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J. S. ZUCKERBRAUN
CROSSED SLOT SCANNER FOR DEVELOPING A LISSAJOUS
SCANNING PATTERN
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158,335
3,322,953

FIG. 1.

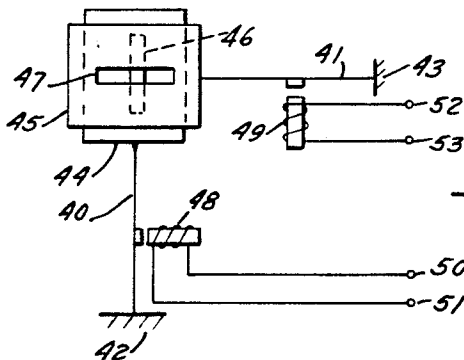
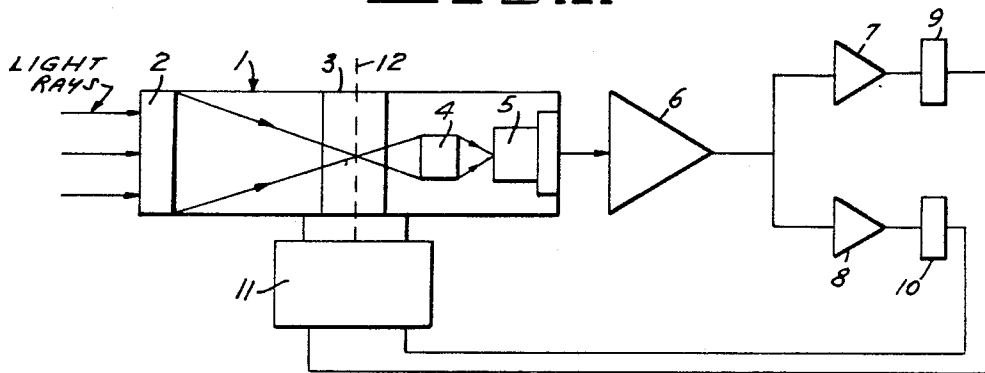


FIG. 2.

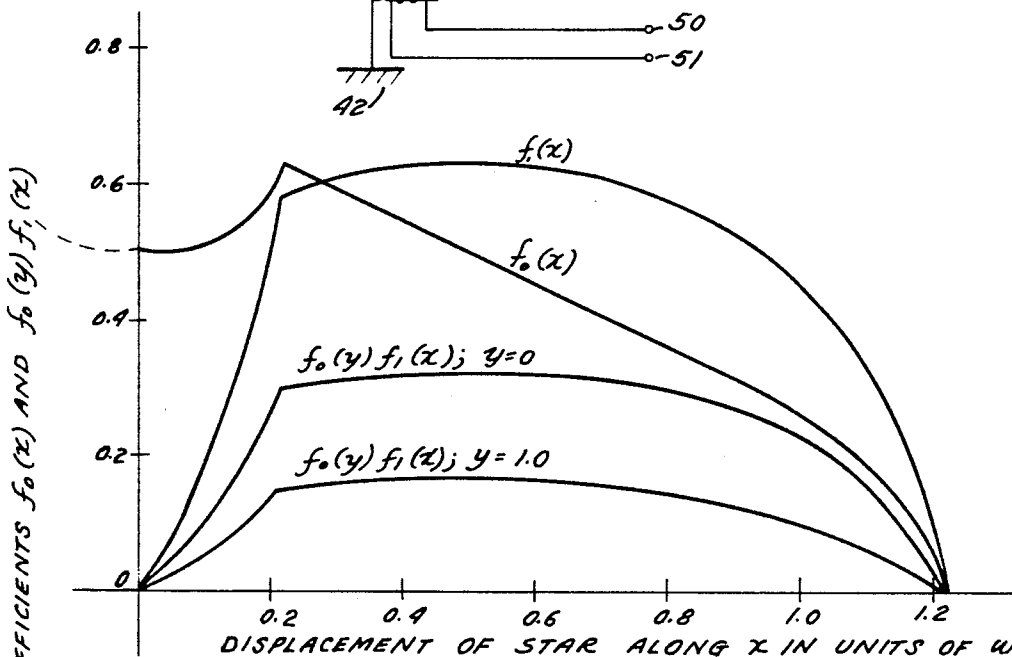


FIG. 3.

INVENTOR.
JACOB S. ZUCKERBRAUN

BY
OSTROLENK, FABER, GERB & SIFFEN

ATTORNEYS

1

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CROSSED SLOT SCANNER FOR DEVELOPING A LISSAJOUS SCANNING PATTERN

Jacob S. Zuckerbraun, New York, N.Y., assignor to Kollman Instrument Corporation, Elmhurst, N.Y., a corporation of New York

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1 Claim. (Cl. 250-203)

This invention relates to a novel reed scanning system for light trackers, and more specifically relates to the simultaneous two-axes scanning for scanning in both azimuth and altitude with a single scanning mechanism.

