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[54] OPTICAL NOISE SUPPRESSION DEVICE AND METHOD

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[52] **U.S. Cl.** .... **350/162 SF**
[51] **Int. Cl.²** **G02B 27/38**
[58] **Field of Search** .... 350/162 SF, 3.5

[56] **References Cited**
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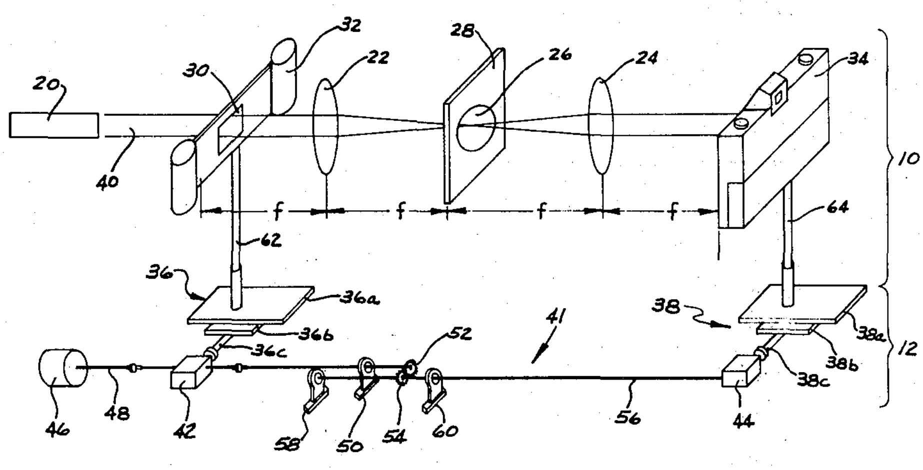
[57] **ABSTRACT**

Disclosed is a device and method for suppression of optical noise in an optical spatial filtering system using highly coherent light. In the disclosed embodiment, input photographic film to be processed in the system, and output photographic film to be exposed, are each mounted on lateral translation devices. During application of the coherent light for exposure of the output film, the two translation devices are moved in synchronism by a motor-driven gear and linkage assembly. The ratio of the resulting output film translation to the input film translation is equal to the magnification of the optical data processing system. The noise pattern associated with the lenses and other elements in the optical processing system remains stationary while the image-producing light moves laterally through the pattern with the output film, thus averaging out the noise effect at the output film.

