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[54] **MULTI-BEAM LASER PRINTER WITH BEAM SPACING DETECTION DURING BLANKING TIME**

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[58] Field of Search 347/250, 257; 346/107.1, 107.4; 358/296, 480, 481

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[56] **References Cited**

U.S. PATENT DOCUMENTS

4,404,521 9/1983 Kitamura 346/76 L
4,622,564 11/1986 Kaku 346/107 R

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Related U.S. Patent Documents

Reissue of:

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Filed: **Apr. 23, 1986**

U.S. Applications:

[63] Continuation of application No. 07/480,935, Feb. 16, 1990, abandoned.

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[51] Int. Cl.⁷ **B41J 2/435**

ABSTRACT

In a laser printer wherein a photoconductive drum is scanned by utilizing a plurality of laser beams, there are detected spacings between the plural laser beams, such detection being confined to a blanking time. On the basis of the detected results, the spacings between the plural laser beams are controlled; and this state is maintained for a printing time. With this arrangement, it is possible to accurately detect the spacings between the plural laser beams thereby to obtain the practicable laser printer employing the plural laser beams.

39 Claims, 2 Drawing Sheets

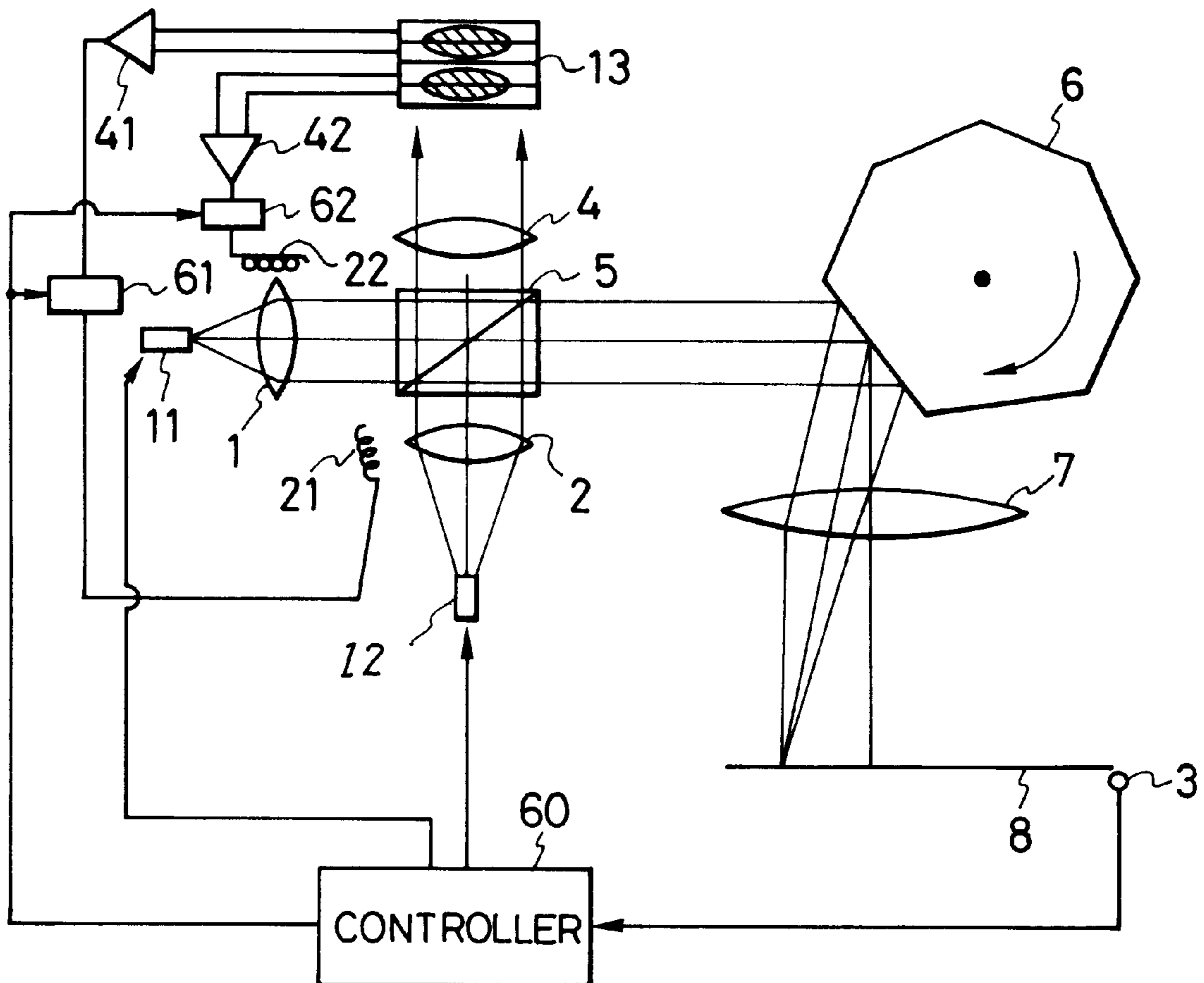


FIG. 1

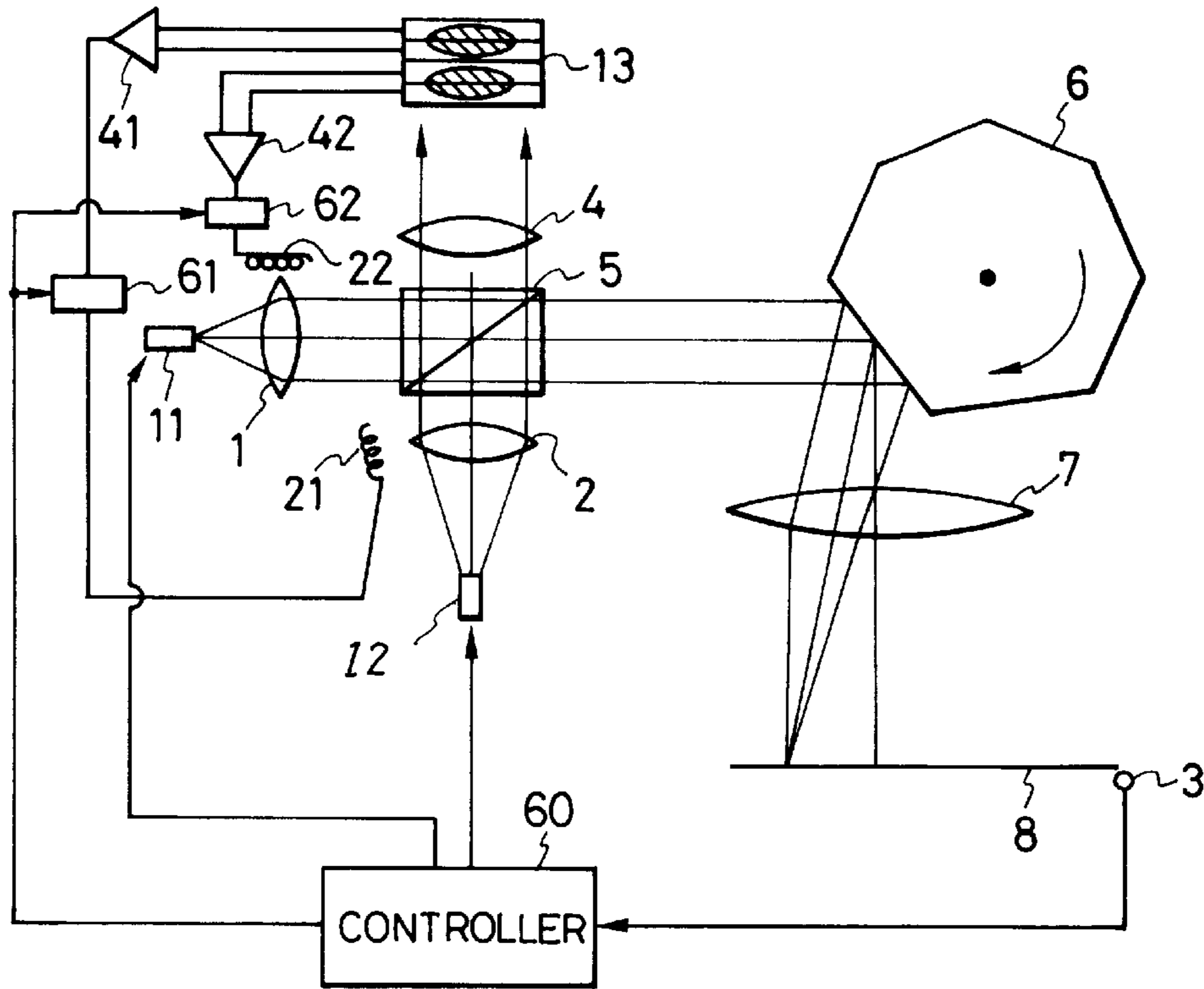


FIG. 2

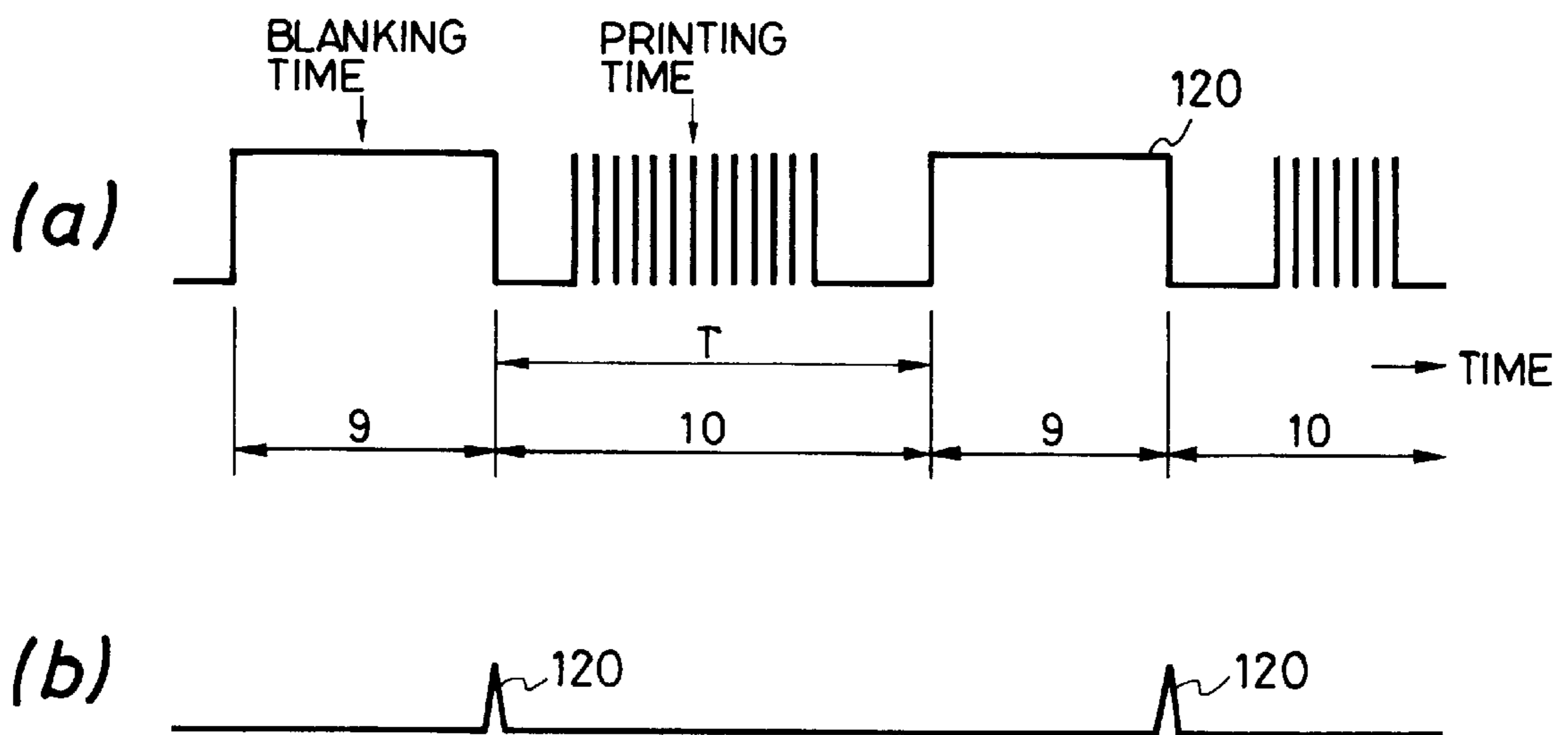
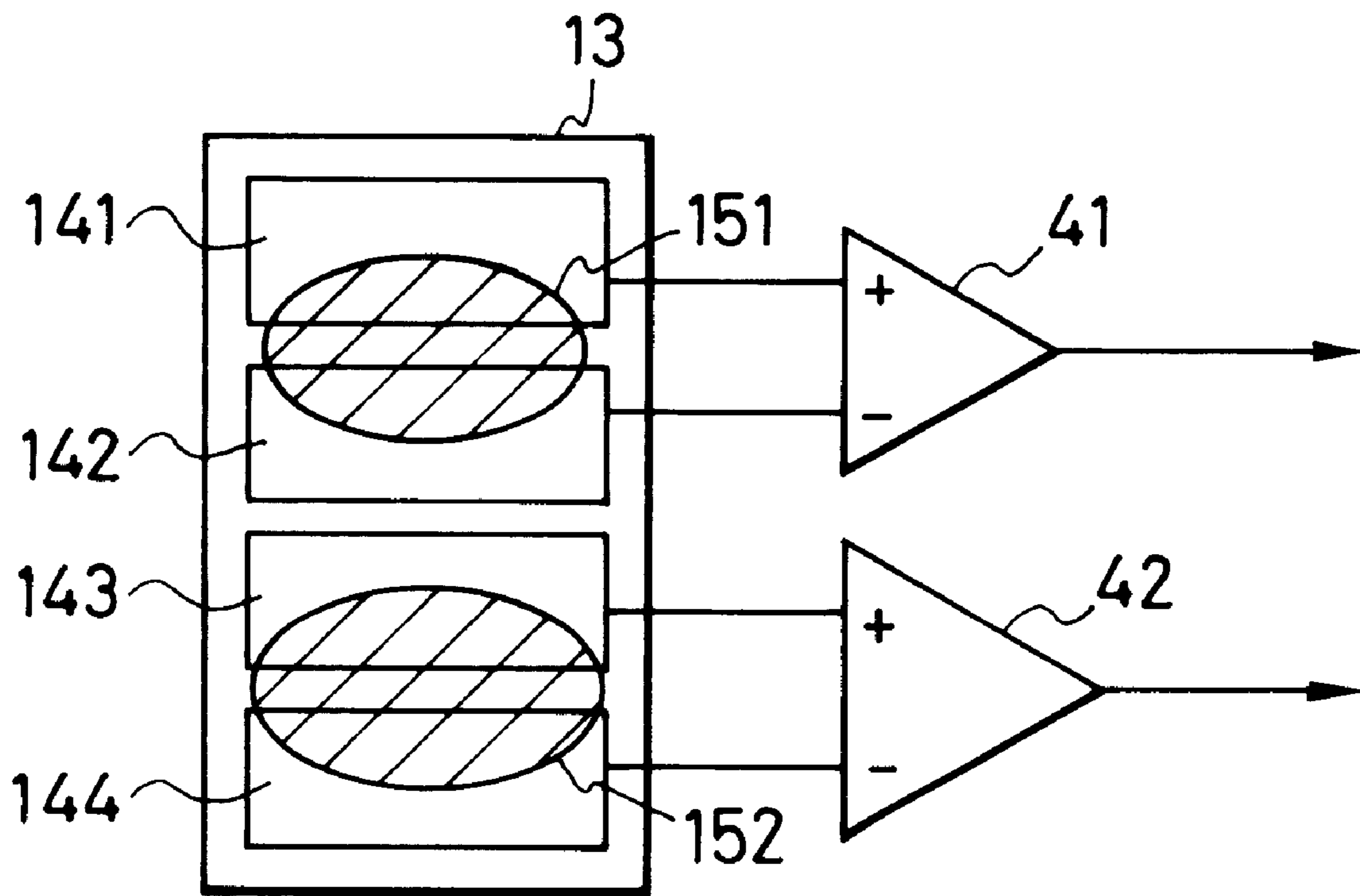


