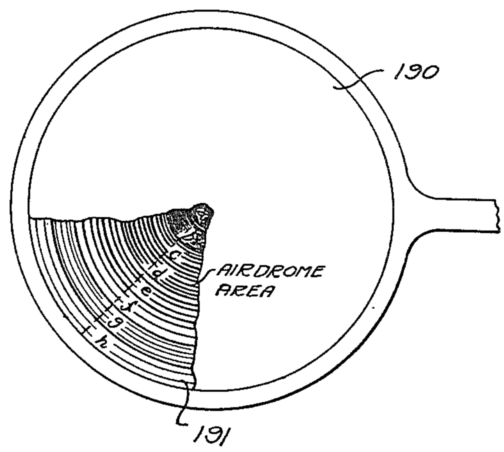
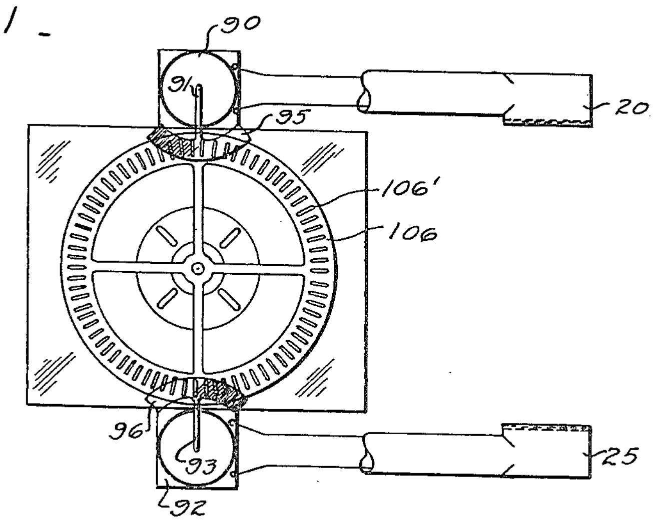


FIG. 11.



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AUTOMATIC AURAL-VISUAL SIGNAL TRANSMITTER FOR AVIATION GROUND TRAINERS

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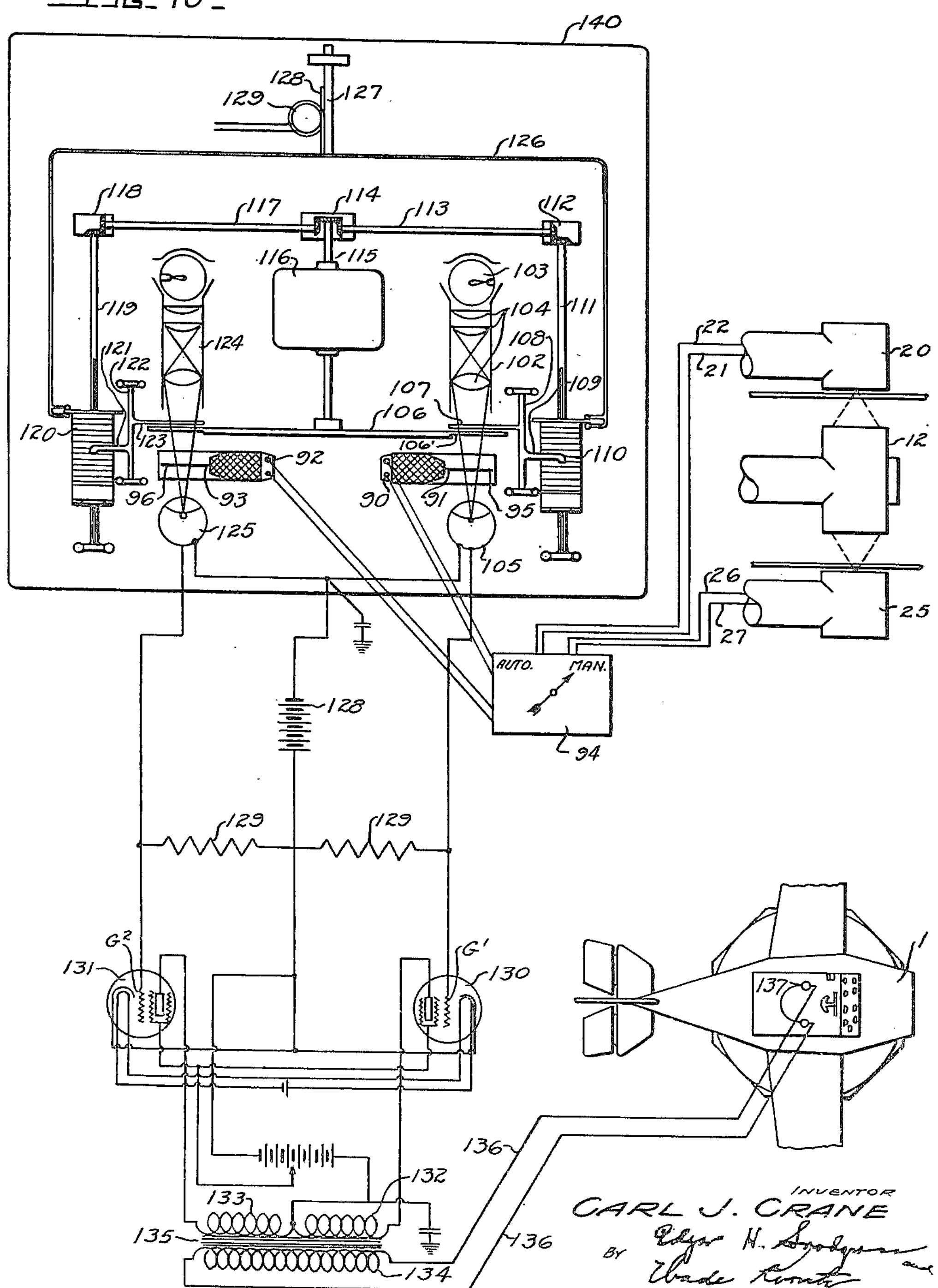
FIG. 10



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2,454,503

AUTOMATIC AURAL-VISUAL SIGNAL TRANSMITTER FOR AVIATION GROUND TRAINERS

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FIG. 7.

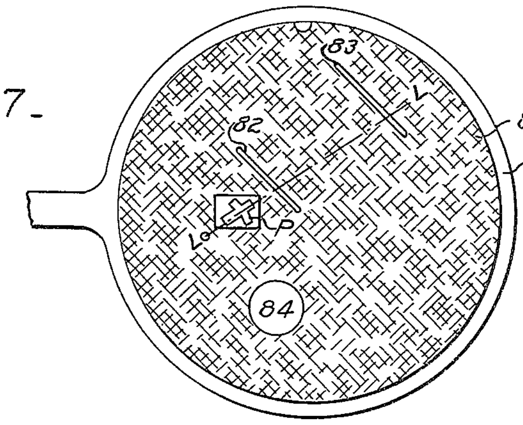


FIG. 6.

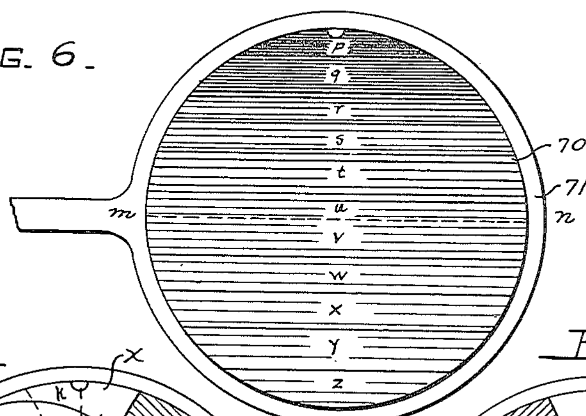


FIG. 5.

"N" SIGNAL ZONE

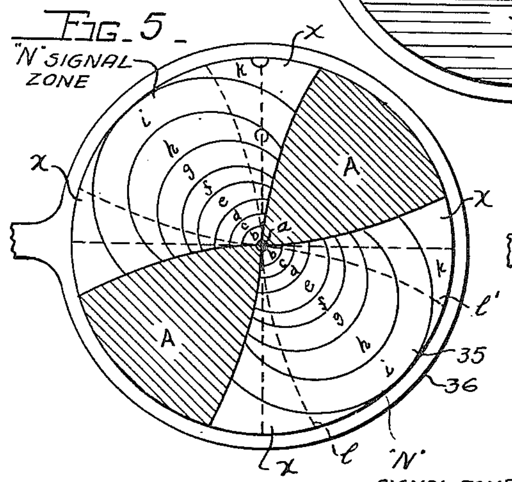
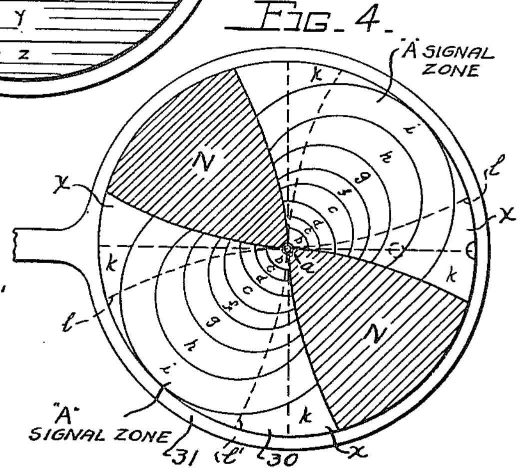


FIG. 4.