23 Claims, 1 Drawing Figure



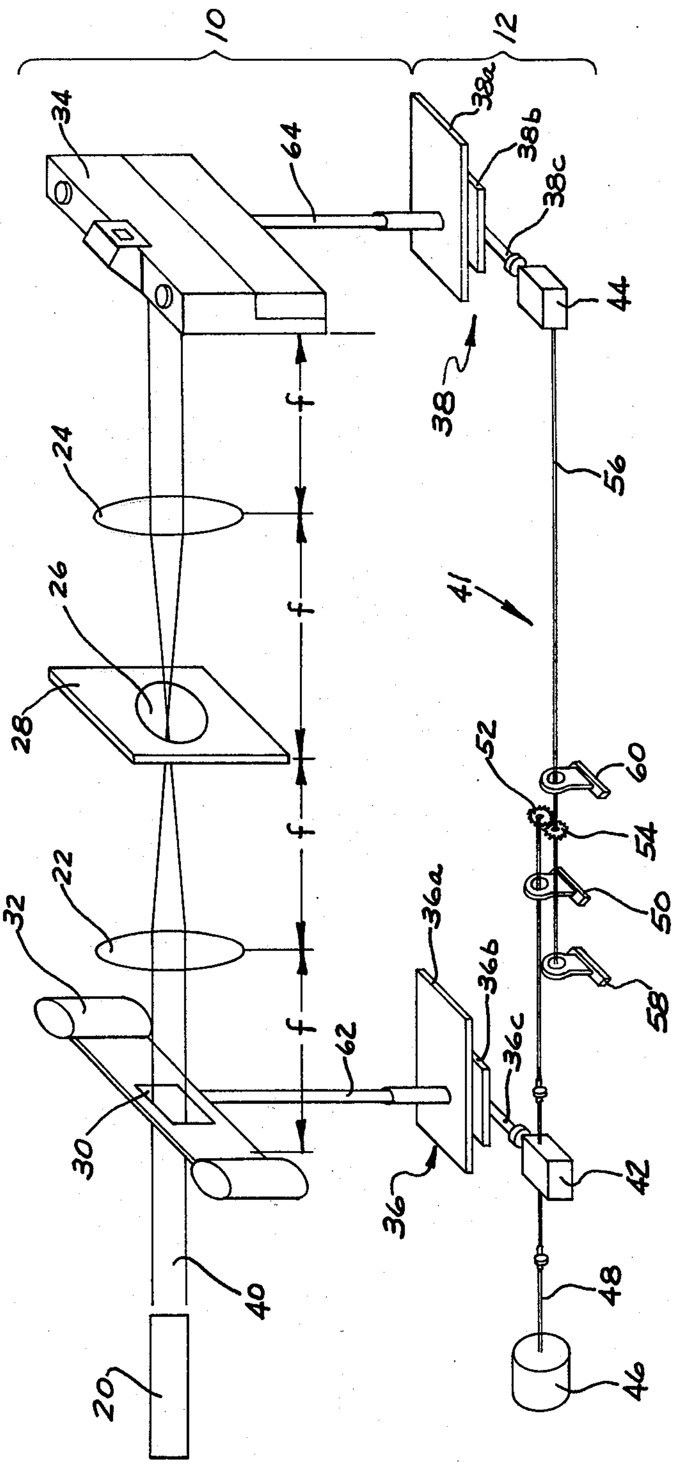

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Fig.

OPTICAL NOISE SUPPRESSION DEVICE AND METHOD

ORIGIN OF THE INVENTION

The invention described herein was made by an employee of the United States Government and 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.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention pertains to the suppression of optical noise in light systems. In particular, the present invention relates to translation devices by which input and output elements in a spatial filtering system are moved synchronously along parallel paths which are perpendicular to the optic axis of the spatial filtering system. This lateral motion of the elements causes the object, the image, and the information-carrying light to move laterally relative to the optical-noise-producing sources in the system, thus averaging out the optical noise pattern and yielding a noise-free image at the output element.

2. Description of the Prior Art

Optical processing systems, particularly using highly coherent light sources, such as lasers or black-bodies, are well known. In a typical arrangement using photographic film for the input and output element, a coherent light beam passes through the input film which bears information to be processed. The light beam, impressed with the information, then passes through a Fourier transform lens in whose back focal plane is located the appropriate spatial filter to carry out the desired operation on the Fourier spectrum. The processed light beam is inverse Fourier transformed by a second lens to produce the "processed" image on the output film. The optical data processing system thus functions as an optical computer by performing mathematical operations on information transported by the light beam.

In addition to the transforming lenses and the spatial filter, other optical elements, such as lenses,

are required in the optical data processing system to guide and focus the light beam. Optical noise arises from the interaction of the light beam with bulk and surface imperfections in all these optical elements. Examples of such noise-producing imperfections are bubbles, inclusions, striae and impurities in the lenses, and dust and other foreign matter on all the surfaces. Lens surfaces are also susceptible to micro-fissures produced as a result of the grinding and polishing operations in manufacturing the lenses. Such minute imperfections are usually of little or no consequence when ordinary light is used. However, when light that is highly coherent interacts with such imperfections, significant amounts of optical noise are generated.

The optical noise arises from the diffraction patterns produced in the light beam when the coherent light is incident on the imperfections. This optical noise manifests itself as a random collection of wavy lines and circles. Bulls-eye type patterns result from interference of the coherent light beam with light reflected at the interfaces of the various lens elements. These designs are registered on the film or other output device superimposed on the desired image. The term "cosmetic

quality" is used to describe the extent of freedom from such noise manifestations in the image. Because of the low tolerances for error in coherent light processes such as optical data processing, optical communications, and holography, it is essential that techniques be discovered to nullify the effects of such optical noise.

Various devices and techniques have been suggested to reduce coherent optical noise. In particular, attempts have been made to nullify the noise by averaging the noise pattern at some point in the optical system to a constant background. However, efforts to develop workable and practical noise averaging systems have thus far met with only limited success.

The noise averaging method of Thomas, as described in Applied Optics 10, 517 (1968), uses a tilted optical flat in the laser beam. During the exposure of the output film this flat is rotated about the optic axis of the optical system. This rotation has the effect of rotating the individual noise sources with respect to the laser beam, and hence averaging out their noise patterns in the beam, while the desired output image is itself stationary. However, the rotating optical flat also causes the Fourier spectrum incident on the spatial filter to rotate. Consequently, the spatial filter must also be rotated, and a very accurate feedback system must be added to synchronize the motions.

The technique of Grabowsky et al, as described in Applied Optics 10, 483 (1971), uses a rotating lens, causing the noise pattern to rotate while the desired image remains stationary, thus averaging out the noise. However, to keep the image stationary, the optic axis of the rotating lens must coincide exactly with the axis of rotation. In a multiple-element lens, this condition is virtually impossible to achieve due to the unavoidable misalignment of the optic axes of the individual elements. Furthermore, in multiplelens systems, a separate rotating device is required for each lens, adding to the alignment problems.

In U.S. Pat. No. 3,729,252, Nelson proposes using *n* separate light sources, each producing a separate noise pattern displaced from all the others in the output plane, while the desired images from all *n* sources coincide. The effect is to reduce the signal-to-noise ratio by a factor of $1/n$. However, the *n* light sources produce *n* individual, displaced, and possibly overlapping Fourier transform spectra. Consequently, to carry out the desired processing, a multiple spatial filter must be employed, with the desired filter characteristics centered on each of the *n* displaced Fourier spectra. Such a multiple spatial filter can be very difficult to fabricate if the desired filter characteristic is complicated.

SUMMARY OF THE INVENTION

The method of the present invention comprises suppressing optical noise in an optical system by moving the input and output devices in the object and image planes of the system respectively so that the desired image is always stationary with respect to the output device. During this motion, the optical noise sources in the optical system remain stationary with the remainder of the optical system elements. Consequently, the output device and the desired image move with respect to the optical noise pattern at the image plane, and the "detected" noise pattern is averaged out to a constant background. The motions of the input and output devices are perpendicular to the optic axis of the rest of the optical system. Consequently, when the method of the present invention is applied to a spatial filtering

Gas pressure will thus simultaneously flow from a pair of simultaneously fired electric ignition elements **11**, through fluid communicative passages **23A**, **23F**, **23C**, **18B** and **24** to cause a similar operation within the corresponding cylinders **20** as aforementioned.

Various modifications, alterations or changes may be resorted to without departing from the scope of the invention as defined in the appended claims.

I claim:

1. In lap belt tightener apparatus for use with aircraft seat belts,

an anchor loop adapted to be secured to a fixed seat support of an aircraft,

said anchor loop having means at one end for attaching a seat belt and means including an elongated slot at another end for slidable connection to a fixed seat support,

a piston and cylinder arrangement respectively secured to said seat support and anchor loop, said cylinder including means responsive to selectively delivered fluid pressure for imparting belt tightening motion to said cylinder and anchor loop,

a tightener housing member integral with and extending laterally of said cylinder, and

means mounting an electric ignition element on said tightener housing member,

said ignition element having a lug releasably secured to a slotted bayonet connector on an electric wire,

said tightener housing member having a passageway for delivering pressure fluid developed by said electric ignition element to said cylinder.

2. The structure in accordance with claim **1** wherein said mounting means includes an internally threaded recess in said tightener housing member and in fluid communication with said passageway, and said electric ignition element is sealingly secured in said threaded recess.

3. The structure of claim **1** wherein said mounting means includes an adapter swivelly connected to said tightener housing member, said adapter having an internally threaded recess, said recess being in fluid communication with said passageway, and said electric ignition element is sealingly secured in said threaded recess.

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the screw drive 36*c* advancing the carriage 36*a* in one direction while the rotating shaft 56 operates through the gear box 44 to turn the screw drive 38*c* advancing the carriage 38*a* in the direction opposite that of the carriage 36*a*. Since the gears 52 and 54 are identical, their gear ratio is one. Therefore, the motor 46 causes the carriage 36*a* to move in one direction perpendicular to the optic axis of the optical system at 10, and simultaneously causes the carriage 38*a* to move in the opposite direction, with both carriages moving at the same speed. If the direction of operation of the motor 46 is reversed, the two carriages 36*a* and 38*a* reverse their respective translational motions.

The translation tables at 36 and 38 may be mounted, via their respective ways 36*b* and 38*b*, on the same optical bench or other appropriate equipment (not shown) as are the elements of the optical system at 10. The input film holder 32 is mounted by a post 62 on the carriage 36*a*, and moves with that carriage; the camera 34 is similarly mounted by a post 64 on the carriage 38*a*, and likewise moves with that carriage. The carriage 36*a* and the input film holder 32 are so positioned and oriented that when the motor 46 is effecting translational motion of that carriage, the input film 30 moves in the front focal plane of the lens 22, perpendicularly to the optic axis of the optical system at 10. Similarly, the carriage 38*a* and the camera 34 are so positioned and oriented that when the motor 46 is effecting translational motion of that carriage, the output film (not shown) in the camera moves in the back focal plane of the lens 24, perpendicularly to the optic axis of the optical system at 10.

With the operation of the motor 46 and the drive shaft assembly at 41, the resulting motions of the input 30 and output (not shown) films possess three features essential to the successful operation of the optical noise suppression device at 12, and to the practice of the noise suppression method of the present invention. First, the input film 30 remains flat in the front focal plane of the Fourier transform lens 22, the object plane; the output film (not shown) remains flat in the back focal plane of the inverse Fourier transform lens 24, the image plane. Consequently, the position of the Fourier spectrum at the spatial filter 26 never changes, and, therefore, the operation of the filter on the spectrum is not affected by the motion of the input and output films. Furthermore, the image produced by the second lens 24 is always in focus in the back focal plane of that lens.

Secondly, the input film 30 and the output film (not shown) move simultaneously along parallel paths. In the present application to an optical system producing an inverted image, these motions of the input 30 and output (not shown) films are in opposite directions along the parallel paths. As the input film 30 is made to move, say, from right to left across the front focal plane of the first lens 22, the image formed in the back focal plane of the second lens 24 moves from left to right across the back focal plane of the second lens 24. Therefore, by reversing the rotation of the shaft 56 compared to the rotation of the drive shaft 48, using the gears 52 and 54, the output film (not shown) is made to move in the plane of the image in the same direction as the image there moves. In applications of the present invention to optical systems producing erect images, the image at the camera 34 moves in the same direction as the moving input film 30. Therefore, in such a case, the shaft 56 is made to rotate in the same direction as the drive shaft 48 to move the camera 34 in the same direction as the input film 30 is made to move.

Finally, the translational speeds of the input film 30 and the output film (not shown) are synchronized and tied to the overall magnification M of the optical system at 10. The ratio of the translational speed of the camera 34 to the translational speed of the input film 30 is the same as the inverse of the gear ratio of the gears 52 and 54. In the embodiment presented herein, that gear ratio is unity. For every point on the input film 30, acting as an object, there is a corresponding position in the image in the back focal plane of the second lens 24. As the input film 30 is moved in one direction by the translation table at 36, each of the points in the image, corresponding to positions in the input film, move at a speed equal to the translational speed of the input film multiplied by the magnification M of the optical system; and all the image points move at the same speed. Consequently, since, in the present case, M is unity, the same as the gear ratio, the output film (not shown) moves across the back focal plane of the second lens 24 at the same speed as the image moves across that same plane. Therefore, the image and the output film (not shown) are always stationary with respect to each other. To use the optical noise suppression device at 12 with an optical system of magnification M that is different from unity, the ratio of the gears 52 and 54 must be changed accordingly. In all cases, the linking gear ratio between the shafts 48 and 56 must be equal to the inverse of the magnification M of the optical system. In the particular cases where the image at the camera 34 moves in the opposite direction from the direction of motion of the input film 30, such as the present case, the gear linkage between the shafts 48 and 56 must also cause the shafts to rotate in opposite directions.

It will be appreciated that all three essential features of the motion of the input film 30 and of the output film (not shown) may be achieved by using variations of the drive shaft assembly at 41, modifications in the translation tables at 36 and 38, modifications in the gear boxes 42 and 44, or combinations thereof, without departing from the invention. For example, the motor 46 could be linked directly to the shaft 56 rather than the shaft 48. Another possibility is to use one shaft 48 connected to both gear boxes 42 and 44, and to either modify the gear boxes or modify the screw drives 36*c* and 38*c* to obtain the needed ratio and reversal characteristics. The motor 46 may also be placed on a line with and between the translation tables at 36 and 38, with a drive shaft extending in both directions from the motor and tied to appropriate screw drives pointing from the respective translation tables directly at the motor. Still another method of achieving the same three characteristics of the motions of the input 30 and output (not shown) films involves operating each translation table by a separate motor, with the two motors synchronized electronically or otherwise.