FIG. 3



MULTI-BEAM LASER PRINTER WITH BEAM SPACING DETECTION DURING BLANKING TIME

Matter enclosed in heavy brackets [] appears in the original patent but forms no part of this reissue specification; matter printed in italics indicates the additions made by reissue.

This application is a continuation application of Ser. No. 07/480,935, filed Feb. 16, 1990, now abandoned, which is a reissue application of U.S. application Ser. No. 06/854,947, filed on Apr. 23, 1986, now U.S. Pat. No. 4,725,855, issued Feb. 16, 1988.

BACKGROUND OF THE INVENTION

The present invention relates to a laser printer which is capable of printing high grade characters and images by scanning laser beams.

A conventional laser printer whose printing velocity is medium or low usually utilizes a single diode laser beam. On the other hand, a printer in which the printing is effected at an extra-high speed is at present arranged such that the single gas laser beam is intactly employed, or this single gas laser beam is divided into plural gas laser beams by means of an acoustic optical deflector; and both the frequency band region of a modulator and the rate at which a rotating polygonal mirror rotates are reduced by scanning the plural gas laser beams simultaneously.

In either case, however, so far as the gas laser is employed as mentioned above, it is impossible to steer clear of the large consumption of electricity and miniaturize the apparatus. Under such circumstances, there is recently focussed an introduction of a semiconductor laser which is capable of executing direct modulation for itself. However, this kind of semiconductor laser involves defects wherein the wavelength thereof is 1.5~2-fold as long as that of the gas laser, which requires a large-sized configuration of the rotating polygonal mirror, and it has been quite difficult to constitute a laser printer by using a single laser beam on account of deteriorated photoconductivity which responds to a long wavelength of the foregoing semiconductor laser.

Such being the case, there is a growing expectation in a method where parallel scanning is effected by making use of a plurality of semiconductor laser beams. Some means for actualizing this end have been disclosed in the specifications of U.S. patent application No. 680497, West German patent application No. P3445751.8, U.S. patent application No. 804940 and West German patent application No. P3543472.4 with which some of the inventors of the present invention are associated. However, provided that the printing is performed during the detection of the spacings between plural semiconductor laser beams, it is inconveniently unfeasible to accurately detect it.

SUMMARY OF THE INVENTION

Accordingly, it is a primary object of the present invention which obviates the above-described problems to provide a laser printer which is capable of precisely detecting spacings between a plurality of laser beams thereby to control the desired spacings. To accomplish this end, the present invention is characterized such that there is prescribed a timing at which to detect the spacings between the aforementioned plural laser beams.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a view showing a constitution of a laser printer of one embodiment according to the present invention, the

laser printer utilizing a plurality of laser beams to control the spacings therebetween;

FIG. 2 is a view showing the timing at which locations of the laser beams relative to this invention are detected; and

FIG. 3 is a view showing a constitution of a photodetector for detecting the spacings between the plural laser beams relative to the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to FIG. 1, there is shown a laser printer which employs two semiconductor lasers of one embodiment according to the present invention.

Laser beams respectively emitted from two lasers 11, 12 pass through a synthesizing prism 5 where the laser beams are synthesized in the same direction at such a spacing that the two laser beams slightly deviate from each other. In the wake of this, the beams are directed toward a rotating polygonal mirror 6 and then turns to an F θ lens 7 serving as a scanning lens. On a photoconductive drum 8, the two laser beams are adjusted to a predetermined spacing, and at the same time, it is required to render this spacing immutable. As shown in FIG. 1, for this purpose is proposed an apparatus in which the spacing between the two laser beams is read with the aid of a divided detector 13 by making use of the light which is partially leaked out of the prism 5 designed for synthesizing the beam; and the above-described spacing is controlled by virtue of the resultant signal.

The laser printer employing the semiconductor, however, creates the following drawback. It is feasible for the laser itself to modulate at a printing time, so that the modulated light enters the divided detector 13. As a result, intensity of the laser beams varies and hence it is difficult to detect the position thereof. Consequently, as for the present invention, the arrangement is such that the detection is carried out within a blanking time for which the printing is not effected; the spacings between the laser beams are controlled on the basis of the thus detected results; and this state is maintained in a printing time. If the rotating polygonal mirror is commonly used, an angle at which the light is theoretically able to scan in the case of an n-faced mirror can be given by:

$$360/n$$

Inasmuch as the light which is incident upon the rotating polygonal mirror usually has a specified magnitude, it is common that the actual angle at which the photo-scanning is performed on the polygonal mirror comes to 60~70% of the above-described theoretical value.