Scanning mechanisms of the type to which the invention is directed are set forth, for example, in my copending application Ser. No. 47,837, filed Aug. 8, 1960, now Patent Number 3,244,886, entitled "Light Modulation System" (K-102), which is assigned to the assignee of the present invention.

In such scanning systems, since it is necessary to scan the light image of a remote light source in both azimuth and altitude to obtain the position of the image, a first scanning mechanism is arranged to scan the light image in a first direction, and a second mechanism which is independent from the first mechanism scans in a direction perpendicular to the scanning of the first.

With this system, and even though the two mechanisms are provided, only one can work at any one time so that the remote light source is alternately tracked in azimuth and in altitude. Thus, where the two mechanisms provide crossed slots which define an aperture, the first slot is first oscillated to define a moving opening which scans the light source in the first direction, and this is then stopped and the other slot oscillated to define a moving opening which is perpendicular or at an angle to the original motion.

Where it is desired to simultaneously scan in both directions, it has been proposed to split the light image into two separate images which are each operated upon by their own respective scanning means which scan perpendicularly with respect to one another and with respect to the two images. Such mechanisms are set forth in my copending application Ser. No. 77,198, filed Dec. 20, 1960, now abandoned, entitled "Scanning Device For Light Tracking Systems" (K-105), and assigned to the assignee of the present invention.

In accordance with the present invention, I have found that I can provide crossed slots in respective plates which are oscillated perpendicularly to one another. By oscillating the first plate at a first frequency and the second plate at a second frequency, I have found that the modulated light which passes through the aperture defined by the intersection of the two slots carries information therein to both azimuth and altitude, which information can be removed from the light signal and used to control the positioning apparatus of the tracking mechanism.

Accordingly, a primary object of this invention is to provide a novel two-axes reed scanner which continually tracks the image of a radiant body.

Another object of this invention is to provide two slits which are perpendicular to one another for a scanning mechanism wherein the two slits are oscillated perpendicularly to one another and at different frequencies.

Another object of this invention is to provide a light scanning mechanism which is simple in construction.

A further object of this invention is to provide a novel scanning mechanism for light tracking devices which has few movable parts and is highly reliable.

These and other objects of this invention will become apparent from the following description when taken in connection with the drawings, in which:

2

FIGURE 1 schematically illustrates the telescope to be used with the novel scanning mechanism of the invention.

FIGURE 2 illustrates a novel crossed aperture arrangement of the present invention.

FIGURE 3 illustrates the characteristic of various measured parameters when the apertures of FIGURE 2 are oscillated at different frequencies.

As pointed out above, the concept of the present invention is to oscillate cross slots in the light scanning mechanism at different frequencies. An analysis of the output light in such an arrangement is as follows:

Consider a star image of Φ lumens focused in the plane of a single, vibrating-slot aperture. The signals developed can be described by the following equation:

$$\Phi_x(t) = \Phi[f_0(x) + f_1(x) \sin \omega_x t + f_2(x) \cos 2\omega_x t + \dots]$$

where

$f_0(x)$ = D.C. component, which is an even function of x

$f_0(x) \geq 0$

$f_1(x)$ = fundamental coefficient

$f_2(x)$ = second harmonic coefficient

x = displacement of star image from null measured along the x axis.

If this modulated light is now passed through a second identical slot vibrating in the same plane, but at right angles to the first, the resultant output signals will be given by:

$$L \times y(t) = \Phi[f_0(x)f_0(y) + f_1(x)f_0(y) \sin \omega_x t + f_2(x)f_0(y) \cos 2\omega_x t + f_0(x)f_1(y) \sin \omega_y t + f_0(x)f_2(y) \cos 2\omega_y t + \text{sum and difference terms}]$$

The scan frequencies ω_x and ω_y (or frequency of vibration of the two crossed slots respectively) are chosen to be non-integral multiples of each other in order to keep sum and difference terms outside the passbands of follow-up amplifiers.

The significant flux components that reach a photo-sensing device are identified as follows:

