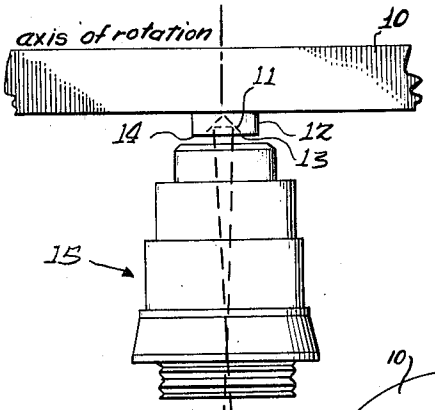
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June 28, 1960 E. M. JONES 2,943,210

CYCLIC PULSE GENERATING SYSTEM

Filed Dec. 14, 1954



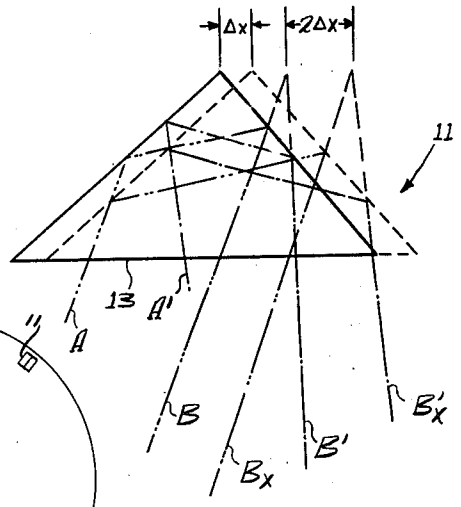


Fig. 2.

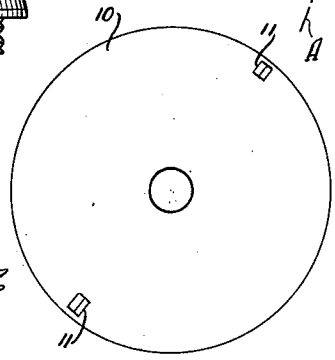


Fig. 4

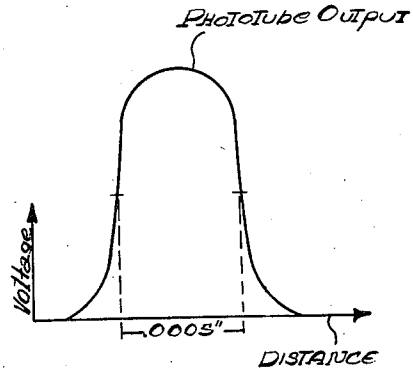


Fig. 3.

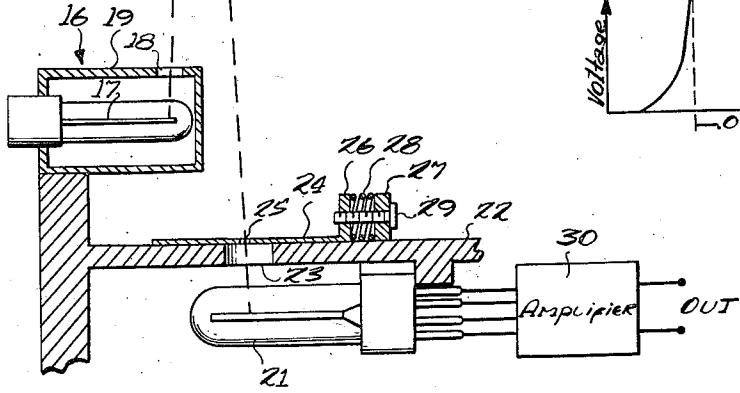


Fig. 1.

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CL 250/230

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CYCLIC PULSE GENERATING SYSTEM

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7 Claims. (Cl. 250—230)

This invention relates to a position determining system for movable surfaces, and more particularly to such a system in which the position of one or more selected points on such a surface will be accurately fixed one or more times during a given cycle of movement of the surface with respect to one or more external reference points. The present invention constitutes an improvement in the pulse generating portion of the system illustrated in Figure 19 of the copending application of the present inventor entitled "Electronic Synchronizing System for Producing Pitch Discs and the Like," Serial No. 436,831, filed June 15, 1954, now Patent No. 2,924,138. A rudimentary description of the system is also shown in Figure 8 of the copending application of the present inventor entitled "Digital Pattern Producing Equipment," Serial No. 456,204, filed September 15, 1954, wherein the invention covered herein is used to generate reset pulses for triggering a chain of flip-flops used to time a light source employed to expose paths on a photographic plate mounted on a turntable in a system for producing code discs for angular encoders of the photoelectric type. Further reference may be had to Figure 3 of page 291, volume 11, of the Proceedings of the N.E.C., 1955.

Accordingly, it is an object of this invention to provide a new and improved system for determining the position of one or more selected points on a cyclically movable surface with respect to one or more external reference points one or more times during a given cycle of movement of the surface.

It is another object of this invention to provide an improved system for indicating when one or more points on a movable surface move past an external reference point.

It is still another object of this invention to provide an improved system for indicating with a high degree of accuracy when a selected point on a movable surface passes one or more external reference points.