Accordingly, a period of 60~70% is, as described above, employed for printing, whereas a period of 30~40% is defined as non-scanning time. Generally speaking, this non-scanning time is considered to be rather disadvantageous, since effective utilization of the laser beams is unfeasible during this time. The present invention, however, is characterized in detecting the position by setting the two laser beams in a state of "ON" for this blanking time. FIG. 2(a) shows the timing relative to modulation of semiconductor lasers (marked with 11, 12 in FIG. 1) of an embodiment according to the present invention. Namely, in case that the positional control is conducted with respect to the two laser beams which are respectively emitted from the semiconductor lasers 11, 12 by the use of a signal (hereinafter referred to as a spacing error signal) which is detected for the blanking time, it is, as mentioned before, not easy to obtain the spacing error signal for the printing time. Hence the

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so-called sample holding mode is adopted, wherein the
aforecited positional control is performed by using the
spacing error signal obtained for the blanking time only, and
such a state is arranged to be kept for the printing time. A
blanking time **9** can be detected as follows. It can be
observed through FIG. 1 that the photodetector **3** is disposed
outside a print starting position on the scanning line for the
laser beam, this photodetector **3** being designed for setting
the start timing at which the laser beam is scanned. To be
specific, the time just when the scanning laser beam passes
through the photodetector **3** is defined as the scanning start
timing. The timing positions are indicated by the reference
numeral **120** in FIGS. 2(a), 2(b). It is to be noted that FIG.
2(b) shows the timing of an output signal emitted from the
photodetector **3**. A width **T** of a scanning period **10** for which
the scanning is effected with respect to a predetermined
width measured from the point **120** is expressed such as:

$$T=L/(4\pi n f)$$

where **L** is the printing width of a rotating polygonal mirror,
n is the number of revolution thereof, and **f** is the focal
length of the **F θ** lens **7** employed therein. After traversing the
width **T**, the blanking time **9** is present. For this period, the
laser beam continue to light up on direct current. Namely,
the blanking time **9** is a time till the laser beam in the next
scanning plan comes to the photodetector **3** again. The
divided type photodetector **13** detects the spacing error for
the blanking time. A configuration of such a photodetector
is, as described at full length in the specifications of U.S.
patent application Ser. No. 680,497 or West German patent
application No. P3445751.8, typified by that of the photo-
detector **13** shown in FIG. 3. The photodetector **13** is
constituted by two pairs of divided detectors **141**, **142** and
143, **144** and is arranged to read the positions of the
respective laser beams by a differential motion.

In FIG. 3, suppose that the laser beams on the detectors
151, **152** are so located as to be impartially applied to the
divided detectors **141**, **142** and **143**, **144**, the foregoing
differential output is zero. However, if the beams are located
so that they are asymmetrically applied thereto, there
appears a differential signal which displays the differential
output corresponding to the positions of the laser beams.
Consequently, there are provided controllers **61**, **62** consist-
ing of, for example, a gain adjusting unit or the like which
has a function to effect a negative feedback with a view to
controlling actuators **21**, **22**. With this arrangement, the
differential signal remains to be zero, this signal being
obtained by means of differential devices **41**, **42** (for
instance, a differential amplifier or the like) shown in FIG.
1.

Coupling lenses **1**, **2** are moved by dint of the motion of
the actuators **21**, **22** in such a way that the surfaces of the
lenses are so directed to be perpendicular to the optical axes,
whereby two spots irradiated with the laser beams are
adjusted in order that no positional deviation is produced.

With the aid of the signals (See FIG. 2(b)) created when
the scanning laser beams shown in FIG. 1 passes through the
detector **3**, the controller **60** shown in the same Figure
performs controlling operations with respect to "ON" and
"OFF" of the laser beam, the sample holding processing,
detection of the spacing error signal and the timing of
various kinds of operations as in the case of the actuators **21**,
22 by which the above-described differential signal comes to
zero.

As can be clarified from the description thus far made, the
present invention yields the following effects.

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An output-load of the laser for use is reduced by executing
the positional control of the aforementioned laser beams.
Moreover, it is feasible to actualize an extra-speed laser
printer which is capable of effectively decreasing a light
modulation frequency of the laser.

What is claimed is:

1. A laser printer comprising: a source for generating a
plurality of laser beams;
an optical device deflecting said plural laser beams for
scanning;
a printing photoconductive drum scanned simultaneously
and parallelly by specific irradiation of said [polarized]
plural laser beams;
a detector for optically detecting deviation in spacings
between said plural laser beams by making use of part
of said plural laser beams; and
actuators for adjusting spots irradiated with said plural
laser beams in response to an output signal of said
detector, wherein
there is provided a controller which performs a control-
ling operation so that the detection of positional devia-
tion relative to the spacings between said laser beams
is carried out only for a blanking time associated with
said laser printer.
2. A laser printer as set forth in claim 1, wherein opera-
tional timing of a controlling means for detecting said
blanking time is effected with the aid of an output signal of
a photodetector for detecting a scanning start point provided
in the vicinity of a print starting position on the scanning line
for said laser beam on said printing photo conductive drum.
3. A laser printer as set forth in claim 1, wherein said
source for generating said plural laser beams is constituted
by a plurality of semiconductor lasers.
4. A laser printer as set forth in claim 1, wherein said
controller controls said source for generating a plurality of
laser beams so that said laser beams are in the ON condition
without intensity variation thereof during said blanking time
so as to enable accurate detection of positional deviation
relative to the spacings between said laser beams.
5. A laser printer as set forth in claim 3, wherein there is
provided a prism for synthesizing said plural laser beams
from said source in the same direction at such spacings that
said plural laser beams slightly deviate from each other.
6. A laser printer as set forth in claim 5, wherein said
detector receives beams which are partially taken out of said
prism.
7. A laser printer as set forth in claim 1, wherein there is
provided a scanning lens between said optical device for
deflecting said plural laser beams and said printing photo-
conductive drum.
8. A laser printer as set forth in claim 7, wherein said
scanning lens is an **F θ** lens.
9. A laser printer as set forth in claim 1, wherein said
optical device is a rotating polygonal mirror.
10. A laser printer comprising:
a plurality of semiconductor lasers generating a plurality
of laser beams;
a prism synthesizing said plural laser beams in the same
direction and with slightly deviated positions from each
other;
a deflector deflecting said plural beams for scanning;
a photoconductive element scanned parallelly on the sur-
face thereof by said plural laser beams;
a detector detecting deviation between said plural laser
beams on said surface by part of said plural laser
beams; and

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actuators adjusting the positions of said plural laser beams from each other on said surface in accordance with said detected deviation within a blanking time of said laser printer.

11. A laser printer as set forth in claim 10, wherein there are provided a photodetector which detects each printing start timing for scanning lines on said surface of said photoconductive element and a controller which is connected to said actuators and said photodetector, said controller controlling operations of said actuators in accordance with an output signal of said photodetector so that the positions of said plural laser beams on said surface are adjusted in accordance with said detected deviation within a blanking time of said laser printer and are kept for a printing time of said laser printer.

12. A laser printer as set forth in claim 11, wherein said controller is connected to said plural semiconductor lasers and controls said plural semiconductor lasers so that said laser beams are in the ON condition within said blanking time in order to detect the deviation between said laser beams.

13. A laser printer as set forth in claim 11, wherein said detector receives beams which are partially taken out of said prism.

14. A laser printer as set forth in claim 11, wherein there is provided a scanning lens between said deflector and said photoconductive device.

15. A laser printer as set forth in claim 14, wherein said scanning lens is an F θ lens.

16. A laser printer as set forth in claim 11, wherein said deflector is a rotating polygonal mirror.

17. A laser printer as set forth in claim 11, wherein said detector has a plurality of segments combined with each other so as to receive respective images of said plural laser beams and detects the deviation between said plural laser beams on the basis of a relation between the segments.

18. A laser printer comprising:

a source for generating a plurality of laser beams;

a deflector deflecting said plural laser beams for scanning;

a photoconductive device scanned parallelly on the surface thereof by said plural laser beams;

a detector detecting deviation between said plural laser beams on said surface by part of said plural laser beams;

actuators connected to said detector and adjusting the positions of said plural laser beams on said surface in accordance with said detected deviation within a blanking time of said laser printer;

a photodetector detecting a predetermined position corresponding to each start position of an effective part of said surface for printing; and

a controller connected to said actuators and said photoconductor, said controller controlling the operations of said actuators in accordance with an output signal of said photodetector so that the positions of said plural laser beams on said surface are kept for a printing time of said laser printer.

19. A laser printer as set forth in claim 18, wherein said photodetector is provided to receive said laser beams deflected by said deflector.

20. A laser printer as set forth in claim 18, wherein said source for generating said plural laser beams is constituted by a plurality of semiconductor lasers.

21. A laser printer as set forth in claim 18, wherein said controller is connected to said source for generating a

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plurality of laser beams and controls said source for generating a plurality of laser beams so that said laser beams are in the ON condition within said blanking time so as to detect the deviation between said laser beams.

22. A laser printer as set forth in claim 20, wherein there is provided a prism between said semiconductor lasers and said deflector, said prism synthesizing said plural laser beams from said plural semiconductor lasers in the same direction at spacings such that said plural laser beams slightly deviate from each other.

23. A laser printer as set forth in claim 22, wherein said detector receives beams which are partially taken out of said prism.

24. A laser printer as set forth in claim 18, wherein there is provided a scanning lens between said deflector and said photoconductive device.

25. A laser printer as set forth in claim 18, wherein said deflector is a rotating polygonal mirror.

26. A laser printer as set forth in claim 18, wherein said detector has a plurality of segments combined with each other so as to receive respective images of said plural laser beams and detects the deviation between said plural laser beams on the basis of a relation between the segments.

27. A laser printer comprising:

a source for generating a plurality of laser beams;

a deflector deflecting said plural laser beams for scanning;

a photoconductive device scanned parallelly on the surface thereof by said plural laser beams;

a detector having a plurality of segments combined with each other so as to receive respective images of said plural laser beams and detecting deviation between said plural laser beams and said surface, on the basis of a relation between the segments;

means for maintaining the deviation between said plural laser beams by a negative feedback control operation using said detected deviation so that the positions of said plural laser beams on said surface are held in a predetermined relation;

a photodetector provided in the vicinity of said photoconductive device for detecting a position corresponding to each start position of said surface for printing; and

a controller connected to said maintaining means, said source and said photodetector, said controller controlling the operation of said maintaining means so that said negative feedback control operation is kept during a printing time of said laser printer and controlling said source so that said laser beams are in the ON condition within a period other than said printing time so as to detect the deviation between said laser beams, in accordance with an output signal of said photodetector.

28. A laser printer as set forth in claim 27, wherein said maintaining means includes actuators which are driven in accordance with outputs of said segments.

29. A laser printer as set forth in claim 27, wherein said source for generating said plural laser beams includes a plurality of semiconductor lasers.

30. A laser printer as set forth in claim 27, wherein said photoconductor is disposed so as to receive said laser beams deflected by said deflector.

31. A laser printer as set forth in claim 29, wherein said controller controls said semiconductor lasers so that said laser beams are in the ON condition within said period.

32. A laser printer as set forth in claim 29, wherein there is provided a prism between said semiconductor lasers and

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said deflector, said prism synthesizes said plural laser beams from said plural semiconductor lasers in the same direction and with positions slightly deviated from each other.

33. A laser printer as set forth in claim 32, wherein said detector receives beams which are partially taken out of said prism. 5

34. A laser printer as set forth in claim 27, wherein there is provided a scanning lens between said deflector and said photoconductive device.

35. A laser printer as set forth in claim 27, wherein said deflector is a rotating polygonal mirror. 10

36. A laser printer comprising:

two semiconductor lasers;

a prism synthesizing two laser beams generated from said two semiconductor lasers in the same direction and with positions slightly deviated from each other; 15

a deflector deflecting said two laser beams for scanning;

a photoconductive device scanned parallelly on the surface thereof by said two laser beams;

a detector which has a plurality of segments combined with each other so as to receive respective images of said two laser beams by part of said two laser beams, and which detects a deviation between said two laser beams on said surface on the basis of a relation between the segments; 20

actuators adjusting the positions of said two laser beams on said surface in accordance with said detected deviation; 25

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a photoconductor provided in the vicinity of said photoconductive device to receive said laser beams deflected by said deflector and detecting a position corresponding to each start position of said surface for printing; and

a controller connected to said actuators, said semiconductor lasers and said photodetector, said controller controlling the operations of said actuators so that the positions of said two laser beams on said surface are kept for a printing time of said laser printer and controlling said semiconductor lasers so that said two laser beams are in the ON condition within a blanking time of said laser printer so as to detect the deviation between said two laser beams, in accordance with an output signal of said photodetector.

37. A laser printer as set forth in claim 36, wherein said detector receives beams which are partially taken out of said prism.

38. A laser printer as set forth in claim 36, wherein there is provided a scanning lens between said deflector and said photoconductive device.

39. A laser printer as set forth in claim 36, wherein said deflector is a rotating polygonal mirror.

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