

May 15, 1962

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3,034,405

T-2681

MULTISLIT SCANNER

Filed Oct. 13, 1953

3 Sheets-Sheet 1

Fig. 1.

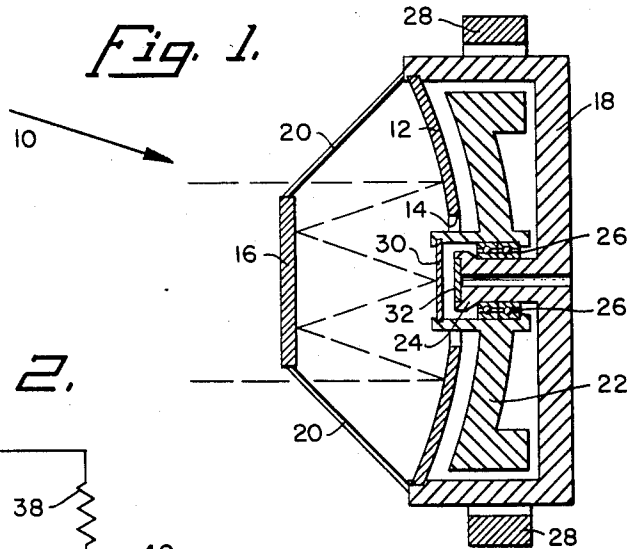


Fig. 2.

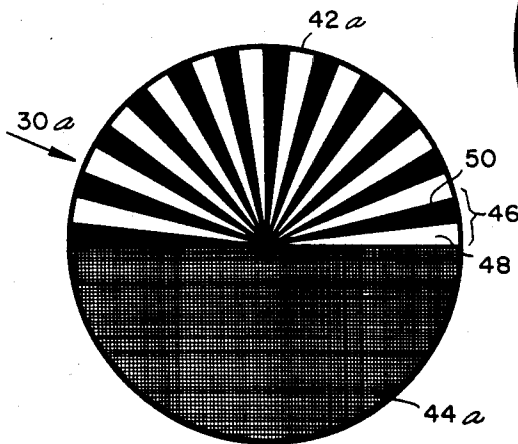
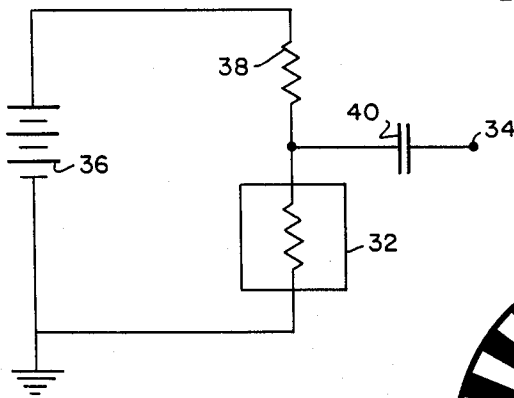


Fig. 3.

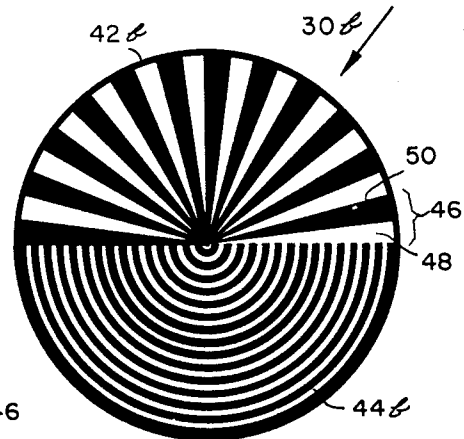


Fig. 4.

