United States Patent

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[73] Assignee **Michael Reese Hospital and Medical Center**

[54] **PATIENT-POSITION-MONITORING METHOD AND SYSTEM FOR USE DURING MEDICAL DIAGNOSTIC AND THERAPEUTIC PROCEDURES**
21 Claims, 3 Drawing Figs.

[52] **U.S. Cl.** ..... **250/221,** 128/2.1 R, 128/24.1, 250/65, 250/103
[51] **Int. Cl.** **G03b 41/16**
[50] **Field of Search** ..... 250/65, 93, 95, 103, 216, 217, 221, 222, 224; 128/201 R, 2.1 A, 24.1

[56] **References Cited**

UNITED STATES PATENTS

3,192,321	6/1965	Nassimbene	250/221 X
3,432,671	3/1969	Edmonds	250/217
2,948,890	8/1960	Barth et al.	250/221 X

OTHER REFERENCES

Willis, G. R.; IBM Technical Disclosure Bulletin; Vol. 6, No. 6; Nov., 1963; pp. 13; 250-221.

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ABSTRACT: A light beam is directed upon a retroreflective element, located adjacent the pertinent portion of the patient's body and is reflected upon a photocell or some other photoresponsive means. If there is any appreciable change in the patient's position, the signal from the photocell will change. The changed signal can be employed to perform a control function, such as actuating a warning device, or terminating the diagnostic or therapeutic procedure, so that the radiation will not be misdirected. The light beam is preferably produced by an optical system comprising a lamp, an apertured member to produce a small spot of light, a partially light-transmitting mirror, and a lens for focusing the beam upon the retroreflective element. The reflected beam is preferably focused by the lens through the mirror and upon the photocell. The retroreflective element is preferably in the form of a small piece of retroreflective adhesive tape, to be stuck to or adjacent to the patient's body.