The present invention may be used with variations of the standard afocal coherent light optical system as disclosed herein. An example of such a system occurs where an additional lens is used to magnify the Fourier spectrum before the second lens 24 performs the inverse Fourier transformation. In some systems, the image in the back focal plane of the inverse Fourier transform lens moves in the same direction as the input device 30 moving perpendicularly to the optic axis. Then, the reversal feature of the linking gear assembly

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by said first translation means and said second translation means.

11. An optical noise suppressor as defined in claim **4** wherein said synchronizing means further comprises gear train means to effect said simultaneous motions by said second translation means and said first translation means.

12. An optical noise suppressor as defined in claim **10** wherein said synchronizing means further comprises automatic control means for selectively actuating said power means.

13. An optical noise suppressor for averaging out optical noise, in combination with a coherent light optical system which includes along its optic axis a spatial filter, an input device in an object plane, and an output device for recording light in an image plane, comprising:

a. input carriage means on which is mounted said input device in said object plane;

b. input ways means for constraining said input carriage means to confine said input device to said object plane while permitting said input carriage means to move said input device perpendicularly to said optic axis;

c. input screw drive means for propelling said input carriage means;

d. output carriage means on which is mounted said output device in said image plane;

e. output ways means for constraining said output carriage means to confine said output device to said image plane while permitting said output carriage means to move said output device perpendicularly to said optic axis;

f. output screw drive means for propelling said output carriage means; and

g. power means equipped wih drive shaft assembly means for selectively causing simultaneous rotary motion of said input screw drive means and said output screw drive means to propel said input carriage means and said output carriage means so as to simultaneously move said input device and said output device along parallel paths perpendicular to said optic axis.

14. An optical noise suppressor as defined in claim **13** wherein said drive shaft assembly means comprises:

a. rotatable first shaft means linked to said input screw drive means;

b. rotatable second shaft means linked to said output screw drive means; and

c. gear train means linking said first shaft means and said second shaft means for simultaneous rotational motion of said first shaft means and said second shaft means when said drive shaft assembly means is actuated by said power means.

15. An optical noise suppressor as defined in claim **14** further comprising:

a. input gear box means for transferring rotary motion from said first shaft means to said input screw drive means; and

b. output gear box means for transferring rotary motion from said second shaft means to said output screw drive means.

16. An optical noise suppressor as defined in claim **13** further comprising automatic control means to actuate said power means to cause said input device and said output device to be in said respective motions when said output device is actuated to record light in said optical system.

17. An optical noise suppressor as defined in claim **15** further comprising automatic control means to actuate said power means to cause said input device and said output device to be in said respective motions when said output device is actuated to record light in said optical system.

18. An optical noise suppressor as defined in claim **13** wherein the ratio of the speed of said output device motion to the speed of said input device motion is equal to the overall magnification of said optical system.

19. An optical noise suppressor as defined in claim **15** wherein said gear train means has an overall gear ratio equal to the inverse of the overall magnification of said optical system so as to constrain said motion of said output device to be at the same speed as the motion, in the image plane, of the image of said optical system caused by said motion of said input device.

20. A method of suppressing optical noise in an optical system, wherein an output device is detecting information from an input device by way of said optical system, comprising the steps of:

a. moving said input device perpendicularly to the optic axis of the optical system;

b. simultaneously moving said output device along a path parallel to that of the movement of said input device; and

c. synchronizing said motions of said input device and said output device so that the ratio of the speed of said output device to the speed of said input device is equal to the overall magnification of the optical system.

21. A method of suppressing optical noise as defined in claim **20** further comprising the steps of:

a. constraining said motion of said input device to the object plane of the optical system; and

b. constraining said motion of said output device to the image plane of the optical system.

22. A method of suppressing optical noise as defined in claim **20** further comprising the step of effecting said motions of said input device and said output device by automatic power means.

23. A method of suppressing optical noise as defined in claim **20** further comprising the step of effecting said simultaneous movement of said input device and said output device in opposite directions along said parallel paths.

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