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3 Sheets-Sheet 2

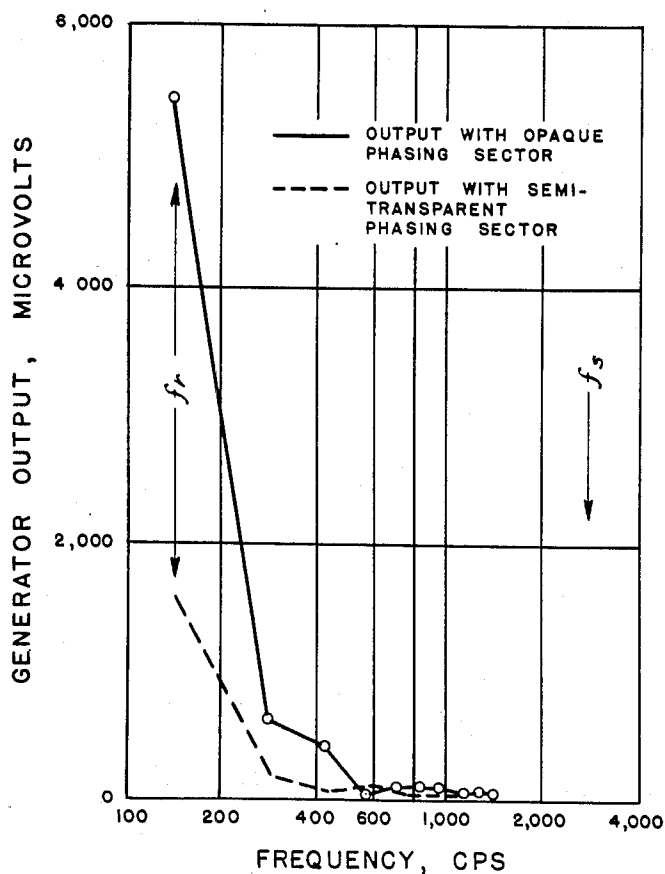


Fig. 5.

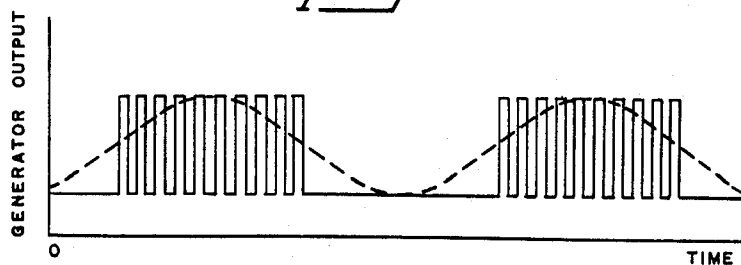


Fig. 7.

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3 Sheets-Sheet 3

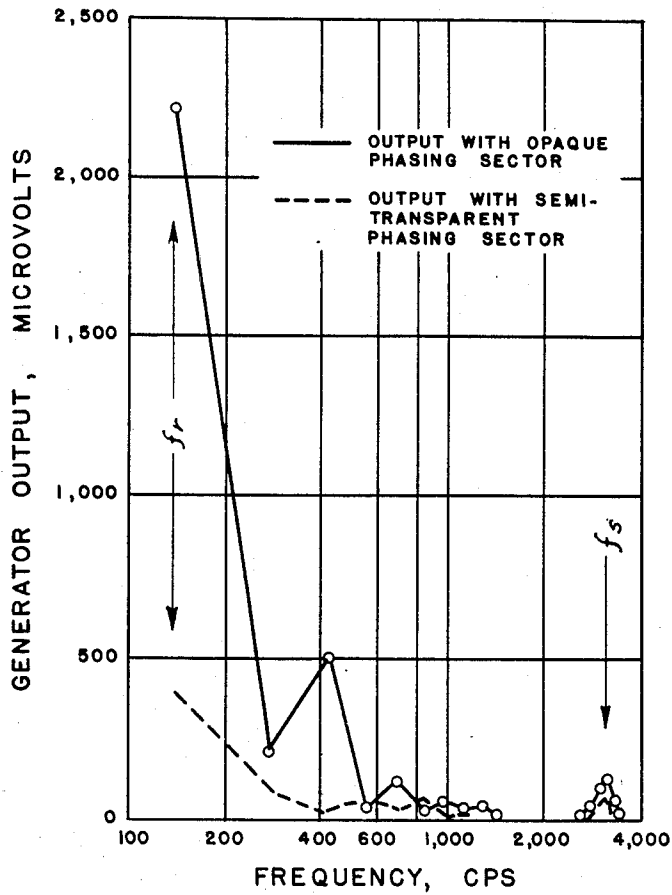


Fig. 6.

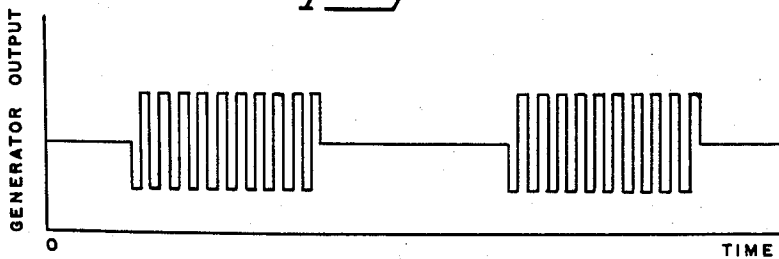


Fig. 8.

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1

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MULTISLIT SCANNER

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Filed Oct. 13, 1953, Ser. No. 385,901

16 Claims. (Cl. 88-61)

(Granted under Title 35, U.S. Code (1952), sec. 266)

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

This invention relates to scanning devices, and particularly to multislit scanners for use in target signal generators such as are disclosed in U.S. patent application No. 373,693, filed August 11, 1953, by Edwin G. Swann, and entitled Electrical Gate Phase Discriminator, now Patent No. 2,963,241.

The quality of the output signal of a target signal generator determines, to a large extent, the effectiveness of the overall guidance system of which the target signal generator is but a component. Studies of the output signals of target signal generators shown that the output signals have three components, one component, the target signal, which is due to the contrast between the radiation from a target as compared with the radiation from the background of the target, for example, from the sky; a second component, the background signal, which is due to variations in the intensity of radiation from the background; and a third component which is due to circuit noise. The target signal is, of course, the useful component, and it has been found that properly designed scanners can greatly reduce the background signal resulting from variations in the sky radiation.

It is, therefore, an object of this invention to provide a scanner for a target signal generator which substantially eliminates the background signal from the output voltage of a target signal generator.

It is a further object of this invention to provide a scanner for a target signal generator which emphasizes the target signal and substantially suppresses the background signal in the output voltage of the generator.

Other objects and many of the attendant advantages of this invention will be readily appreciated as the same become better understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein:

FIG. 1 is a schematic diagram of one form of a target signal generator;

FIG. 2 is a wiring diagram of a target signal generator;

FIG. 3 is a plan view of one form of the improved scanner;

FIG. 4 is a plan view of a second form of scanner;

FIG. 5 is a plot of the output voltage of the target signal generator plotted against frequency obtained from a sky background;

FIG. 6 is a plot of the output voltage of the target signal generator plotted against frequency obtained from a target against a daytime sky;

FIG. 7 is a plot of the output voltage of a target signal generator having an opaque phasing sector plotted against time, and

FIG. 8 is a plot of the output voltage of a target signal generator having a semi-transparent phasing sector plotted against time.

In FIG. 1, one form of a target signal generator 10 is illustrated. It consists of a modified Cassegrain telescope having a spherical reflector 12 provided with an opening 14 in the center, and a plane reflector 16 which is mounted on the inner gimbal 18 by narrow supports 20. Spherical

2

reflector 12 is likewise secured to the inner gimbal 18. Rotor 22 is supported for rotation about axle 24 by anti-friction bearings 26. Axle 24 is mounted on inner gimbal 18 which in turn is mounted in a conventional manner, which is not illustrated, within outer gimbal 28. The rotor 22, inner gimbal 18 and outer gimbal 28 constitute components of a two degrees of freedom gyroscope. Scanner 30 is mounted on rotor 22 at the focal plane of the telescope, and photo sensitive detector 32 is mounted on axle 24. The Cassegrain telescope comprising spherical reflector 12 and plane reflector 16, scanner 30, and photo sensitive detector 32 constitute target signal generator 10.

Photo sensitive detector 32, in a preferred example, is formed of lead sulfide, the resistance of which varies inversely with the intensity of the incident radiation. The circuit of FIG. 2 illustrates one manner in which the variation in resistance of detector 32 can be converted into an A.C. output voltage between terminal 34 and ground by a source 36 of substantially constant D.C. potential, a fixed dropping resistor 38, and condenser 40.