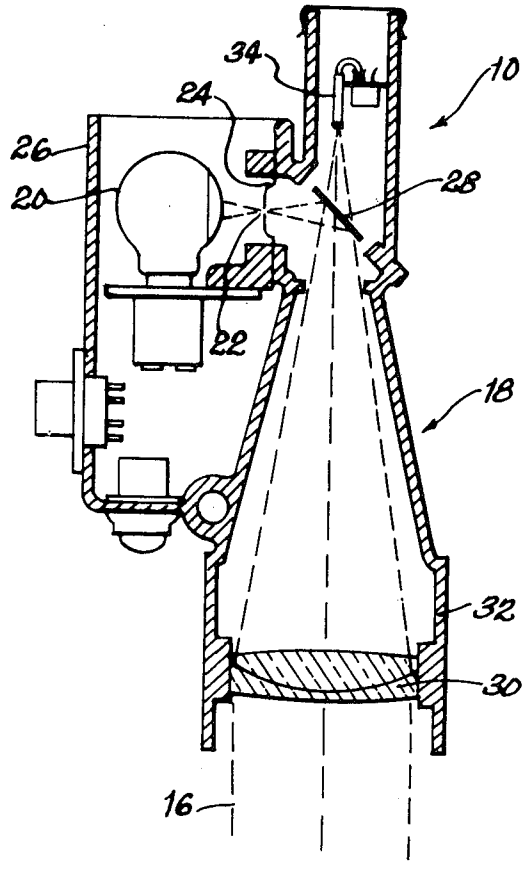


FIG. 1

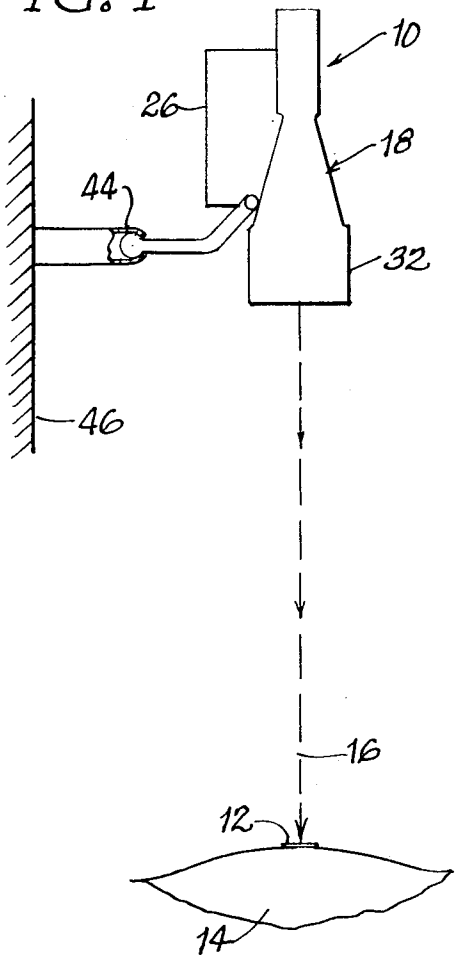
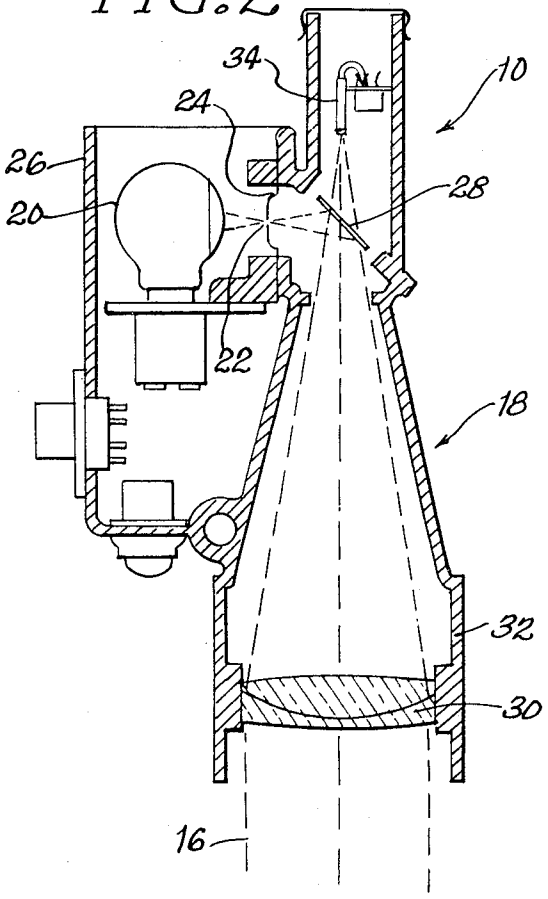


FIG. 2



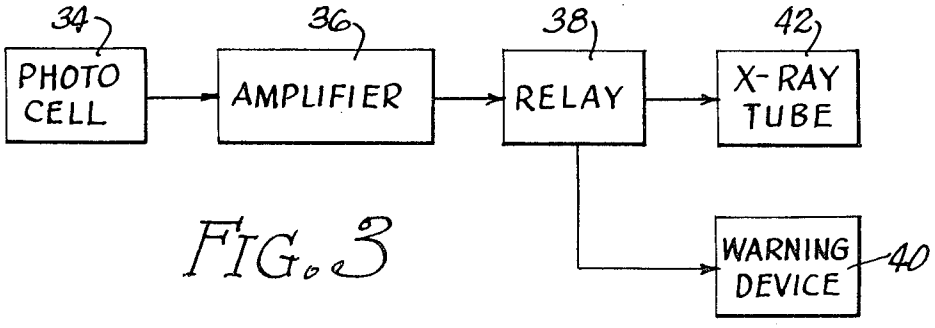


FIG. 3

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PATIENT-POSITION-MONITORING METHOD AND SYSTEM FOR USE DURING MEDICAL DIAGNOSTIC AND THERAPEUTIC PROCEDURES

This invention relates to a method and system for indicating any appreciable change in the position of a patient during medical procedures utilizing a high-energy beam source such as radiography, radioisotope or ultrasonic scanning, radiation therapy, laser beam treatment or the like, or utilizing a high-energy source. Any change in the position of the patient is undesirable, because such change may cause the high-energy beam or radiation to be misdirected, or because inaccurate sensing of the high-energy source may give false data.