It is still another object of this invention for indicating when a given point of a movable surface passes a selected external reference point with a high degree of accuracy while maintaining the system simple and dependable in operation with a minimum amount of easily accomplished maintenance work.

A still further object of the invention is to generate accurately an electrical impulse during relatively short travel of a predetermined point on a movable surface.

Other objects and advantages of the invention will be apparent during the course of the following description when read in connection with the accompanying drawings, wherein:

Figure 1 is a partly sectioned view showing the overall system of this invention;

Figure 2 is a schematic view of the optical prism mounted to the movable surface and diagrammatically shows the path of two light rays entering the prism in a first position of the movable surface and in a second position a small incremental distance ΔX from the first position;

Figure 3 represents the voltage output pulse of the phototube or the amplifier obtained when a light is reflected from the prism to the phototube during travel of the movable surface; and

Figure 4 is a plan view of the underside of a disc which constitutes a modification of the disc illustrated in Figure 1.

The present invention covers a device for indicating the position of a movable member in which a source of light is mounted in a fixed position relative to the member and confronting the member, and a light reflecting means having intersecting light reflecting surfaces disposed at an angle to each other is mounted on the member in a position to receive light from the light source in at least one position of the movable member. A convergent optical system is mounted at a distance from the light reflecting surfaces between the focal length of the optical system and twice the focal length thereof, and the light source is aligned with the optical system at a distance more than twice the focal length of the optical system on the side thereof opposite the light reflecting means.

Referring now more particularly to Figure 1, there is shown a movable turntable surface **10** on which is mounted a reflector comprising a 90° optical prism **11** fixed to the turntable in a suitable holder **12**. One surface **13** of the prism **11** is flush with the holder surface **14** which is remote from the turntable. In one typical embodiment, the prism **11** is mounted at a radius of 9½ inches from the center of the turntable.

A 16 millimeter microscope objective **15** is mounted at a distance from and confronting the prism **11** so as to transmit any light reflected from the prism **11** and to provide magnification for any such transmitted light image. A radiant energy light source **16** having a narrow filament **17** directs a narrow beam of light energy shown by dotted lines through an aperture **18** in the light source housing **19**. This narrow beam of light is directed through the microscope **15** to enter the surface **13** of the prism **11** whenever it is positioned in alignment with the microscope **15**. The beam entering the prism **11**, designated A, converges to an image of the lamp filament **17** inside the prism and is reflected back out of the prism as ray B. If the prism moves a distance X, the emerging rays shift the distance $2X$, as will be explained below. This distance is multiplied by the magnification factor of the microscope (ten in the present embodiment) as the beam B passes through the microscope **15**, and the movement X of the prism has thus been multiplied by a total factor of twice the magnification of the optical system, or in the present case twenty. A radiant energy responsive device, or phototube **21**, is mounted within a housing **22**, which has a slot **23** therein. The slot **23** is covered by a movable element **24** which has a slit **25** aligned therein with the slot **23**. The slit **25** is in the focal plane which has a final magnified image of the light source and, for one particular position of the prism, this image coincides with the slit.

The movable element **24** has a vertical shoulder **26** abutting against a fixed shoulder **27** which is part of the housing **22**. A compression spring **28** is positioned between the shoulders **26** and **27**, and serves to take up any play between the screw **29** which passes through shoulder **27** and engages threaded shoulder **26**. The screw **29** permits adjusting the position of movable element **24** and its slit **25** to provide a fine adjustment relative to the position of turntable **10** when the light beam B impinges on the photosensitive surface of the phototube **21**. In the construction referred to above, the slit **25** of the movable element **24** is ten mils in width.

The phototube **21** is merely representative of one of a number of photosensitive translating devices that may be employed, such as photocells, phototransistors and the like. An amplifier **30**, as is well known in the art, may

be connected to the phototube **21** to amplify the light converted electric output signals of that tube.

Referring to Figure 2 for an explanation of the multiplication factor of two provided by the prism **11**, it is seen that a light beam A entering the surface **13** of prism **11** through the microscope will leave the prism at B, while a light beam A′ entering the prism will leave the prism at B′. In the interest of simplying the tracing of the beams, no refractive effects of the prism are shown in Figure 2. If the prism is now moved a distance ΔX, light beam A will leave the prism at B_X, while light beam A′ will leave the prism at B'_X. As can be clearly seen, the distance that the reflected rays shift is twice the distance of the actual movement X of the prism in a period Δ. It, therefore, is the prism structure which gives us the multiplication factor of two previously referred to. It will be understood that the prism **11** may be replaced by two mirror surfaces at 90° as an alternative to the use of the reflecting surfaces of the prism.

Referring to Figure 3, it is seen that in the described construction the width of the electrical pulse appearing at the output of the phototube is generaed during approximately the movement of .0005 of an inch of the surface of the turntable. Since the prism **11** is located 9½ inches from the center of the turntable, this means that the pulse width is equivalent to ten seconds of arc of rotation of the turntable. Greater accuracy of position in terms of arc length may be obtained by positioning the prism at a larger distance from the center of the turntable, or by reducing the widths of the slit and the light source filament.

Additional prisms **11** may be mounted on the surface **10** to cooperate with one or more external optical systems as herein disclosed for providing additional position controlled indications for the surface **10**. Figure 4 shows a plan view of the underside of a disc **10** with prisms **11** mounted 180° apart. It should also be noted that the same external optical system consisting of light source **16**, microscope **15**, and phototube **21** may cooperate with a number of prisms **11** mounted on the surface **10** to provide position indications for a number of selected points on this surface.

While there has been shown and described an invention in connection with certain specific embodiments, it will, of course be understood that it is not intended that the invention be limited thereto, since it is apparent that the principles herein disclosed are susceptible of numerous other applications, and modifications may be made in the circuit arrangement and in the instrumentalities employed without departing from the spirit and scope of this invention as set forth in the appended claims.

I claim as my invention:

1. A position determining system comprising, in combination, a movable member, a source of light mounted in fixed position relative to said member, a prism mounted on said member and positioned to receive and reflect said light from said source in at least one position of said member, an optical element so located relative to said prism as to produce a reduced size image of said source inside of said prism and then magnify the reflected image, a phototube fixed with respect to said member so as to receive said light from said optical element, and a second element having a slit therein in front of said phototube which slit coincides with said magnified reflected image for at least one position of said member.

2. A position determining system comprising, in combination, a movable member, a source of light mounted in fixed position relative to said member, a prism mounted on said member and positioned to receive and reflect said light from said source in at least one position of said member, an optical element so located relative said prism as to produce a reduced size image of said source inside of said prism and then magnify the reflected image, a light responsive device fixed with respect to said member so as to receive said light from said optical element, and

a second element having a slit therein in front of said light light responsive device which slit coincides with said magnified reflected image for at least one position of said member.

3. A position determining system comprising, in combination, a movable member, a source of radiant energy mounted in fixed position relative to said member, a prism mounted on said member and positioned to receive and reflect said radiant energy from said source in at least one position of said member, an optical element so located relative to said prism as to produce a reduced size image of said source inside of said prism and then magnify the reflected image, a radiant energy responsive device fixed with respect to said member so as to receive said radiant energy from said optical element, and a second element having a slit therein in front of said radiant energy responsive device which coincides with said magnified reflected image for at least one position of said member.

4. A position determining system comprising, in combination, a movable element, a source of electromagnetic waves in fixed position relative to said element, a reflecting means mounted on said element and positioned to receive said waves from said source in at least one position of said element, an amplifying device positioned in close proximity to said reflecting means serving to transmit said electromagnetic waves from said source to said reflecting means and to retransmit said reflected waves from said reflecting means, wave responsive means fixed with respect to said element so as to receive said electromagnetic waves from said amplifying device and fixed at a large distance from said amplifying device compared to the distance between said amplifying device and said reflecting means, and an adjustable second element having a slit therein for varying the relative position between said wave responsive means and said movable element when wave energy reflected from said reflecting means is received by said means.

5. A position determining system comprising, in combination, rotatable member, a source of light mounted in a fixed position, relative to said member a pair of reflecting surfaces mounted on said rotatable member at an angle of 45° with respect to the direction of motion and positioned to receive and reflect said light from said source in at least one selected position of said member, an optical element positioned in close proximity to said reflecting surfaces serving to transmit said light from said source thereto and to magnify said reflected light therefrom, a phototube fixed with respect to said members so as to receive said light from said optical element and fixed at a large distance from said optical element compared to the distance between said optical element and said reflecting surfaces, a second element having a slit therein in front of said phototube adjusted to coincide with the magnified image of said source when the said rotatable member is in the said selected position, said phototube producing an electrical output pulse corresponding to said selected position on said rotatable member.

6. A device for indicating the position of a rotatable disc comprising a light reflecting means having two orthogonal intersecting light reflecting surfaces, said light reflecting means being adapted to be mounted to the disc with the reflecting surfaces intersecting on a radius of the disc and disposed at approximately 45 degree angles relative to the disc, a convergent optical system confronting one point of the path of the light reflecting means and mounted at a distance from the light reflecting surfaces between the focal length of the optical system and twice the focal length thereof, a light source aligned with the optical system at a distance greater than twice the focal length of the optical system on the side thereof opposite the light reflecting means, said source being focused on the light reflecting means when aligned therewith by the optical system, and a photosensitive device

aligned with the optical system and disposed at the image of the light reflecting means.

7. A device for indicating the angular position of a shaft comprising a disc coaxially mounted normal to the shaft for rotation therewith, a light reflecting means mounted to the surface of the disc adjacent to the periphery thereof with reflecting surfaces intersecting on a radius of the disc and disposed at approximately 45 degrees relative to the disc, a convergent optical system confronting one point of the path of the light reflecting means and mounted at a distance from the light reflecting surfaces between the focal length of the optical system and twice the focal length thereof, a light source aligned with the optical system at a distance greater than twice the focal length of the optical system on the side thereof opposite the light reflecting means, said source being focused on the light reflecting means when aligned therewith by the optical system, and a photosensitive device aligned with the optical system and disposed at the image of the light reflecting means.

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