The Cassegrain telescope focuses radiation from sources within the view of the telescope onto scanner 30. Scanner 30 rotates with rotor 22 at the spin frequency, f_r , of rotor 22. The incident radiant energy falling on scanner 32 is chopped by the scanner and variations in the intensity of the incident radiation falling on detector 32 generate the A.C. output voltage of the target signal generator 10.

A systematic series of investigations was carried out to determine the character of the radiant energy from various types of sky backgrounds. From these investigations it has been learned that the sky varies in radiometric brightness over the field of view of the telescope and produces a background signal that is rich in harmonics of the frequency of rotation, f_r , of the scanner, or its scan frequency, which signal is due to nonlinear gradients of the radiometric brightness of the sky background. As the area of the sky scanned is reduced, or the abruptness of the discontinuity in the brightness increases; e.g., a small bright cloud in the field of view, the harmonics of the sky signal increase in number and in amplitude. However, in nature, such discontinuities are rarely very sharp, so that substantially no component of the output voltage of target generator 10 due to the nonlinear sky gradients is found above the eighth harmonic of the spin frequency, f_r . Investigations of the character of radiant energy from targets such as aircraft show that the target signal is rich in harmonics to and above the twentieth harmonic of the scan frequency f_r .

The scanners of FIGS. 3 and 4 are so designed that the frequency of the target signal, f_s , is greater than the eighth harmonic of the frequency of rotation, f_r , of scanner 30 with the result that substantially none of the background signal is present. Scanners 30a, 30b each consist of two semicircular sectors 42a, 42b and 44a, 44b. Sectors 42a, 42b are for target sensing, and comprise a plurality of slits 46, each slit 46 consisting of a transparent sector 48 and an opaque sector 50 which sectors are of equal size. Sectors 44a and 44b are for indicating the phase of the signal generated by the target sensing sectors and are semitransparent so as to permit one-half of the radiant energy T falling on the phasing sector to be transmitted, or the phasing sectors, to describe them in another way, have an optical density D of .3, which follows from the relationship:

$$D = \log_{10} \frac{1}{T}$$

The optical density of the target sensing sectors is also .3. In FIG. 3 the desired optical density is achieved by the use of a cross hatched pattern having a fine structure which is smaller than the least size of the target image.

In FIG. 4 the desired optical density is achieved by the use of a plurality of alternately transparent and opaque concentric bands of equal width. Scanners 32 can be made by a photoengraving process in which, by the use of bichromated gelatin, the desired patterns are etched in a surface of silver on glass. The desired patterns can be prepared by photographic reduction of hand drawn masters.

From FIG. 5 it can be seen that there are substantially no harmonics of the background signal which are greater than eight times the spin frequency of the scanner, and from FIG. 6 it can be seen that at the target signal, or slit frequency, f_s , there is a signal of appreciable magnitude generated when a target is within the field of view of the telescope. Slit frequency, f_s , is determined by the number, n , of the slits 46 in the target sensing portion of the scanner, the frequency of rotation, f_r , of the scanner and a constant K , whose value is equal to the ratio of the angular extent of a circle divided by the angular extent of the target sensing section 42a, or

$$(1) \quad f_s = Knf_r$$

and

$$(2) \quad \frac{f_s}{f_r} = Kn$$

In order for the target signal, having a frequency equal to the slit frequency, f_s , not to contain portions of the background signal, f_s should be at least eight or more times greater than f_r , so that Kn is equal to or greater than 8. In scanners 32a, 32b, n is 12 and K is 2 so that f_s is the 24th harmonic of f_r . There is, however, an upper limit to the value of Kn which is determined by the frequency limitations, or time constants, of detector 32, and by the decrease in amplitude of the target signal as slit frequency, f_s , increases. Detector response time is limited by the time for the detector 32 to change its resistance responsive to changes in the incident radiant energy. The signal rise and decay periods are in the order of 100 microseconds. Thus the slit frequency must be a high enough harmonic of the spin frequency of the scanner so that substantially no background signal is present and yet low enough not to exceed the time constant of the detector. Since the magnitude of f_r is determined by the angular velocity of rotor 22 and the angular velocity of rotor 22 is determined by the characteristics desired of the gyroscope, the possible number, n , of slits 46 is limited, and a suitable compromise must be made which considers all the possible variants.

A comparison of FIGS. 5 and 6 shows that the maximum amplitude of the background signal when using an opaque phasing sector is much greater than the maximum amplitude of the background signal when a semitransparent phasing sector having the same optical density as the target sensing sector is used. FIG. 6 shows that the amplitude of the target signal at slit frequency is of the same order of magnitude as the maximum amplitude of background signal which occurs at the spin frequency, f_r . This favorable comparison of the amplitudes makes it relatively simple to build a narrow band pass amplifier which amplifies the target signal at the slit frequency and substantially suppresses the background signal.

FIGS. 7 and 8 explain the benefits of the semitransparent phasing sector. The output voltage does not have central symmetry when an opaque phasing sector is used; i.e., the optical densities of the phasing and target sensing sectors are unequal, and therefore, has a strong fundamental frequency corresponding to the average value of the dashed line illustrated in FIG. 7. When a semitransparent phasing sector is used, i.e., the optical densities of the phasing and target sectors are substantially equal, the output voltage of the generator 10 has central symmetry so that the amplitude of the background signal at the spin frequency, f_r , is greatly reduced as seen in FIGS. 5 and 6.

Obviously many modifications and variations of the present invention are possible in the light of the above teaching. It is, therefore, to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described.

What is claimed is:

1. A scanner comprising a target sensing section and a phase sensing section, the optical densities of said phase sensing section and said target sensing section being substantially equal.

2. A scanner as defined in claim 1 in which the optical densities of the target sensing and phase sensing sections are substantially equal.

3. A scanner comprising a target sensing section and a phase sensing section, said target sensing section comprising a plurality of slits, each slit consisting of a transparent and an opaque sector, the number of slits multiplied by the ratio of the angular extent of a circle to the angular extent of the target sensing section being greater than eight.

4. A scanner as defined in claim 3 in which the transparent and opaque sectors of each slit are of equal size.

5. A scanner as defined in claim 4 in which the phasing sector is semitransparent.

6. A scanner as defined in claim 5 in which the semitransparency is provided by means of a cross hatched pattern.

7. A scanner as defined in claim 5 in which the semitransparency is provided by a plurality of alternately opaque and transparent concentric bands.

8. A scanner comprising a semicircular target sensing portion and a semicircular phasing portion, said target sensing portion being comprised of a plurality of slits, each slit consisting of a transparent sector and an opaque sector, the number of slits in said target sensing portion being greater than four.

9. A scanner as defined in claim 7 in which the transparent and opaque sectors of each slit are of equal size.

10. A scanner as defined in claim 9 in which optical density of the phasing portion substantially equals the optical density of the target sensing portion.

11. A scanner as defined in claim 10 in which the desired optical density of the phasing portion is achieved by means of a crosshatched pattern.

12. A scanner as defined in claim 10 in which the desired optical density of the phasing portion is achieved by means of a plurality of alternating opaque and transparent concentric bands.

13. In a target signal generator having means for focusing electromagnetic radiation on a scanner, means for rotating said scanner, and means for changing the variations in the electromagnetic radiation caused by said scanner into an A.C. signal, the improvements comprising a target sensing sector in said scanner comprised of a plurality of slits, each slit comprising an opaque and a transparent sector, and a phase sensing sector, the slit frequency of said scanner being greater than the eighth harmonic of the spin frequency of said scanner.

14. The scanner as defined in claim 13 in which the optical densities of the target sensing and phase sensing sectors are substantially equal.

15. In the scanner as defined in claim 14 in which the desired optical density of the phase sensing sector is achieved by a cross-hatched pattern.

16. In the scanner as defined in claim 14 in which the desired optical density of the phase sensing sector is achieved by a plurality of alternating transparent and opaque concentric bands.

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