A misdirected radiation therapy beam may have serious effects on the intended cure of the patient. All high-energy beams such as radiation beams must be considered as potentially harmful, even at levels used in diagnostic procedures, and a misdirected diagnostic beam will usually necessitate a repeat procedure. By reducing the number of these repeats, the system will achieve the goal of reducing unnecessary exposure of patients in diagnostic procedures utilizing X-rays or radioactive isotopes, as well as in therapy procedures.

The method and system of the present invention may be employed to perform a control function, such as producing a warning signal, or shutting off the source of radiation or source of other high-energy beam. In either case, the operator will reposition the patient before continuing the procedure.

It is an object of the present invention to produce a monitoring system which is reliable and highly effective, and easy to use in the presence of normal room light.

Thus, the present invention preferably involves directing a light beam upon a retroreflective element, associated with, mounted on, or adjacent the pertinent portion of the patient's body. The light beam is reflected upon a photocell or some other photoresponsive means. If there is any appreciable movement of the patient's body, the signal from the photocell or other photoresponsive means will be changed, or will otherwise indicate the change of position or movement. Such signal is preferably fed through an amplifier to a relay which can actuate a warning device, and can also, if desired, control or turn off the X-ray tube or any other source of radiation or high energy.

The retroreflective element is preferably in the form of a small piece of retroreflective adhesive tape or other similar sheet material. In this way, the retroreflective element can easily be applied to a pertinent portion of the patient's body.

The light source preferably comprises a lamp, an apertured member to produce a small spot of light from the lamp, and an optical system for focusing the beam upon the retroreflective element. Such an optical system preferably comprises a partially light-transmissive mirror and a lens. The reflected beam is preferably focused by the same lens, through the mirror and upon the photocell.

The signal from the photocell is preferably fed through an amplifier to a relay which may perform various control functions, such as actuating a warning device or turning off the source of radiation, or both.

Further objects, advantages and features of the present invention will appear from the following description, taken with the accompanying drawings, in which:

FIG. 1 is a diagrammatic elevation of a patient-position-monitoring system, to be described as an illustrative embodiment of the present invention.

FIG. 2 is an elevational view, partially in section of the optical system of FIG. 1.

FIG. 3 is a block diagram of the electrical system of FIG. 1.

As shown in FIG. 1, the invention is embodied in a monitoring system **10**, comprising a retroreflective element **12**, mounted on the pertinent portion of the patient's body **14**. Preferably, the retroreflective element **12** takes the form of a small piece of retroreflective tape or other sheet material, with adhesive material on the back side thereof, so that the element **12** can easily be stuck to the patient's body. The adhesive material is preferably of the pressure sensitive, permanently tacky tape.

The retroreflective element **12** is preferably applied to the patient's body at or near the site of the patient's exposure to radiation. If the patient is immobilized, then the element **12** may be applied to the table or couch to which the patient is fixed. The size of the retroreflective element is chosen according to the required tolerance for displacement of the patient. Thus, any movement of the retroreflective element out of the light beam will indicate that the irradiated portion of the patient's body has moved more than a prescribed amount.

A light beam **16** is projected upon the retroreflective element **12** and is reflected back by the element. The material of which the retroreflective element is made has the characteristic that any impinging light beam is reflected directly back, along its path of impingement, even if the surface is not normal to the path of impingement of the light beam. Such a material is available from the 3M Company and has been used for making reflective highway signs and the like.

A retroreflective target with the coaxial light source and detector described herein achieves a high contrast between the target and the background in the presence of normally encountered ambient light.

The light beam is produced and is also utilized by an optical unit **18**, shown in section in FIG. **2**. The light is produced by a lamp **20** and is directed through a small aperture **22** in a plate **24** or the like. In effect, a small spot of light is produced at the aperture **22**. The lamp **20** is mounted in a housing **26**.

The small spot of light is projected upon the retroreflective element **12** by a mirror **28** and a lens **30**, mounted in a tubular housing **32**. The mirror **28** is at an oblique angle to the optical axis of the lens **30**, so that the lamp **20** and the apertured plate **24** can be disposed laterally from the axis of the lens. As shown, the light beam is reflected at an angle of about 90° by the mirror **28**. The lens **30** focuses the light beam so as to produce an image of the small spot of light, on the retroreflective element **12**. Although a lens such as that illustrated in the drawings will function satisfactorily, an axicon lens system will perform in a superior manner in this application. Axicon lenses are described in U.S. Pat. No. 2,759,393, and are used in coaxial light-emitting systems. In the present invention and axicon lens achieves a sharp focus over an extended distance to enhance the utility of the system.