$\Phi f_0(x) \cdot f_0(y)$ = average flux

$\Phi f_0(y) \cdot f_1(x) \sin \omega_x t$ = x axis position signal

$\Phi f_0(y) \cdot f_2(x) \cos 2\omega_x t$ = x axis recognition signal

$\Phi f_0(x) \cdot f_1(y) \sin \omega_y t$ = y axis position signal

$\Phi f_0(x) \cdot f_2(y) \cos 2\omega_y t$ = y axis recognition signal

The equation for $f_0(x)$ or $f_0(y)$ is given by—

$$f_0(x) = \frac{\sin^{-1} \frac{1}{A}(\frac{1}{2} - x) + \sin^{-1} \frac{1}{A}(x + \frac{1}{2})}{\pi}; 0 \leq x \leq A - \frac{1}{2}$$

$$f_0(x) = \frac{1}{2} + \frac{1}{\pi} \sin^{-1} \frac{1}{A}(\frac{1}{2} - x); A - \frac{1}{2} \leq x \leq \frac{1}{2}$$

$$f_0(x) = \frac{1}{2} - \frac{1}{\pi} \sin^{-1} \frac{1}{A}(x - \frac{1}{2}); \frac{1}{2} \leq x \leq A + \frac{1}{2}$$

where

A = excursion amplitude of the slots

$$= \frac{\sqrt{2}}{2} W$$

and

W = slot width

A plot of this term is shown in FIGURE 3, where it can be seen that $f_0(x)$ is at least 0.5 in the range

$$-\frac{1}{2} \leq x \leq \frac{1}{2}$$

If this technique of modulation is compared to that of the beam splitter method of my above noted application Ser. No. 77,198, now abandoned, (K-105) for telescopes

3

of the same objective lens diameter, it can be readily seen that over the above ranges for x and y the position and recognition signals are essentially the same in both methods. An additional important advantage to the new method is that the noise power caused by the star at null will be one-half the value obtained with the beam splitter method. The new method also holds the same noise advantage over a rotary scanner of the type set forth in U.S. Patent 2,905,828.

One manner in which the above concepts can be embodied in a physical construction is shown in FIGURES 1 and 2. FIGURE 1 illustrates a telescope 1 having an objective 2 which focuses the light rays (which are so labeled) from a remote radiant body toward the scanning mechanism 3 which is contained within telescope housing 1.

After operation on these light rays by the scanning mechanism, as will later be described, the resultant output signals pass through a lens system 4 which focuses the output light on a photo-sensing device 5.

The photo-sensing device 5 generates an output which is amplified by amplifier 6. Appropriate amplifiers and filters 7 and 8 then receive the x axis position signal and y axis position signal, by, for example, being responsive only to frequencies ω_x and ω_y respectively, and their outputs are then delivered to demodulator means 9 and 10 respectively, which are synchronous demodulators. Thus demodulator 9 receives star signal frequency ω_x and a fixed reference of the same frequency, while demodulator 10 receives star signal ω_y and a fixed reference of ω_y . The demodulators 9 and 10 then deliver appropriate correction signals to the servo system 11 which controls the position of telescope 1 and attempts to retain the telescope pointed directly at the light source being tracked.

The scanning mechanism 3 is shown in FIGURE 2 as including a first and second magnetic reed 40 and 41 which are mounted on fixed supports 42 and 43 within the telescope housing 1. Each of the thin reeds 40 and 41 mount thin plates 44 and 45 which have slits 46 and 47 therein. The slits 46 and 47 are perpendicular to one another, as illustrated, so that they define a square-shaped aperture at their intersection.

The plate 44 and its aperture 46 are oscillated by means of a magnetic drive system which includes the solenoid drive 48, while reel 41 and its plate 45 is oscillated by the solenoid drive system 49.

In accordance with the invention, the solenoid 48 has its terminals 50 and 51 connected to an A.-C. source of frequency ω_x . The solenoid 49 has its terminals 52 and 53 connected to a source of power having a frequency ω_y . Thus, the plate 44 will oscillate at a frequency ω_x while plate 45 will oscillate at frequency ω_y . Hence, since these frequencies are different from one another, the

4

square aperture defined by the intersection of slits 46 and 47 will describe a Lissajous figure and modulate the image of the light source being tracked in accordance with the equations set forth above.

Although this invention has been described with respect to its preferred embodiments it should be understood that many variations and modifications will now be obvious to those skilled in the art, and it is preferred, therefore, that the scope of this invention be limited not by the specific disclosure herein but only by the appended claims.

What is claimed is:

A scanning system for a light tracking device; said light tracking device including a telescope for forming the image of a light source to be tracked, means for scanning the image of said light source, photosensing means positioned to receive the scanned image of said light source, and servo means connected between the output of said photosensing means and said telescope to retain said telescope pointed at said light source; said scanning means including an aperture movable with respect to said image of said light source; said aperture being moved in a Lissajous scanning pattern whereby signal information for both azimuth and altitude of said light source is continuously produced in said photosensitive means; said scanning means including a pair of crossed slots movable perpendicular to one another; the first slot of said pair of crossed slots moved at a first frequency; the second slot of said pair of crossed slots moved at a second frequency distinct from said first frequency; said first and second slots moving with simple harmonic motion.

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RALPH G. NILSON, *Primary Examiner.*

WALTER STOLWEIN, *Examiner.*

CHESTER L. JUSTUS, J. D. WALL, E. STRICKLAND,
Assistant Examiners.