"A" SIGNAL ZONE



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AUTOMATIC AURAL-VISUAL SIGNAL TRANSMITTER FOR AVIATION GROUND TRAINERS

Filed March 30, 1940

8 Sheets-Sheet 3

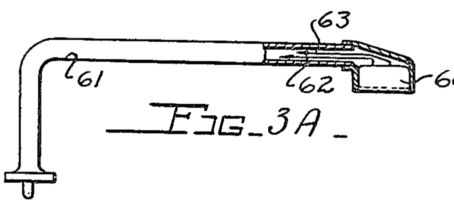

FIG_3A_

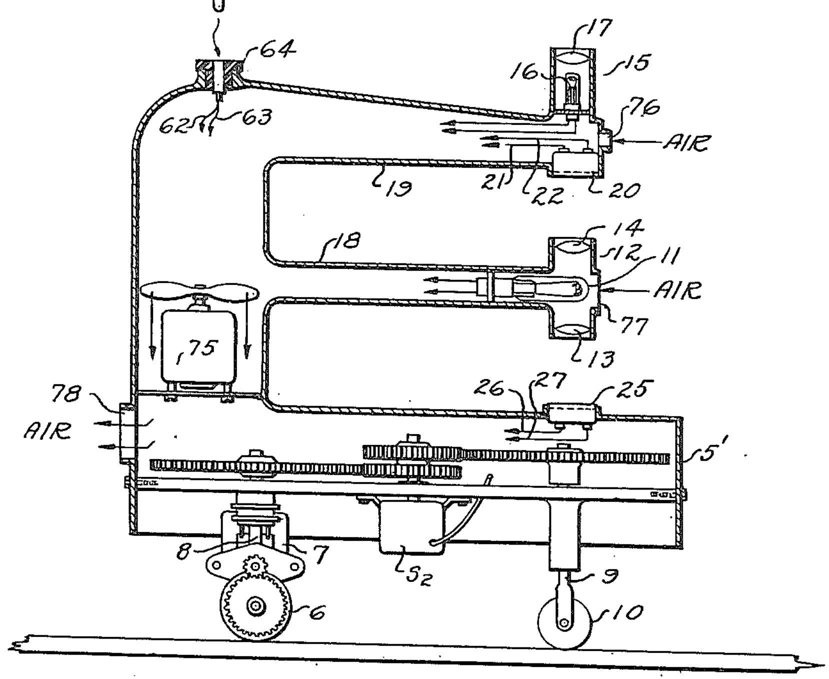

FIG_3_

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FIG. 2.

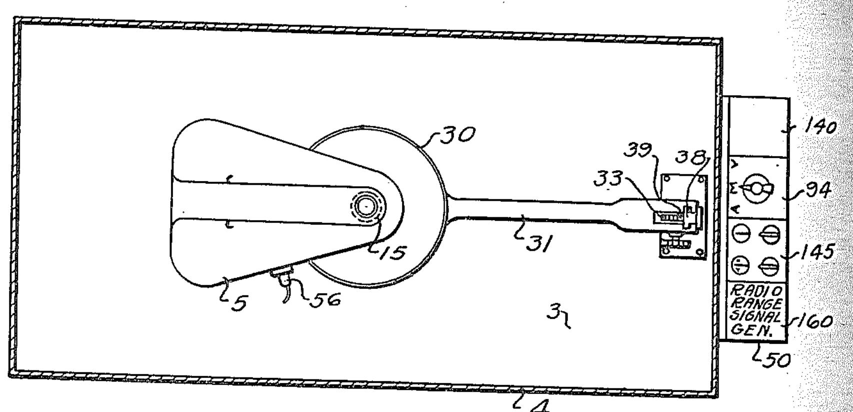


FIG. 8.

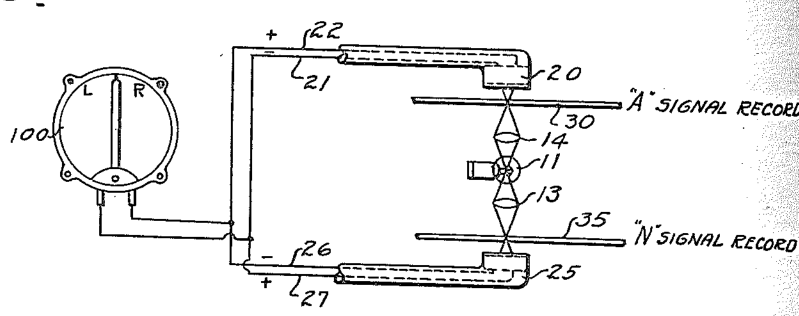
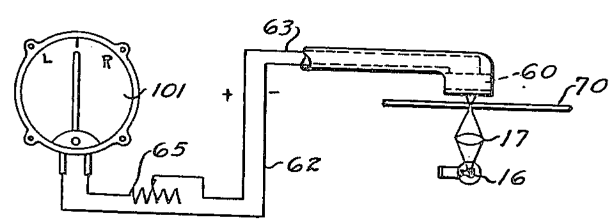


FIG. 9.



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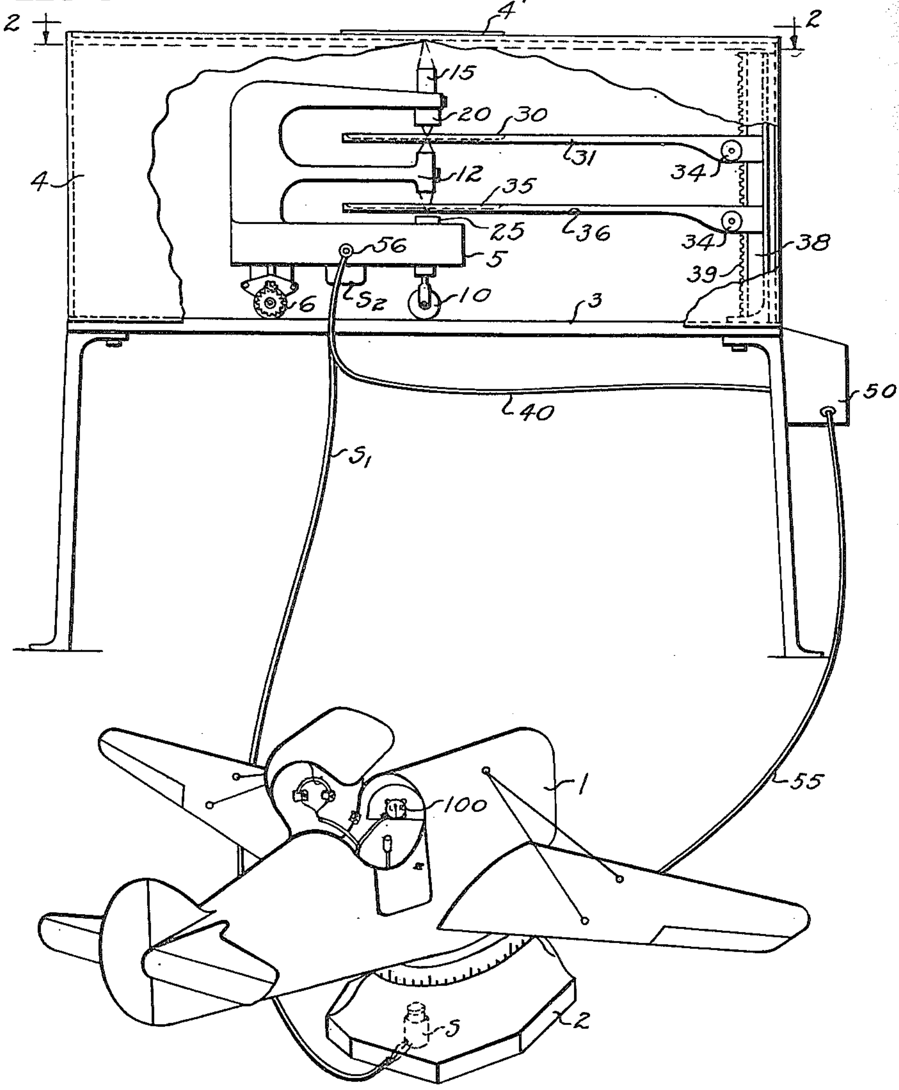
Nov. 23, 1948. C. J. CRANE 2,454,503

AUTOMATIC AURAL-VISUAL SIGNAL TRANSMITTER
FOR AVIATION GROUND TRAINERS

Filed March 30, 1940 8 Sheets-Sheet 1

FIG. 1.



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Patented Nov. 23, 1948 **2,454,503**

UNITED STATES PATENT OFFICE

2,454,503

AUTOMATIC AURAL-VISUAL SIGNAL TRANSMITTER FOR AVIATION GROUND TRAINERS

Carl J. Crane, Dayton, Ohio

Application March 30, 1940, Serial No. 327,003

20 Claims. (Cl. 35—10)

(Granted under the act of March 3, 1883, as amended April 30, 1928; 370 O. G. 757)

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The invention described herein may be manufactured and used by or for the Government for governmental purposes, without the payment to me of any royalty thereon.

This invention relates to a novel photoelectric means for transmitting positional information to the occupant of an aviation ground trainer, in accordance with the position of a course indicator on a reference surface, the course indicator being controlled by the trainer in such a manner that its movement represents, to a reduced scale, the simulated flight course of the trainer.

Aviation ground trainers for instructing students in the art of instrument flying are well known and generally comprise a dummy aircraft tiltably and rotatably mounted on a base and actuated by power means under the control of the occupant, to simulate all of the normal flight maneuvers of an airplane in flight. Trainers of the type described are also provided with instruments which simulate the indications of corresponding flight instruments used on aircraft for determining the various attitudes of an airplane during flight. For a more complete description of one form of trainer of the type above described, reference may be had to United States Patents Nos. 1,825,462 and 2,099,857 granted to Edwin A. Link, Jr.

In conjunction with aviation ground trainers, it is customary to employ an automatic course indicator, or recorder, which indicates or traces the simulated flight course of the trainer and is directionally controlled thereby. Such automatic course indicators comprise a frame supported on steerable rollers and the steering means interconnecting the rollers with an electric motion transmission receiver, which is controlled by a transmitter unit, in turn actuated by change in the azimuth heading of the trainer. At least two of the supporting rollers, generally three in number, are provided with driving means in the form of small electric motors, which may drive the course indicator over the surface of a record table at a velocity proportional to a simulated velocity in flight of the associated ground trainer. The third roller may be inked by a felt pad and serves as a marker wheel to record the simulated flight course of the trainer on a suitable record sheet or map. The position of the marker wheel relative to the record map serves as an indicator of the position of the recorder apart from its function as a marker wheel. For a more detailed description of one form of automatic course indicator of the type described, reference

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may be had to United States Patent No. 2,179,663, granted to Edwin A. Link, Jr.

Instruction in the use of radio navigational aids employed particularly to blind flying, by simulated flights with aviation ground trainer apparatus, is accomplished by providing a signal system which may be actuated to give signals simulating the signal received by an aircraft flying on a radio range. The course indicator moves over a chart laid out to represent one or more radio ranges, and the instructor watches the movement of the course indicator relative to the assumed radio range on the record chart and actuates the signal system manually to transmit the proper signal to the student in the trainer cockpit. As the course indicator approaches the simulated radio range station on the record chart, the instructor must also actuate the volume control to vary the signal volume, and when the course indicator reaches the cone of silence zone, the signals must be cut off and again renewed with the proper character and volume as the course indicator moves out of the cone of silence zone. The manual actuation of the signal generator is subject to personal errors on the part of the instructor and renders difficult the comparison of results under the direction of different instructors. For a more detailed description of one form of manually actuated signal control system of the type above described, reference may be had to my United States Patent No. 2,110,869, pertaining to electrical signalling apparatus.

In order to avoid the errors incidental to manual actuation of a radio range signal generator, the present invention incorporates a novel photoelectric means, which cooperates with a light source and an aviation ground trainer course indicator to transmit automatically an aural or visual signal to the student in the trainer, indicative of the position of the course indicator on the reference table, relative to a predetermined point on said table, representing, for example, a radio range or a landing runway localizer beam transmitting station.

A further feature of the invention is the employment of the photoelectric means above noted, to actuate a visual indicator located adjacent the manual-control means for the conventional aural radio range signal generator, to indicate the type and approximate signal volume which should be transmitted to the student in the trainer, by the instructor, thus relieving the instructor from the necessity of watching the marker wheel position while manipulating the manual signal control.

The system is arranged so that it may be switched from full automatic to semiautomatic operation, at the option of the instructor.

The invention further provides a means for utilizing a photoelectric device to indicate the heading of the aviation ground trainer and course indicator relative to an assumed landing runway, represented on the reference chart, in combination with a means response to the simulated rate of descent of the ground trainer and a photoelectric means controlled by the course indicator in accordance with its distance from a predetermined point on the axis of the simulated landing runway, to simultaneously indicate the heading of the trainer relative to the runway and its simulated descent relative to a predetermined glide path, to thereby enable a simulated instrument blind landing to be made in the ground trainer. In conjunction with the blind landing apparatus, a further photoelectric device is used to actuate marker beacon signal simulating means mounted in the trainer cockpit to indicate predetermined points on the simulated landing runway.

The principal object of the invention is the provision, in combination with an aviation ground trainer and a course indicator directionally controlled thereby, of a photoelectric means and a light source mounted on the course indicator and movable therewith, cooperating with a translucent record placed between the light source and the photocell device, to cause said photocell device to control the transmission of positional signals to said trainer.

A further object of the invention is the provision of a photoelectric means responsive to the movement of a course indicator for an aviation ground trainer, for indicating the position of said course indicator relative to a predetermined point on a supporting surface, the photoelectric means including a photocell device, a light source, and a translucent record placed between the light source and the photocell device, so that relative movement between the light source and the translucent record causes said photocell device to control the transmission of a visual or aural signal to a single-receiving means connected thereto.

A further object of the invention is the provision, in an aviation ground training system, of an aviation ground trainer, a course indicator directionally controlled by said trainer, a reference surface supporting said course indicator, a photoelectric device responsive to the variation in the position of said course indicator from a predetermined position and connected to control the character of an aural or visual signal receiver, and a second indicator device, including a photoelectric device responsive to the change in distance of said course indicator from a predetermined point on said reference surface and to the simulated rate of descent of said trainer, to indicate simulated descent of said trainer relative to a predetermined simulated glide path.

A further object of the invention is the provision of a novel photoelectric means for actuating marker beacon simulating signal means mounted in the cockpit of an aviation ground trainer, in accordance with the position of a course indicator directionally controlled by said trainer, at predetermined points on a desired predetermined course of said course indicator.

A further object of the invention is the provision, in combination with a course indicator having a photoelectric cell and a light source mounted thereon and movable therewith, of a

translucent record placed between said light source and said photocell, the said record having portions thereof of varying degrees of translucency in a predetermined pattern, such that the departure of said course indicator from a predetermined course will cause said photocell to control an aural or visual indicator to indicate the deviation of said course indicator from said predetermined course.

Other objects of the invention will be apparent by reference to the specification and the appended drawings, in which:

Fig. 1 illustrates, partly in section, a general assembly of the elements of the invention as used in conjunction with an aviation ground trainer;

Fig. 2 illustrates a top plan view of the record table taken along section line **2—2** of Fig. 1;

Fig. 3 is a side elevation, partly in section, of the course indicator, or recorder, employed in the invention according to Fig. 1;

Fig. 3*a* illustrates, partly in section, an attachment for use with the course indicator illustrated in Fig. 3, whereby three photocells may be simultaneously employed;

Fig. 4 illustrates one form of translucent record, called an A signal record, for use in conjunction with the devices of Fig. 1;

Fig. 5 illustrates a second form of translucent record similar to that illustrated in Fig. 4 and called an N signal record;

Fig. 6 illustrates a form of translucent record employed for indicating alignment with a simulated landing runway;

Fig. 7 illustrates the type of translucent record employed in operating marker beacon signals;

Fig. 8 illustrates a form of circuit used with a pair of photoelectric cells for direct actuation of an indicator;

Fig. 9 illustrates a modified form of circuit, employing a single photoelectric cell and record;

Fig. 10 illustrates schematically the apparatus employed in automatically transmitting aural radio range signals to the ground trainer in the device of Fig. 1;

Fig. 11 illustrates the arrangement of Fig. 10;

Fig. 12 illustrates schematically a means for semiautomatically transmitting the aural radio range signals to the trainer and for automatically transmitting visual signals to the trainer with a switching mechanism for selecting the means of transmission of signals;

Fig. 13 illustrates schematically the form of circuit employed with the device of Fig. 1 for blind landing instruction;

Fig. 13*a* is a curve illustrating the requirements for light transmission in the glide path indicator of Fig. 13;

Fig. 14 is a front elevation of the indicator of Fig. 12, taken on the line **13—13** of Fig. 12; and

Fig. 15 is an illustration of a distance type translucent record employed in the system illustrated in Fig. 12.

Referring to Fig. 1, the numeral **1** represents an aviation ground trainer tiltable and rotatable about the base **2**. The trainer has associated therewith an automatic course indicator **5**, movable over the surface of the record table **3**, which is enclosed by a hood **4**, which prevents external light from entering. The interior of the hood **4** is coated with a light-absorbing paint. The course indicator **5** is provided with a pair of power-driven rollers **6** and a marker wheel **10**, which are steerable and interconnected to an electric motion transmission receiver S_2, which may be of the well-known "Selsyn" type. The receiver

S_2 is electrically connected by a cable S_1 to a corresponding transmitter S, the rotor of which is rotated by the trainer as it changes its azimuth heading. The course indicator **5** is thus directionally controlled by the trainer **1**.

The course indicator **5** is provided with a pair of light sources, generally indicated by the reference numerals **12** and **15**, respectively, and a pair of photoelectric devices **20** and **25**, respectively, which are adapted to cooperate with the light source **12**. A stationary translucent record **30** is placed between the light source **12** and the photoelectric cell **20**, and a similar record **35** is placed between the light source **12** and the photoelectric cell **25**. The translucent records **30** and **35** are arranged to have varying degrees of translucency in predetermined patterns in a manner hereinafter more fully described. The movement of the course indicator **5** over the surface of the record table **3** causes light from the source **12** to pass through the translucent records **30** and **35** to impinge on the photoelectric cells **20** and **25**, respectively, to thereby generate electric currents which are carried by conductors in a cable **40** to a control cabinet **50** mounted on the trainer table, from which aural or visual signals are transmitted by electrical conductors in a cable **55** to the cockpit of trainer **1**.

The translucent records **30** and **35** are each respectively mounted in frames **31** and **36**, which are enlarged at the ends to fit in a grooved vertical support **38**, having a rack **39** secured thereto. (See Fig. 2.) The frames **31** and **36** are each provided with a gear **33**, which meshes with the rack **39**, and the gears **33** are rotated by adjustment knobs **34** so that the translucent records **30** and **35** may be raised or lowered in a vertical plane to adjust the cone of silence zone, as hereinafter more fully described.

All of the electrical connections to the course indicator, light sources, and photoelectric cells are made through a multiple contact plug **56**.

Referring to Fig. 3, in which a detail view of the course indicator employed is disclosed: The course indicator rollers **6** are adapted to be driven by small electric motors **7** supplied from a power source (not shown). The rollers **6** are pivotally mounted on vertical shafts **8**, rotatably mounted on the indicator frame, and the marker wheel **10** is similarly mounted on a vertical shaft **9**. The shafts **8** and **9** are each connected by gearing to the "Selsyn" receiver S_2 in the manner shown, so that rotation of the rotor of the "Selsyn" receiver S_2 causes an equal change in the azimuth heading of the rollers **6** and **10**. The roller **10** may be inked by means (not shown) to leave a trace on a suitable record sheet or chart placed on table **3**. The course indicator thus far described is of well-known construction. The course indicator **5** is provided with a hollow metal housing **5'** having two parallel hollow horizontal arms **18** and **19**, respectively. The arm **18** serves as a support for the light source **12**, which comprises an exciter lamp **11** and lenses **13** and **14**, respectively, located below and above the exciter lamp and arranged to focus light from the lamp **11** at points on the vertical axis of the marker wheel shaft **9**. A photoelectric cell **20** of the type requiring no external battery, known as a "photronic" cell, is mounted in the hollow arm **19** above and in spaced relation from the lens **14** and arranged concentric with the axis of the marker wheel shaft **9**. The "photronic" cell **20** is provided with output leads **21** and **22**, which conduct current generated by the cell to external

devices through the plug **56** of Fig. 1. A similar "photronic" cell **25** is arranged in the casing **5'** in spaced relation below the lens **13** and concentric with the axis of marker wheel shaft **9**. The "photronic" cell **25** is provided with output leads **26** and **27**, which conduct current generated by the cell **25** to external devices by means of plug **56** of Fig. 1.

The hollow arm **19** also serves as a support for a second light source assembly **15**, which comprises an exciter lamp **16** and a lens **17**, arranged so as to direct a beam of light vertically upward along the axis of the marker wheel shaft **9**. The light projected from the lamp **16** may be employed to form a spot on a ground glass screen **4'** (Fig. 1) in order to indicate the instant position of the course indicator to an observer or to trace the course of the indicator on sensitized blueprint paper, or it may be used, by adjustment of the lens **17**, to cooperate with a photoelectric cell attachment illustrated in Fig. 3*a*.

A small motor-driven fan **75** is mounted in the casing **5'** of the course indicator **5** and may draw air through screened openings **76** and **77** for cooling the various lamps and preventing an undue rise in temperature. The heated air is exhausted through the opening **78** in the casing **5'**.

As seen in Fig. 3*a*, a photoelectric cell **60**, of the photronic type, is mounted on a lightweight tubular member **61**, and the cell **60** is provided with output leads **62** and **63**, which terminate in plug-type terminals which can be inserted in the receptor socket **64**, also serving as a means for attaching the tubular member **61** to the course indicator **5**. By means of the attachment **61**, three photoelectric cells may be employed simultaneously with as many associated translucent records.

Figs. 4 and 5 illustrate the form of translucent records employed in the device of Fig. 1, for simulating radio range signals; and, as seen in Fig. 4, the record **30** comprises a circular disc made of glass or other similar light-transmitting material and having two diametrically opposed sectors N, which are substantially opaque, and an opaque circular zone *a* at the center of the disc, representing the radio range cone of silence. The remaining two diameterically opposed sectors are divided into eccentric zones from *b* to *k*, having graduated degrees of translucency from a density of transparency at zone *b* to a considerable degree of opacity at zone *k*. The disc **35**, illustrated in Fig. 5, is identical except that the opaque zones indicated as A are displaced ninety degrees from the position of the N zones of Fig. 4. In both Figs. 4 and 5 the dotted lines **1**, **1'** indicate the position of the opaque zones of the other record when the records are superimposed.

When the records **30** and **35** are superimposed in the manner illustrated in Fig. 1, light from the exciter lamp **11** will be directed by lens **14** onto record **30**, and light passing therethrough will impinge on the surface of the "photronic" cell **20**, generating a current proportional to the intensity of the light striking the cell. Light from exciter lamp **11** will also pass downward through lens **13** and record **35** to impinge on "photronic" cell **25**, generating a current therein proportional to the transmitted light intensity. If, for example, the course indicator is positioned such that the light strikes zones *a* on each record, no light will pass through to cells **20** and **25**, and no currents will be generated. This position represents the position directly over the transmitter station of a radio range and corresponds to the well-known cone of silence. If the course indicator is positioned between the dotted lines **1**, **1'** (Fig. 4), light will pass through the record **30** in one of the zones *b*, *c*, *d*, etc., depending on the radial distance of the axis of the marker wheel shaft **9** from the center of the discs, and the intensity of light falling on the photocell **20** will thus be dependent on the zone through which it passes. The light received by the cell **20** will cause a current to be generated thereby, which can be utilized for signal-generating purposes. At the same time, light from exciter lamp **11** will be projected downward on the semiopaque area A of record **35**, and the intensity of light falling on photocell **25** will be very low and a very weak current will be generated thereby. If the current generated by photocell **20** is employed in controlling the generation of the familar A signal of a radio range, and the current generated by cell **25** is similarly employed to control the generation of the familiar N radio range signal, for the condition above described, the A signal will be much stronger than the N signal, and hence will predominate.

If the course indicator is positioned so that the light source is within the N zone of record **30** (Fig. 4), the conditions above described will be reversed, and the light passing from the exciter lamp upward through zone N of record **30** will cause only a feeble current to be generated by cell **20**, while the light passing vertically downward from lamp **11** will pass through one of the translucent zones *b*, *c*, *d*, etc., of record **35**, causing cell **25** to generate a current dependent on the zone through which the light passes. By utilizing the currents from cells **20** and **25** to respectively control the intensity of the respective A and N radio range signals, the N signal will now predominate.

It will be noted from Figs. 4 and 5 that, when the records **30** and **35** are superimposed in the manner indicated, four narrow zones indicated by the letter X will be formed, in which light from the exciter lamp **11** can pass through each record with equal intensity and that the translucency will vary similarly for each record, in accordance with the radial distance from the disc centers. When the course indicator is positioned such that the light from exciter lamp **11** passes through any one of these zones, equal currents will be generated by the photocells **20** and **25**, and the A and N signals generated under the control thereof will be of equal intensity; and if the signal generator is arranged to transmit the A and N signals sequentially, a continuous On Course radio range signal will be heard in the usual headphones connected to the signal apparatus. It is thus seen that records of the type disclosed in Figs. 4 and 5 may be employed for the purpose of transmitting radio range signals to the trainer, dependent on the position of the course indicator relative to an assumed radio range station point on the record table, located at the point of intersection of the vertical axis passing through the disc centers with the table surface. Though the assembly of the disc, as seen in Figs. 4 and 5, is illustrated for a ninety-degree radio range, the records may be made to duplicate any desired radio range with any desired angles between the On Course signal legs.

Fig. 6 illustrates a form of record employed with a single photocell for indicating the deviation from a course aligned with a predetermined course, such as a simulated landing runway localizer beam. The record **70** is made of glass, or other similar material, and is mounted in a frame **71**,

similar to the frames **31** and **36** of the device of Fig. 1, and is adapted to be mounted in a similar manner on the guide **38** of Fig. 1. The record **70** is divided into parallel zones *p* to *z*, inclusive, which are made of a progressively increasing degree of translucency, or light-transmitting character, and the line *m*—*n* represents the line of constant density and also represents the axis of a predetermined landing runway localizer beam or other predetermined course. If the course indicator **5** travels along line *m*—*n*, there will be no change in light intensity, while if the course indicator moves to the right or left of the line *m*—*n* in the direction of point *n*, there will be a greater or less intensity of light transmitted through the record, which — when impinging on a photocell — may be utilized for actuating a visual type indicator in a manner hereinafter described.

Fig. 7 illustrates a form of record which may be employed to actuate a marker beacon indicator by means of a photoelectric cell. The circular record **80** is mounted in a frame **81** which may be mounted on the vertical guide **38** of Fig. 1. The record **80** is made opaque except for the narrow transparent strips **82** and **83**, which are spaced at predetermined distances from a landing field indicated by the letter P and shown only for purposes of illustration. The strips **82** and **83** are spaced along the line L—L which represents the axis of the airport landing runway and the conventional landing runway localizer beacon. The lengths of the strips **82** and **83** are made such that they represent approximately to a predetermined scale the width of the vertical marker beacon transmitter radiation at predetermined altitudes along the localizer beam. The record may be employed to flash a marker beacon signal lamp in the trainer cockpit by having a photocell actuate a relay to close the marker beacon lamp circuit. As the course indicator **5** moves along the landing runway axis L—L, light from the exciter lamp will not pass through the record **80** except when the beam strikes the transparent strips **83** and **82**, at which time the photocell used in conjunction with the exciter lamp will be energized and will close the lamp flashing relay. The marker beacon record is particularly well adapted for use with the record **70** of Fig. 6, which may be employed to indicate deviation from a predetermined landing runway localizer beam.

The circular transparent spot **84** on the record **80** of Fig. 7 is an illustration of the means for employing such a record for simulating the familiar "Z" marker beacons used in conjunction with radio ranges, and the marker beacon signal apparatus in the trainer cockpit is operated in the same manner as above described with reference to the landing runway localizer beam marker beacon device.

Fig. 8 illustration one form of circuit used in actuating a visual type indicator such as the indicator **100** of Fig. 1, when visual reception of the radio range signals in terms of directional indications are desired. The course indicator **5** is employed in conjunction with the radio range A and N signal records **30** and **35**, above described with reference to Figs. 4 and 5. The positive lead **22** of the "photronic" cell **20** is connected to the negative lead **26** of cell **25**, and the negative lead **21** of cell **20** is similarly connected to the positive lead **27** of the cell **25**, the cells thus being connected in opposition. The indicator **100**, a sensitive zero center type electrical meter, is connected in parallel across the interconnected photocell leads. The indicator dial is marked by the symbol L to indicate a deflection of the pointer to the left, and R to indicate deflection of the pointer towards the right. In operation, if equal intensities of light strike the photocells **20** and **25**, each will generate equal amounts of current, so that there will be no potential difference across the meter terminals, and the pointer will remain centered. This condition will prevail whenever the course indicator is in one of the On Course signal zones x on the records **30** and **35**, as previously described. If the course indicator is moving towards the center of the discs and deviates to the right of the On Course zone into an A signal zone, the indicator will deflect to the right; and if the course indicator deviates toward the left into an N signal zone, the pointer will deflect toward the left. If the course indicator is moving away from the vertical axis passing through the record disc centers, the pointer deflections will be reversed from that above described for right and left deviations from an On Course signal leg. It will be seen, however, that whenever the course indicator is in an A signal zone the pointer will be deflected to the right, and when in an N signal zone the pointer will deflect to the left, depending, of course, on the convention adopted. It is thus seen that the symbols L and R of the indicator **100** can be replaced by A and N symbols respectively. While the circuit illustrated in Fig. 8 and the other circuits disclosed employ "photronic" type photoelectric cells, it is to be understood that cells of other types, such as the "selenium," caesium, etc., cells, may be used in conjunction with the necessary local battery or vacuum tube amplifier. The photronic type of cell generates sufficient current to actuate a sensitive meter, or relay, without the necessity of employing a local battery and is entirely satisfactory for the purposes of the invention. The term "photocell" as used in the specification is thus intended to be a generic term covering all types of light responsive cells, irrespective of whether or not an additional power source must be used in conjunction therewith.

Fig. 9 schematically illustrates a form of circuit employed when using a single photoelectric cell, such as the cell **60** of Fig. 3a, in conjunction with a translucent record of the type illustrated in Fig. 6. The cell **60** (Fig. 3a) of the "photronic" type is connected in series with a sensitive electric meter **101**, such as a microammeter, and a small adjustable resistance **65** is also connected in the line. When the cell **60** receives no light through the record **70** (Fig. 3a) from the exciter lamp **16** (Fig. 3), the indicating pointer will be to the extreme left of the scale, since no current will be generated by the cell; and as light impinges on the cell with increasing intensity, the pointer of indicator **101** will deflect to the right. In operation with the translucent record **70**, the resistance **65** is adjusted so that the indicator pointer is centered when the course indicator light source **15** is located on the constant density line m—n of the record **70**, as illustrated in Fig. 6. If the course indicator passes along line m—n of the record **70**, a constant intensity of light will be transmitted to the cell **60**, and the pointer of indicator **101** will remain centered. If the course indicator deviates to the right, assuming the course indicator to be moving from point m towards point n, as seen in Fig. 6, the light from exciter lamp **16** will pass through a zone of a greater degree of transparency and cause a correspondingly greater current to be generated by the cell **60**, causing a deflection of the pointer past the center index to the right. If the course indicator should deviate to the left, the light will pass through a zone of greater density, and light of less intensity will fall on the photocell, thus generating less current and causing the pointer to deflect to the left or the center index toward the zero point of the meter. The meter dial is provided with the L, R, and center indicia, in the same manner as provided on the indicator **100**, as above noted. The correlating of the indicia with a given direction of movement can be adjusted by reversal of the indicator connections.

The circuit of Fig. 9 is particularly well adapted to use in conjunction with the record **70** of Fig. 6 in a blind landing indicating system for use with a ground trainer, hereinafter more fully described.

Figs. 10 and 11 illustrate the form of apparatus employed for automatically transmitting aural simulated radio range signals to the headphones worn by the student in the cockpit of the trainer. The apparatus is employed as a part of the device of Fig. 1 and, as seen in Fig. 10, the cells **20** and **25** are each respectively connected to the relays **90** and **92** through a manually controlled switching device **94**. The relays **90** and **92** are each sensitive electrical meters having pointers **91** and **93**, respectively, which deflect from a zero position an amount proportional to the current developed by the respective cells **20** and **25** when cooperating with the radio range records **30** and **35**, respectively, of the device of Fig. 1. As best seen in Fig. 11, the pointers **91** and **93** are each provided at their outer ends with arcuate translucent vanes, or shields, **95** and **96**, respectively, each of which is made so as to continuously vary in translucence, or light-transmitting character, from a maximum value, such as transparent, at one end of the shield, to a minimum value, such as semiopaque, at the other end of the shield. The shields are so arranged that as the relay pointers deflect from the zero position, due to increase of current being generated by the associated photocell, the shields will permit an increased amount of light to pass therethrough.

Referring again to Fig. 10, the shield **95** of the relay **90** is interposed between a light projector **102** and a photocell **105** so as to intercept a beam of light transmitted from the projector to the cell. The projector **102** comprises an exciter lamp **103**, supplied with direct current from a source (not shown) and a lens system **104** for focusing the light projected from the exciter lamp onto the light-sensitive element of the photoelectric cell **105**, which preferably is of the caesium or similar type, employing a battery in conjunction therewith. Thus the intensity of light which falls on the light-sensitive element of the photoelectric cell **105** is dependent on the position of the translucent vane **95** of the relay **90**, and the electromotive force developed in the circuit connected to the cell will be varied in direct proportion to the deflection of the pointer **91** and the translucent vane **95** of the relay **90**. A light chopper wheel **106** having slotted apertures **106'** (see Fig. 11) is inserted in the path of the light beam from projector **102** to the translucent vane **95** of relay **90**. The chopper wheel is mounted on one end of the armature shaft **115** of an electric motor **116**, and the apertures **106'** interrupt the light beam at a frequency sufficient to correspond to a desirable audible tone. An opaque shield **107** is interposed between the projector **102** and the chopper wheel **106** so as to completely block the light beam when the shield is in one position. The shield **107** is mounted on a pivot shaft **108**, which has connected thereto an arm **109**, which in turn contacts any one of a plurality of cams 110, slidably keyed to a shaft 111, driven through a reduction gear 112 from a shaft 113, driven by a gear transmission 114 from the other end of the armature shaft 115 of the motor 116. One of the cams of the cam assembly 110 is cut so as to raise the arm 109 to move the shield 107 out of the path of the beam of light from the projector 102 for a short interval of time, corresponding to the Morse dot signal, and a short time interval later to again raise the arm 109 for a time corresponding to a dash signal, the cam thus causing the light beam to be keyed one or more times per cam revolution to form the familiar dot-dash or A signal. The other cams of the assembly may be cut so as to transmit other desired signals, such as station-identifying signals.

The translucent vane 96 of the relay 92 is interposed between a light projector 124 and a photoelectric cell 125, similar in all respects to projector 102 and cell 105, previously described. The light beam from projector 124 is interrupted by the apertures 106′, in the same manner as the beam from projector 102 is interrupted. A light-interrupting shield 123, pivotally mounted by a shaft 122, is provided with a cam follower arm 121, which engages any one of a plurality of cams 120, slidably keyed to a shaft 119, driven through a gear reduction 118 and shaft 117 from the gear transmission 114, driven by the armature shaft 115 from the motor 116. One of the cams of the assembly 120 is cut so that it actuates the follower 121 and shield 123 to interrupt the beam of light from projector 124, one or more times for each revolution of the cam, to form the familiar dash-dot or N signal. The A signal cam 110 and the N signal cam 120 are so phased that the signals follow each other successively, the dots following each other with a slight overlap, so that when the signals are of equal intensity the illusion of a continuous note will be formed. The remaining cams of the assembly 120 are cut so as to cooperate with the cam assembly 110 to form the desired signals, such as of station-identifying character. The cam assemblies 110 and 120 are each axially shifted together by means of the forked ends of a yoke 126, which is secured to a shifting rod 127, provided with a rack 128 which meshes with a gear 129 rotated either manually or through a suitable timing device (not shown) so that station-identifying signals may be sent at predetermined time intervals.

The photoelectric cells 105 and 125 are each connected in parallel to a battery 128 which creates a potential difference across the terminals of the cells 105 and 125, determined by the high grid resistances 129. The output leads of the photocells 105 and 125 are respectively connected to the grids G_1 and G_2 of the amplifier vacuum tubes 130 and 131, illustrated as the screen grid type. The plate circuit output of the tube 130 is applied to the coil 132, forming one-half of the primary winding of a coupling transformer 135. The plate circuit output of the tube 131 is applied to the coil 133 of the primary winding of the transformer 135. The secondary winding 134 of the transformer 135 is connected by leads 136 to headphones 137, which are worn by the student in the cockpit of the trainer 1.

Operation

Assuming the course indicator 5 of Fig. 1 to be in operation and causing relative movement between the beams of light projected from the light source 12, and the respective A signal record 30 and the N signal record 35, the "photronic" cells 20 and 25 will generate currents in the manner above described with reference to Figs. 4 and 5. The translucent shields 95 and 96 of the respective relays 90 and 92 will allow light from the projectors 102 and 124 to impinge on the photoelectric cells 105 and 125, respectively, of an intensity directly proportional to the current developed by the respective "photronic" cells 20 and 25. The chopper wheel 106 causes the light beams from projectors 102 and 124 to be interrupted at and audio frequency, and the shields or shutters 107 and 123 alternately key the light beams to form the radio range A and N signals, respectively. The grid of the tube 130 will then receive a pulsating direct current having pulsations of an audible frequency and keyed to form an A signal, which will be amplified in the plate circuit of the tube and transmitted by means of transformer coils 132 and 134 to the headphones 137 in the trainer cockpit. The current which will flow in the grid circuit of the tube 130 will be directly proportional to the intensity of light received by the photoelectric cell 105, so that the intensity of the aural A signal heard in the headphones 137 will similarly vary with the change in light intensity. The N signal will similarly be changed from light pulsations into a variable potential grid current in the tube 131, which will be amplified in the plate circuit of the tube and transmitted by transformer coils 133 and 134 and conductors 136 to the headphones 137 as an aural signal.

When the course indicator 5 is in one of the On Course signal zones of the records 30 and 25, the A and N signals will be transmitted with equal intensity to the headphones 137, giving the continuous On Course signal; while if the course indicator moves into the A signal zone, the A signal will be transmitted to the headphones 137 with greater intensity than the N signal, the latter being suppressed into the background; and a similar operation takes place when the course indicator moves into an N signal zone, the N signal being amplified while the A signal is suppressed into the background. As the course indicator moves from the radial outer portions towards the centers of the discs 30 and 35 (Fig. 1) the A, N, or On Course signals will be transmitted with increasing intensity, dependent on the position of the course indicator. When the course indicator reaches the opaque *a* zone, or cone of silence at the center of the discs, no signal will be heard in the headphones. By adjusting the vertical position of the discs 30 and 35 (Fig. 1) a small quantity of light may be allowed to spill over, thus the effect of the variation of the width of the cone of silence at varying altitudes may be simulated.

The device illustrated in Figs. 10 and 11 forms a means for automatically transmitting radio range, as well as other aural signals, to the headphones in the trainer. It is to be noted that the chopper wheel 106 is not a necessary element where the exciter lamps of the projector units 102 and 124 are energized by alternating current, which will cause a pulsating current in the photocell circuits due to the rectifier action of the photocells; and the usual 60-cycle alternating current will give a distinct audible tone. The entire assembly may be enclosed in a cabinet indicated by the numeral 140 in Fig. 2.

Fig. 12 illustrates the system employed in selectively switching from the full automatic transmission of aural radio range signals to semiautomatic transmission of aural radio range signals or to visual type radio range indication, at the will of the instructor. The switch generally indicated as **94** in Fig. 10, as seen in Fig. 12, comprises, as schematically shown, three pairs of double-pole single-throw switches **94***a*, **94***c*, and **94***d* and a single-pole switch **94***b*. Upon closing of switches **94***a*, the photocells **20** and **25** are respectively connected to the relays **90** and **92** for automatic transmission of radio range signals, the switch **94***b* being simultaneously closed to energize the filament circuits of the power amplifier tubes **130** and **131**, the system being identical to that illustrated in Fig. 10.

Upon closing the switches **94***c*, the "photronic" cells **20** and **25** are connected by leads **141** to a meter and control assembly generally indicated by the reference numeral **145**, which includes a sensitive zero center meter **142**, connected in series with a sensitive thermal type microammeter **146**, and forming a circuit exactly similar to that illustrated in Fig. 8 and described above. The zero center meter **142** is provided with A, N and On Course indicia in place of the Left and Right indications as described with reference to the circuit of Fig. 8. The meter **142** is provided with an indicating pointer **143**, colored black and actuated by the meter, and a transparent pointer **144** loosely mounted on a pivot and actuated by a cable or other manual-control means **149**, controlled by movement of the signal-control knob **150** and always remaining parallel thereto. The microammeter **146** is similarly provided with an indicating pointer **147**, colored black, and a loosely mounted transparent pointer **148**, controlled by the cable, or other manual control **153** actuated by the volume-control knob **154**, so that the transparent pointer **148** always remains parallel to the indicating axis of the knob **154**.

The knob **150** controls a signal-control potentiometer **151**, connected by leads **152** to a radio range signal generator **160** of well-known construction. The knob **154** actuates a signal-volume control rheostat or potentiometer **155**, which is connected by leads **156** to the radio range signal generator **160**. The radio range signal generator **160**, signal-control potentiometer **151**, and volume-control potentiometer **155** form the conventional manually controlled radio range signal generator now employed in conjunction with aviation ground trainers. The signal output of the radio range signal generator is led to the headphones **137** by leads **138**, which are connected in parallel with the leads **136** of the automatic signal generator of Fig. 10.

Operation

The "photronic" cells **20** and **25** cooperate with the records **30** and **35**, respectively, to cause actuation of the pointer **143** of the indicating meter **142** to give a visual radio range signal indication, and the ammeter **146** indicates the current flow, which is indicative of the radial position of the course indicator from the center of the signal records, representing on the record chart the position of the assumed radio range station. The combined indications of the meters **142** and **146** are thus the equivalent of the visual observation of the position of the course indicator by the instructor according to the conventional system for actuating the radio range signal generator. The meters **142** and **146** are actually mounted on a single panel above the control knobs **150** and **154**, and the instructor then actuates the signal-control knob **150** and the volume control knob **154**, so that the transparent pointers **144** and **148** actuated thereby coincide with the black pointers **143** and **147**, respectively. The signal-control potentiometer **151** and the volume-control potentiometer **155** condition the radio range signal generator **160** to transmit the proper radio range signal with the proper intensity to the headphones **137** in the cockpit of the trainer **1**.

By actuating the switches **94***d*, the indicator **100** mounted in the cockpit of the trainer **1** is connected by the leads **162** to the "photronic" cells **20** and **25**, respectively, in a visual radio range indicating circuit identical to that described above with reference to Fig. 8. The L and R indicia, shown in Fig. 12 on the indicator **100**, can be replaced by the A and N signal indicia if desired, as noted with reference to the description of Fig. 8.

The switches **94***a*, **94***b*, **94***c*, and **94***d*—though illustrated as of the blade type—are preferably constructed in the form of a rotary switch so that only one of the circuits can be closed at a time, thus avoiding a plurality of the individual switches being closed at the same time.

Figs. 13 to 15 inclusive illustrate schematically the apparatus employed with the device of Fig. 1 in order to simulate blind landings in accordance with any of the systems employing a radio glide path beam in conjunction with a directional landing runway radio beacon or a leader cable, such as the system of the Bureau of Standards, Lorenz, Bendix, or others.

The system employs three translucent records and three cooperative "photronic" or other type photoelectric cells mounted on the course indicator, such as provided in the course indicator **5**, illustrated in Figs. 3 and 3*a*. An indicator generally indicated by the reference numeral **170** is mounted on the instrument board of the trainer **1** and includes a sensitive meter **171**, having a vertical pointer **172**, and a similar sensitive type of meter **173**, having a horizontal pointer **174**, each provided with center indicia marks.

Directional indication

The meter **171** is connected to the leads **21** and **22** of the "photronic" cell **20** to form a circuit exactly of the type illustrated in Fig. 9. A translucent record **70**, such as illustrated and described with reference to Fig. 6, is employed in conjunction with the light source **12** and the cell **20**. The line *m*—*n* (Fig. 6), which may be placed on any part of the record in a predetermined manner, represents the axis of the landing runway localizer radio beam or leader cable, and any deviation of the course indicator from a path along this line will immediately cause the pointer **172** to deflect to the right or left of the center indicia to indicate the direction of such deviation. Thus by proper control of the trainer **1** by the student, the course indicator controlled by the trainer may be kept aligned with the simulated landing runway radio beam or leader cable by keeping the pointer **172** vertical.

Marker beacon indicating device

As the course indicator progresses in its movement toward the simulated landing field position on the record table, it is essential to indicate the arrival at points located at predetermined distances from the simulated landing field. The marker beacon indicating means employs a marker beacon translucent record of the type illustrated in Fig. 7 by the numeral **80**, employing the transparent slots **82** and **83**. The record **80** cooperates with the "photronic" cell **60** (Fig. 3*a*) and the light source **15** carried by the course indicator, so that whenever the course indicator moves into the predetermined positions, the beam projected from the light source **15** can pass through one of the transparent slots **83** and **82**. The current generated by the light impinging on the "photronic" cell **60** will actuate the sensitive electric relay **175** to close a circuit including the battery **176** and the lamp **177**, which is mounted on the instrument board of the trainer and serves as a marker signal.

The glide path indication device

In order to indicate simulated descent in the trainer along a predetermined glide path representing, for example, the well-known curved radio glide path beam, the indicator meter **173** is connected to the "photronic" cell **25**, mounted on the course indicator **5**, and to a similar "photronic" cell **178**, mounted adjacent an altimeter **180**, which may be the instrument now located on the instrument board of the trainer **1**, or one located remote thereto but indicating in unison therewith. The meter **173** is electrically connected in series with the cells **25** and **178**, but the meter may be of the zero center type and connected in a circuit of the type illustrated in Fig. 8.

The cell **25** cooperates with a translucent record **190**, termed a distance record and illustrated in Fig. 15. The record is made opaque except for the sector indicated as the Airdrome Area **191**, which represents the extent of the simulated glide path beam. The zone **191** is gradually changed in translucency from zone *a*, representing the point of contact of the airplane following the glide path with the ground where the area **191** is most dense, outward to zone *h*, which represents the outer radial limit of the landing beam. As the course indicator moves the light beam from source **12**, within the area **191**, from zone *h* to zone *a*, the intensity of light received by the cell **25** will continuously decrease, and the current developed by the cell will accordingly decrease.

The altimeter **180** is of a standard type equipped with two pointers—one indicating altitude in hundreds of feet, and the other indicating altitude in thousands of feet. The altimeter is connected by a pipe **181** to a suction source (not shown), which is regulated by the climbing attitude of the trainer and by the setting of a simulated throttle (not shown). When the trainer is placed in a descending attitude the vacuum is gradually relieved, thus simulating the descent of an aircraft. The means for thus simulating ascent and descent of the flight trainer forms part of the standard equipment of the "Link" trainer and is well known in the art. A translucent disc **182** is mounted on the pointer shaft **183**, which is adapted to actuate the hundreds-of-feet indicating pointer. The thousands-of-feet indicating pointer **184** is mounted on the shaft **183**, the altitude scales not being shown in the drawing. The disc **182** may be used with a single pointer altimeter, however, by gearing the disc to the pointer shaft so that any predetermined range of altitude will cause one revolution of the disc. The disc **182** is divided into sectors *a'*, *b'*—h' (see Fig. 14), each of which varies gradually in translucency from zone *a'* to zone *h'* such that zone *a'* passes the least amount of light, while zone *h'* passes the greatest amount of light. A small light projector **186**, comprising an exciter lamp and lens combination, is mounted by a suitable bracket on the instrument panel of the trainer in front of the disc **182**, so that a light beam from the projector **186** will pass through the translucent zones and impinge on the light-sensitive element of the "photronic" cell **178**, which is mounted on the instrument panel behind the disc **182** and on the axis of the beam of light from projector **186**.

Operation

In reference to Fig. 13*a*, the assumed glide path is indicated by the letter *g*, and the meter **173** must indicate a constant light intensity along the simulated glide path. Since the meter **173** is connected in series with the photronic cells **25** and **178**, in order that the pointer **174** remain centered it is necessary that the sum of the voltage developed by the respective cells initially be sufficient to deflect the pointer to the middle of the scale. This condition corresponds to the fact that the sum of the light intensities must equal a constant value sufficient to develop sufficient current to deflect the pointer downward from a zero position in a counterclockwise direction to the mid portion of the scale. Then in position **1** (Fig. 13*a*) the abcissae *a'*, representing both the distance traversed in a given time from the origin and the light intensity received by cell **25**, plus the ordinate *b*, representing the rate of descent as well as the light received by the cell **178**, must be such that the sum of the ordinates $a'+b$ equals a constant *k*. At any other point on the glide path the same condition must hold for a constant horizontal position of pointer **174**—i. e., at point **2**, $f'+c=k$; and at point **3**, $b'+a=k$.

If the rate of descent is not sufficient for the corresponding simulated velocity of the trainer, represented to some predetermined scale by the velocity of the course indicator, the light received by the cell **25** will be decreasing in intensity at a greater rate than the intensity of light passing through disc **182** is increasing; and the pointer **174** will then move up towards the meter zero, due to decrease of the total electromotive force being generated by the cells **25** and **178**. If the rate of descent is greater than the optimum value required to stay on the glide path, the electromotive force will increase above the constant value required to keep the pointer **174** horizontal, and the pointer will move down due to the increase of current generated by the cells **25** and **178** above the optimum constant value. Upon the altimeter reading zero, a landing is assumed to have been made.

To utilize the circuit of Fig. 8 with the structure shown in Fig. 13, the translucent disc, or altitude record, **182** must be made such that the light-transmitting character of the disc gradually decreases as the disc rotates counterclockwise with decrease of simulated altitude, so that the currents developed by the cells oppose each other and remain equal, so the pointer **174** of meter **173** will remain centered, the meter now being of the zero-center type, such as the meter **100** of Fig. 8. With a descent being simulated and the rate of descent too small a value, the current generated by "photronic" cell **178** will overcome the effect of cell **25** and cause a current flow through the meter **173** in a direction to cause the pointer to move up, indicating that the trainer is above the glide path in its simulated descent. In a similar manner, if the rate of descent is too high, the cell **25** will deliver more current than cell **178**, causing a flow of current through the meter, so as to cause the pointer 174 to move down, indicating that the simulated position of the trainer is below the glide path.

The altitude and distant record shading may be made such that for either type of meter connection a record will be available to use for simulating a desired type of glide path, either curved or substantially straight.

By means of the simulated radio navigational aids above provided, the student may receive training in blind instrument landings by following conventional prescribed procedure for the system being used. The student is enabled to maintain the trainer directionally aligned with the simulated landing runway by watching the pointer 172 and maintaining it substantially centered on the vertical center index mark. The simulated flight may be continued and a simulated descent made to some predetermined altitude of one thousand feet or less, when the simulated glide path will be intercepted and the pointer 174 will drop to the horizontal index mark, and the student must thereafter control the trainer so that in the simulated descent the pointer 174 remains opposite the horizontal index mark. During the simulated descent the marker beacon lamp 177 will flash at predetermined distances from the simulated landing field, and when the altimeter reads zero the landing is assumed to have been accomplished. The method of flight procedure in getting alinged with the landing runway may be according to conventional established procedure as employed with the particular landing system being simulated.

While only illustrative forms of apparatus involving the application of photoelectric devices to radio range signalling and instrument landing indications for use in aviation ground trainers have been shown, it is apparent that many modifications will be apparent to those skilled in the art, falling within the scope of the invention as defined by the appended claims.

I claim:

1. In combination, an aviation ground trainer for simulating the flight of an aircraft, a reference surface, a course indicator movable below said reference surface at a velocity proportional to the simulated velocity in flight of an aircraft and directionally controlled by said trainer, a source of light, a photoelectric cell cooperating with said light source, a translucent record having areas of varying light-transmitting properties arranged in a predetermined pattern and located between said light source and said photoelectric cell, means for causing a relative movement between said light source, said cell and said translucent record responsive to the change in position of said course indicator, and signal-receiving means connected to said photoelectric cell and mounted in the cockpit of said trainer and operative to translate variations in current developed by said photoelectric cell into signals indicative of the position or directional heading of said course indicator.

2. The structure as claimed in claim 1, in which said light source and said photoelectric cell are mounted on said course indicator and movable therewith over the reference surface.

3. The structure as claimed in claim 1, in which said translucent record is stationary and mounted in parallel spaced relation to said reference surface.

4. A radio range signalling system for use with aviation ground training apparatus, comprising a reference surface, a course indicator movable relative to said reference surface and adapted to

trace the simulated flight course of an aircraft, a light source mounted on said course indicator, a pair of photoelectric cells mounted on said course indicator and each adapted to receive light from said source, a signal generator connected to each of said photoelectric cells and adapted to generate a plurality of signals of different character, each respectively controlled by one of said photocells, and a pair of translucent records, each having zones of varying degrees of translucency arranged in a predetermined pattern and each of said records being located between said light source and a respective one of said photoelectric cells, whereby movement of said course indicator relative to said records causes said signal generator to generate signals indicative of the position of said course indicator on said reference surface.

5. The structure as claimed in claim 4, including a means for utilizing the signals generated by said signal generators.

6. In combination, an aviation ground trainer for simulating the flight of an aircraft, a reference surface, a course indicator movable relative to said reference surface at a velocity proportional to the simulated flight velocity of an aircraft and directionally controlled by said trainer, a pair of photoelectric cells mounted on said course indicator and movable therewith and each cooperating with a respective light source mounted on said course indicator, a pair of translucent records, each mounted between a respective one of said photoelectric cells and its associated light source by a stationary support and each of said records having areas of varying degrees of light-transmitting character arranged in a predetermined pattern, each of said patterns having a definite relation to each other and to a point on said reference surface, and a plurality of signal circuits, each connected to a respective one of said photoelectric cells, whereby variable signal control currents are generated by each of said photoelectric cells as said course indicator varies its position relative to said point on said reference surface.

7. The structure as claimed in claim 6, in which each of said signal-control circuits is connected to a visual indicator mounted in the cockpit of said trainer.

8. The structure as claimed in claim 6, including a visual radio range indicator and a visual signal volume indicator connected to said signal control circuits and each of said indicators having a pointer, a radio range signal generator, a respective manual signal and volume control means for said radio range signal generator, a signal receiver connected to said radio range signal generator and mounted in said trainer, a manually set pointer actuated by said signal generator manual signal control means, and a second manually set pointer actuated by said signal generator volume control means, whereby, upon setting said manually controlled pointers into a position corresponding to signal and volume indicator pointers, a corresponding radio range signal of the required intensity will be transmitted to said signal receiver.

9. In combination, a course indicator for aviation ground trainers, a source of light, a photoelectric cell cooperating with said source of light, a translucent record interposed between said source of light and said photoelectric cell, said record having parallel zones of an increasing degree of translucency from one edge to the opposite edge of said record, means for causing the effect of light transmitted through said record

from said light source to said photoelectric cell to be varied in accordance with the change in position of said course indicator, and an indicator connected to said photoelectric cell and operative to indicate the deviation of said course indicator from a course coaxial with a line of constant density of light-transmitting character on said translucent record.

10. A glide path indicator for aviation ground trainers, comprising an aviation ground trainer, a means responsive to the simulated rate of descent of an aircraft, a first photoelectric means responsive to said rate-of-descent-responsive means, a means responsive to the simulated velocity of said aircraft, a second photoelectric means responsive to said simulated velocity-responsive means, and an indicator electrically connected to each of both photoelectric means and operative to indicate the variation in the ratio of the simulated rate of descent to the simulated velocity of said aircraft along a predetermined simulated glide path.

11. The structure as claimed in claim 10, in which the means responsive to the simulated rate of descent of said aircraft is an altimeter simulating device controlled by operating conditions of the trainer, and in which the photoelectric means responsive to said rate-of-descent-responsive means includes a translucent disc varying in light-transmitting character around the circumference and actuated by the altimeter simulating device, a photoelectric cell located on one side of said disc and a light source placed on the other side of said disc opposite said photoelectric cell, whereby the current flow in a circuit connected to said cell is dependent on the position of said disc relative to said light source.

12. The structure as claimed in claim 10, in which the means responsive to the simulated velocity of said aircraft comprises a course indicator moving at a velocity proportional to the simulated velocity of said aircraft and directionally controlled by said trainer, and in which the second photoelectric means includes a photoelectric cell and an associated light source mounted on the course indicator and movable therewith, and a light-transmitting record having a translucent area which varies in light-transmitting character mounted on a stationary support so as to intercept light transmitted from said light source to said photoelectric cell, whereby the current flow in a circuit including said photoelectric cell varies as a function of the velocity of said course indicator in a given direction of movement relative to the translucent area of said record.

13. The structure as claimed in claim 10, in which said first photoelectric means includes a translucent disc having areas of different degrees of light-transmitting character and rotated from an initial position by said rate-of-descent-responsive means, a light source on one side of said disc and a photoelectric cell located on the opposite side of said disc; and in which the second photoelectric means includes a source of light and a photoelectric cell movable together at a velocity proportional to the simulated velocity of said aircraft and a stationary record having a translucent zone which varies in light-transmitting character in a predetermined manner located between said light source and said photoelectric cell; and an indicator connected to both of said photoelectric cells and responsive to electrical difference effect produced by said cells.

14. In a blind landing training system, an aviation ground trainer for simulating the flight of an aircraft, a course indicator movable at a velocity proportional to the simulated flight velocity of said aircraft, a photoelectric device responsive to the departure of said course indicator from a course aligned with a simulated landing runway, a directional indicator mounted in said trainer and actuated by said photoelectric device, a photoelectric device actuated by said course indicator in accordance with the simulated velocity of said aircraft, a photoelectric device actuated in accordance with the simulated rate of descent of said aircraft, and a glide path indicator mounted in said trainer and operatively connected to both of said last two named photoelectric devices for actuation in response to the combined effect thereof, whereby a simulated descent of said aircraft along a predetermined glide path in the plane of a simulated landing runway may be effected.

15. The structure as claimed in claim 14, including a means actuated by said course indicator for indicating, at predetermined points on said simulated landing runway, the arrival of said aircraft in its simulated descent.

16. The structure as claimed in claim 1, in which said translucent record is arranged in a horizontal plane perpendicular to the path of light transmitted from said light source to said photoelectric cell, and means for adjusting the vertical position of said translucent record.

17. In a signal generator of the type described, a means for receiving positional signal currents, a light source for transmitting a beam of light with an intensity varying at an audio frequency, a photoelectric cell cooperating with said light source, a power amplifier connected to said photoelectric cell, a translucent shield actuated by said signal-current-receiving means and operative to vary the intensity of light transmitted to said photoelectric cell in accordance with the magnitude of the signal current received by said signal-current-receiving means, a shutter for interrupting the light transmitted from said source to said photoelectric cell, and cam means for actuating said shutter to key said transmitted light in a predetermined manner.

18. The combination with an aviation ground trainer for simulating the flight of an aircraft, of a remotely located position recording carriage movable responsive to operation of the ground trainer by a student, of a light source for transmitting light relative to the area over which said carriage is movable, photoelectric means attached to said carriage and means cooperating with said light source and photoelectric means for varying the light received by said photoelectric means in accordance with a predetermined intensity pattern corelated to the area over which said carriage is movable to thereby produce an electric current of a strength depending on the intensity of light received by said photoelectric means and signal means operated by said electric current.

19. An aviation ground training system comprising in combination an aviation ground trainer having student actuated controls for simulating the flight of an aircraft, a recording device movable in response to operation of the trainer controls by a student, a source of light, a photoelectric cell supported by and movable with said recording device and cooperating with said light source, an element interposed in the path of transmission of light from said source to said photoelectric cell and having uniformly varying light-absorbing properties arranged in a predetermined absorption pattern corresponding to desired positional

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