The light beam is reflected back through the lens **30** by the element **12** and is focused upon photoresponsive means, illustrated as comprising a photosensitive device such as photocell **34**, disposed behind the mirror **28**. While the mirror could be apertured, it is preferably of the type having a reflective coating which is partially light-transmissive. Thus, the reflected beam is able to pass through the mirror to the photocell **34**. It will be understood that the photocell **34** may be of any suitable type, such as a solid state photodiode.

The reflective element **12** is of small size so that any appreciable or medically significant movement by the patient will move the element **12** out of the path of impingement of light beam **16**, hence will cause a change in the amount of light reflected to the photocell **34**. That is because the retroreflective element will be moved out of the path of the beam of light and thus the light beam will not be reflected back to the photocell. As such, the electrical signal produced by the photocell **34** will exhibit a corresponding change.

As shown in FIG. **3**, the output signal from the photocell is preferably fed into an amplifier **36** which produces a corresponding amplified output, adapted to operate a control relay **38** or the like. The control relay **38** may be arranged to perform various control function, such as actuating a warning device **40**, when the reflected light beam is diminished in magnitude by movement of the patient. The control relay **38** may also be arranged to shut off or deactivate the radiation source, shown as an X-ray tube **42**. It will be understood that the radiation source may comprise any other suitable means for producing radiation, such as an atomic irradiator utilizing radioactive cobalt, for example, or may comprise other means for producing a high-energy beam, such as a laser beam, for example.

The optical unit **18** may have a swivel mounting bracket **44** which provides for universal adjustment, so that the light beam can easily be aimed at the retroreflective element **12**. The bracket **44** is secured to a wall **46** or any other suitable support. In some cases, the optical unit may be mounted on the carriage which supports the X-ray tube **42**. The unit may also be mounted rigidly in the room or affixed to the equipment to serve as a pointer for positioning the patient.

In the operation of the patient position monitoring system, the retroreflective element **12** is mounted on the patient's body, at or near the intended site of the diagnostic procedure or therapy. When the patient has been properly positioned, the light beam **16** is aimed so that it falls directly upon the retroreflective element **12**. The medical procedure is then commenced.

If the patient moves appreciably, the reflected light, projected upon the photocell **34**, diminishes. The resulting signal produced by the photocell may be amplified by amplifier **36**, and is employed to actuate the warning device **40**, and also preferably to deactivate the X-ray tube **42** or other high-energy beam source. The warning device **40** may comprise a buzzer, bell, lamp or the like. In response to the warning, the operator repositions the patient so that the procedure can be completed.

The monitoring system is applicable to certain types of diagnostic X-rays, to X-ray therapy, and to other radiation and high-energy source therapy and diagnostic procedures. Thus, the high-energy source may be a remote beam source, or, for example, a radioactive source administered to the patient, the emission of which is scanned and detected externally of the patient in a known manner. Indeed the system may utilize the eye as the retroreflective element in certain diagnostic and therapeutic procedures.

It will be recognized that the patient position monitoring system is highly reliable and effective, yet is easy to use.

Various modification, alternatives and equivalents can be employed. Thus, for example, it is possible to interchange the positions of the photocell **34** and the lamp **20**, with its apertured plate **24**. Further a concave mirror or mirrors may be used for focusing the emitted and reflected light beams, instead of a lens or lenses.

Also, for example, a continuous laser or a light emitting diode can be used for the light beam source. Such a diode is essentially a point source of light, which can be focused by means of a lens upon the retroreflective element. An optical system is used in connection with the laser, to form a narrow beam of light. The retroreflective element may comprise a corner reflector of mirrors, prisms or transparent jewels, to be attached to the patient's body.

What is claimed is:

1. In combination with a radiation source to be used with a patient in a medical therapeutic or diagnostic procedure, a patient-position-monitoring system comprising a retroreflective element adjacent the pertinent portion of the patient's body, a remote source for directing a beam of light upon said retroreflective element, said light beam being reflected by said element, photoresponsive means for remotely receiving the reflected light beam from said element to develop a signal indicative of any medically significant change in the position of the patient, and means responsive to said signal for signalling said change in position.

2. A system according to claim **1**, in which said retroreflective element comprises a piece of retroreflective material having an adhesive backing for securing said material to the pertinent portion of the patient's body.

3. A system according to claim **1**, in which said light beam source includes a lamp, an apertured member restricting the light from said lamp to a small spot, and means for focusing said small spot upon said retroreflective element.

4. A system according to claim **1**, in which said light beam source comprises a laser beam source.

5. A system according to claim **1**, in which said light beam source includes a light-emitting diode, and means for focusing the light beam from said diode on the retroreflective element.

6. A system according to claim **3**, in which said focusing means comprises a mirror and a lens, said mirror being disposed at an oblique angle to the optical axis of said lens.

7. A system according to claim **6**, in which said photoresponsive means comprising a photosensitive device disposed behind said mirror, said mirror being partially light-transmissive, the reflected light beam being adapted to be focused by said lens, through said mirror and upon said photosensitive device.

8. A system according to claim **1**, in which said light beam source includes means for developing a small spot of light, and a partially light-transmissive mirror and a lens for projecting said spot upon said retroreflective element, the reflected light beam being adapted to be projected upon said photoresponsive means through the agency of said lens and said mirror.

9. In the combination of claim **1** in which said radiation source remotely produces a radiant energy beam directed toward the patient, and said means responsive to said signal controls said radiation source.

10. In the combination of claim **9**, wherein said controlling means is adapted to deactivate said radiation source.

11. In the combination of claim **9**, wherein the retroreflective element is secured to the patient.

12. A system according to claim **9**, in which said light beam source includes means for developing a small spot of light, and a partially light-transmissive mirror and a lens for projecting said spot upon said retroreflective element, the reflected spot of light being adapted to be projected upon said photoresponsive means through the agency of said lens and said mirror.

13. In the combination of claim **12** in which said lens is an axicon lens.

14. A patient position monitoring system for use during a medical procedure involving the exposure of a patient to radiation and for controlling a radiation source comprising: a radiation source, a retroreflective element to be mounted closely adjacent the pertinent portion of the patient's body to be exposed to said radiation, a light source for directing a beam of light upon the retroreflective element, said light beam being reflected by said element, photoresponsive means for receiving the reflected light beam from said retroreflective element to develop a signal indicative of any substantial change in the position of the patient from a first position, and means connected between said photoresponsive means and said radiation source and operative to deactivate said radiation source in response to a change in the signal from said photoresponsive means.

15. A method of sensing medically significant changes in the position of a patient during a medical radiant energy exposure procedure, comprising the steps of mounting a retroreflective element adjacent the patient's body, remotely directing a beam of light upon the retroreflective element, and remotely directing the resulting reflected light beam from the retroreflective element.

16. A method according to claim **15**, comprising the further step of performing a control function in response to a change in the reflected light beam.

17. A method according to claim **15**, comprising the further step of producing a warning signal in response to a change in the reflected light beam.

18. A method according to claim **15**, comprising the further step of discontinuing the medical procedure in response to a change in the reflected light beam.

19. A method of responding to a medically significant change of position of a patient during a medical procedure comprising the steps of providing a retroreflective element in a fixed relation adjacent the pertinent portion of the pateint's body, directing a beam of light from a remote position toward the retroreflective element, remotely detecting the reflected beam of light from said retroreflective element, producing a warning signal in response to a medically significant change of position of the patient from a first position to another position, and discontinuing the medical procedure in response to said warning signal.

20. A method according to claim 19, comprising the further steps of beaming radiant energy toward the patient, and discontinuing said beaming in response to the signal.

21. A method according to claim 20 in which the retro-reflective element is mounted on the patient.

* * * * *

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,629,594 Dated December 21, 1971

Inventor(s) Glen Sandberg

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 4, Claim 19, line 66, "pateint's" should be -- patient's --;

Column 5, Claim 21, line 4, "20" should be -- 19 --.

Signed and sealed this 31st day of October 1972.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents