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NOTICE OF ENTITLEMENT

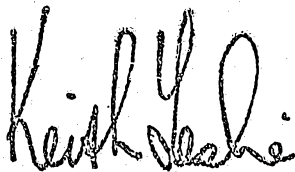
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WE, the above named applicants, state the following:

1. The persons nominated for the grant of the patent have entitlement from the actual inventors as follows:
 - (i) Sumitomo Electric Industries, Ltd. would, on the grant of a patent for the invention to the inventors, Akira INOUE and Yasuji HATTORI, be entitled to have their interests in the patent assigned to it.
 - (ii) Nippon Telegraph & Telephone Corporation would, on the grant of a patent for the invention to the other inventors listed on the patent Request form, be entitled to have their interests in the patent assigned to it.
2. The persons nominated for the grant of the patent are the applicants of the basic application listed on the patent request form.
3. The basic application listed on the request form is the first application made in a Convention country in respect of the invention.



(A member of the firm of DAVIES COLLISON CAVE
for and on behalf of the Applicant)

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- (57) Claim

1. A method for identifying an optical line, comprising the steps of:
forming a plurality of reflecting parts on an optical line along a longitudinal direction of the optical line;
inputting detection light to the optical line;
detecting detection light reflected from the reflected parts; and
identifying the optical line based on a specific combination of specific characteristics of the reflected light.
7. A method for identifying an optical line, comprising the steps of:
connecting a branch optical line to the optical line;
forming a plurality of reflecting parts on the branch optical line along a longitudinal direction of said branch optical line;
inputting detection light to the optical line;

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detecting detection light reflected from the reflected parts; and
identifying the optical line based on a specific combination of specific characteristics of the reflected light.

20. A method for identifying an optical line in a group of optical lines, comprising the steps of:

forming a plurality of bending loss parts on the each optical line as an identification code, the each optical line has a specific combination of relative positions of the plurality;

detecting the relative positions of the plurality based on a backscattering when a detecting light is inputted to the optical line; and

identifying the optical line based on a result of the detecting step.

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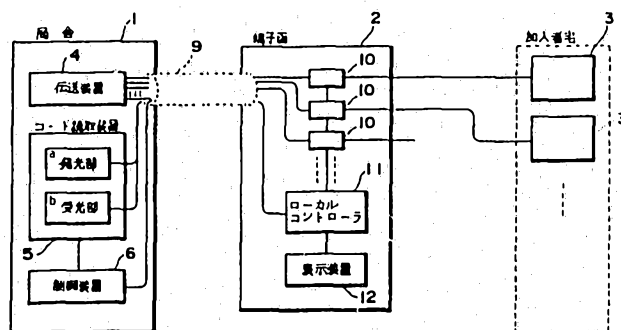
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(54) Title : METHOD FOR IDENTIFYING OPTICAL LINE

(54) 発明の名称

光線路の識別方法



- 1 ... station
- 2 ... terminal box
- 3 ... subscribers' residence
- 4 ... transmitter
- 5 ... code reader
- a: ... light emitting unit
- b: ... light receiving unit
- 6 ... controller
- 11 ... local controller
- 12 ... display

(57) Abstract

A method for easily identifying optical lines without error irrespective of the lengths of the lines. A plurality of reflective parts are provided as an identification mark on each optical line. The combination of the correlative positions of the plural reflective parts of an optical line is different from others. The correlative positions of the reflective parts of a line are determined on the basis of the reflected light of the inspecting light incident upon the optical line. According to the results of the determination, the optical line is identified. More specifically, when inspecting light is incident on the end of an optical line, the light is reflected by the plural reflective parts which function as an identification mark, and is caused to return to the incident end. Since the combinations of the correlative positions of the reflective parts are different from each other, the correlative positions of the plural reflective parts of an optical line are found by measuring the differences between the lengths of the optical paths of the optical lines from the reflective parts by use of an interferometer or by measuring the differences in the times for the reflected light to return from the reflective parts. The optical lines can be identified on the basis of the results of such measurement.

1. DESCRIPTION

Method for Identifying Optical Line

5 TECHNICAL FIELD

This invention relates to a method for identifying an optical line at one end thereof which is used in optical communication system.

BACKGROUND ART

10 A method for identifying an optical line by varying a refractive index of an optical line core in part, and detecting a position of the varied refractive index part at one end of the optical line using the OTDR method has been known ("Remote Fiber Discrimination Method for an Optical Transmission Line Database", 1991, DENSI JYOHOU TSUSIN
15 GAKKAI SHUKI TAIKAI, Reference B-591).

However, according to this method, an identification code composed of the varied refractive index parts on the optical line extends over hundreds meters. For instance, in an example of the reference described above, to record a
20 8 bits identification code on the optical line requires a 50m for a bit and a total of 400m. Accordingly, it is difficult to apply the identification code to a short optical line. Recording the identification code extending over hundreds meters on the optical line has to be done
25 during a manufacturing process of the optical line, which is not practical.



DISCLOSURE OF THE INVENTION

An object of this invention is to provide a method for identifying an optical line easily and accurately regardless of the optical line length.

5

According to a first aspect of the invention there is provided a method for identifying an optical line, comprising the steps of:

forming a plurality of reflecting parts on an optical line along a longitudinal direction of the optical line;

10 inputting detection light to the optical line;

detecting detection light reflected from the reflected parts; and

identifying the optical line based on a specific combination of specific characteristics of the reflected light.

15 When the detecting light is inputted to one end of the optical line, the light is reflected at the plurality of the reflecting parts, and comes back to the input end. A combination of the relative positions of the reflecting parts is changed for every optical line. To detect the relative positions of the reflecting parts forming an identification code, either the optical path difference of the reflected lights is measured with the
20 interferometer or the time difference between the reflected lights coming back from the reflecting parts is measured, so that optical line can be identified based on the result.

Preferably, the method includes the steps of:

forming the plurality of the reflecting parts on the optical line as an identification
25 code, each reflecting part reflecting light having a specific wavelength, and the optical line having a specific combination of the specific reflecting wavelengths; and

detecting wavelengths of the reflected light to thereby identify the optical line.

30 When the detecting light is inputted to one end of the optical line, the light is reflected at the reflecting parts which form an identification code and comes back to the input end. As a combination of the wavelengths of the reflected lights at the reflecting parts is changed for every optical line, the wavelengths of the reflected lights are



measured, so that the optical line can be identified based on the result.

Preferably further, the method includes the steps of:

5 forming the plurality of the reflecting parts on the optical line as an identification code, each reflecting part reflecting a light having a specific wavelength, and the optical line having a specific combination of the specific reflecting wavelengths and reflectance; and

10 detecting wavelengths and reflectance of the reflected light to thereby identify the optical line.

When the detecting light is inputted to one end of the optical line, the light is reflected at the reflecting parts which form an identification code and comes back to the input end. As a combination of the wavelengths and reflectances of the reflecting parts is changed for every optical line, the wavelengths and the light intensities of the reflected lights are measured, and based on the result, the optical line can be identified.

Preferably further, the method includes the steps of:

20 forming the reflecting part on the optical line as an identification code, the reflecting part on the optical line having a specific reflectance characteristic depending on a wavelength; and

detecting reflected light spectra coming back from the reflecting parts when the detection light is inputted to the optical line to thereby identify the optical line.

25 When the detecting light is inputted to one end of the optical line, the light is reflected at the reflecting parts which form an identification code and comes back to the input end. As a reflectance characteristic depending on a wavelength of the reflecting parts is changed for every optical line, the reflected light spectra are measured, and based on the result, the optical line can be identified.

30 The invention also provides a method for identifying an optical line, comprising the steps of:

connecting a branch optical line to the optical line;



forming a plurality of reflecting parts on the branch optical line along a longitudinal direction of said branch optical line;

inputting detection light to the optical line;

detecting detection light reflected from the reflected parts; and

5 identifying the optical line based on a specific combination of specific characteristics of the reflected light.

When the detecting light is inputted to one end of the optical line, the light is reflected at the reflecting parts which form an identification code and comes back to the input end. As a combination of the specific wavelengths and relative positions of the reflecting parts is changed for every optical line, the wavelengths and arrival times of the reflected lights from the identification code are measured, and based on the result, the optical line can be identified.

15 The invention also provides a method for identifying a multi-core optical line which has a plurality of core optical lines, comprising the steps of:

forming reflecting parts on the core optical lines of the multi-core optical line selectively as an identification code,

the multi-core optical line having a specific combination of existences of the reflecting parts and characteristics of reflections;

20 detecting reflected light when detecting light is inputted to the multi-core optical line;

identifying the multi-core optical line based on a result of the detecting step.

25 When the detecting light is inputted to one end of the optical line, the light is reflected at the reflecting parts which form an identification code and comes back to the input end. As a combination of the bending loss parts is changed for every optical line, a time difference between the backscattering lights coming back from the identification code is measured to detect the relative positions of the bending loss parts, and based on the result, the optical line can be identified.

The invention also provides a method for identifying an optical line in a group



of optical lines, comprising the steps of:

forming a plurality of bending loss parts on the each optical line as an identification code, the each optical line has a specific combination of relative positions of the plurality;

- 5 detecting the relative positions of the plurality based on a backscattering when a detecting light is inputted to the optical line; and
 identifying the optical line based on a result of the detecting step.

10 When the detecting light is inputted to one end of the multicore optical line, the light is reflected at the reflecting parts which form an identification code and comes back to the input end. As a combination of the existence of the reflecting parts on every core optical fiber is changed for every multicore optical line, the existence of the reflected lights on the core optical fibers is measured, so that the optical line can be identified.

15 In the methods defined above, the identification code is placed directly on the optical line, but instead of this, it is possible to apply a branch optical line having the identification code to the optical line.

20 The invention also provides a method for identifying an optical line, comprising the steps of:

 connecting a branch optical line on the optical line,

 placing a plurality of bending loss parts on the branch optical line as an identification code, the each branch optical line has a specific combination of relative
25 positions of the plurality;

 detecting the relative positions of the plurality based on a backscattering when a detecting light is inputted to the optical line; and

 identifying the optical line based on a result of the detecting step.

30 BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a block diagram of a control system of optical lines facility which is applied to a method for identifying an optical line of this invention.



Fig. 2 is a block diagram of an inner structure of a code reading device and its peripheral devices according to a first embodiment of the invention.

Fig. 3 shows an example of an identification code.

Fig. 4A and Fig. 4B show a method for converting an interferogram to a binary code information.

Fig. 5 shows a branch optical line on which an identification code is formed.

Fig. 6 is block diagram of another structure of a code reading device.

Fig. 7 is a graph of a detecting result.

Fig. 8 is a block diagram of an inner structure of a code reading device and its peripheral devices according to second, third and fourth embodiments of the invention.

Fig. 9A shows an example of an identification code according to the second, third and fifth embodiments of the invention.

Fig. 9B shows an example of an identification code according to the second, third and fifth embodiments of the invention.

Fig. 10A is a graphic representation which shows a method for converting a reflected light to a binary code information according to the second and fifth embodiments.

Fig. 10B is a table which shows a method for converting a reflected light to a binary code information according to the second and fifth embodiments.

Fig. 11 shows a branch optical line on which an information code is formed.

Fig. 12 is a block diagram of a structure of another code reading device according to the second, third and fourth embodiments.

Fig. 13 is a perspective view of a structure of another reflecting part according to the second, third, fourth and fifth embodiments.

Fig. 14 is a perspective view of a structure of another reflecting part according to the second, third, fourth and fifth embodiments.

Fig. 15A is a graphic representation which shows a method for converting a reflected light spectrum to a quaternary code information according to the third embodiment.

Fig. 15B is a table which shows a method for converting a reflected light spectrum to a quaternary code information according to the third embodiment.

Fig. 16A is a perspective view which shows a method for writing down an



identification code according to the second, third, fourth and fifth embodiments.

Fig. 16B is a perspective view which shows a method for writing down an identification code according to the second, third, fourth and fifth embodiments.

Fig. 16C is a perspective view which shows a method for writing down an
5 identification code according to the second, third, fourth and fifth embodiments.

Fig. 17A is a graphic representation which shows a method for converting a reflected light spectrum to a binary code information according to the fourth embodiment.

Fig. 17B is a table which shows a method for converting a reflected light
10 spectrum to a binary code information according to the fourth embodiment.

Fig. 18 shows a block diagram of a code reading device and its peripheral devices according to the fifth embodiment.

Fig. 19 shows a method for converting a reflected light to a code information according to the fifth embodiment.

Fig. 20 is a perspective view of an example of a code information according to
15 a sixth embodiment of the invention.

Fig. 21A is a graphic representative which shows a method for converting a backscattering light intensity to a binary code information according to the sixth embodiment.

Fig. 21B is a representative which shows a method for converting a
20 backscattering light intensity to a binary code information according to the sixth embodiment.

Fig. 21C is a table which shows a method for converting a backscattering light intensity to a binary code information according to the sixth embodiment.

Fig. 22 is a block diagram of a code reading device and its peripheral devices
25 according to a second embodiment of the invention.

Fig. 23 is a perspective view of an example of an identification code according to the seventh embodiment of the invention.

Fig. 24 is a table which shows a method for converting existences of reflecting
30 parts to a binary code information according to the seventh embodiment of the invention.





1 connected by one respective line.

2 In the optical connector 10, it can be freely operated
3 by hand to switch connections. Before the switching is
4 conducted, first, a route information of the optical lines
5 is checked by an identifying method described thereafter
6 with a code reading device 5 placed inside of the office 1.
7 Then, the route information is transmitted from a control
8 device 6 to a local controller 11, and the information is
9 given to an operator in the field through a display device
10 12. The operator conducts the requested connector
11 switching based on the route information. After the
12 switching is done, the route information is read again by
13 the code reading device 5, and the route information is
14 confirmed at the office 1 side. Then, this route
15 information is displayed at the display device 12 through
16 the control device 6 and the local controller 11, and the
17 operator confirms the condition of the switching.

18 Fig. 2 is a block diagram of an inner structure of the
19 code reading device 5 and its peripheral devices. The code
20 reading device 5 comprises a light emitting unit 20 and a
21 light receiving unit 21, and they are controlled by a
22 computer 22 and a timing control circuit 23 which form the
23 control unit 6.

24 The light emitting unit 20 contains a light source 24
25 for emitting a light having an appropriate spectrum range
such as white ray, an acoustooptic element 25 for

1 controlling an on/off of an irradiation of light from the
light source 24, and lenses 26, 27 placed respectively at an
input and an output of the acoustooptic element 25. A light
emitted from the light source 24 is inputted to one end of
5 the optical fiber 40 as a detecting light through the lens
26, the acoustooptic element 25 and the lens 27. The
optical fiber 40 is a branch optical line which connects the
optical fibers 50 as optical lines to be measured and the
code reading device 5. The optical fiber 40 is connected to
10 the optical lines 50 with a connecting means 38. The
connecting means 38 alternatively connects the optical
fiber 40 to one of the optical lines 50.

The light receiving unit 21 contains a Michelson
interferometer 30, an A/D convertor circuit 36 for
15 converting an output signal from the Michelson
interferometer 30 to a digital value and providing it to the
computer 22, and an acoustooptic element 31 for controlling
an on/off of an input light to the Michelson interferometer
30 based on a signal from the timing control circuit 23.
20 The numerals 32, 33 denote lenses, and the numeral 34
denotes an optical fiber. The Michelson interferometer 30
contains a movable mirror 300, a fixed mirror 301, a beam
splitter 302, a movable mirror moving device 303, a
position-of-movable-mirror reading device 304, a light
receiving element 305, and lenses 306, 307. A light
25 inputted to the Michelson interferometer 30 from the

1 optical fiber 34 is diverged by the beam splitter 302, and
one is led to the fixed mirror 301 and the other one is led
to the movable mirror 300. The lights reflected by the
mirrors come back to the beam splitter 302, and interfere
5 each other. The interference light is inputted to the light
receiving element 305 through the lens 307 and is converted
to an electrical signal. At this time, as the optical path
length inside of the interferometer is varied by moving the
movable mirror 300, an interference waveform called an
10 interferogram is obtained. This is a principle of operation
of the Michelson interferometer 30. Using this principle,
relative positions of the plurality of reflecting parts
which form an identification code 39 are detected.

Every optical line 50 has unique identification codes
15 39 written in. The identification code 39 consists of the
plurality of reflecting parts, and each optical line has a
different combination of relative positions of the
reflecting parts. The reflecting parts forming the
identification code 39 are notches on the optical line 50,
which are discontinuous points of refractive indices. Fig.
20 3 shows an example of the identification code 39. The
identification code 39 contains 4 notches 51-54, and the
notches 52, 53, 54 are respectively at a distance of 3mm,
10mm and 15mm from the notch 51. Accordingly, if the
detecting light from the light emitting unit 20 is inputted
25 to the optical line 50, the reflected light arrived at the

1 light receiving unit 21 from the identification code 39
includes optical path differences produced on the basis of
distances between notch. The optical path differences are
detected by the Michelson interferometer 30, so that the
5 relative positions of the notches 51-54 can be detected.

The identification code 39 is applied to the optical
lines between the local communication office 1 and the
terminal 2, and to the optical lines between the terminal 2
and the houses of subscribers 3 as shown in Fig. 1. If there
10 is a plurality of terminals between the office 1 and the
houses 3, the identification code is also applied to the
optical lines between the terminals.

Next, a method for reading an identification code 39
will be explained. For instance, if the detecting light is
15 inputted to the optical line 50 applied the identification
code including the four reflecting parts 51-54 as shown in
Fig. 3, the light receiving unit 21 collaborates with the
computer 22 to get an interferogram shown in Fig. 4A. This
means that a main interference light intensity is obtained
when the optical path difference is zero, and sub
20 interference light intensities are obtained for all
combination of two reflecting parts chosen from the
reflecting parts 51-54. Concretely, the sub interference
intensities appear at the optical path difference of 3mm,
5mm, 7mm, 10mm, 12mm, and 15mm.

25 Fig. 4B is a chart of an observational result

1 corresponding to a code information. The 15 bits code
information "001010100101001" is obtained from the
observational result in Fig. 4A. The content of the code
information is set freely as selecting a number of the
5 reflecting parts or positions of the reflecting parts.

In this embodiment, the optical line which connects the
office 1 and the house of subscribers 3 consists of two
divided optical lines connected with the terminal 2. Since
the identification code is applied to every divided optical
10 line, they have to be distinguished and confirmed. For this
reason, the acoustooptic element 31 is used. In other
words, the pulsed detecting light is inputted to the optical
line to be measured on the basis of the control of the
timing control circuit 23, and based on the input timing of
15 the detecting light, the reflected light from every
identification code on the same optical line is
periodically pick up by the acoustooptic element 31.
Therefore, the reflected lights from the identification
codes at different points on the same optical line is
20 distinguished. while the computer 22 distinguishes the
reflected light from every identification code, it obtains
a data of the light intensities of the reflected lights, and
gets the interferogram of every identification code on the
same optical line based on the input timing of the detecting
25 light. Picking up the reflected light periodically can be
achieved with an optical gate (optical deflector) instead

1 of the acoustooptic element 31.

Further, instead of writing the identification code directly to the optical line, a branch optical line 101 in which the identification code is written can be connected thereto with a fiber coupler 102 as shown in Fig. 5.

Fig. 6 is a block diagram of a device for an identifying method according to another embodiment of the invention. The embodiment described above is to detect a relative positions of reflecting parts based on an interference of reflected lights. On the other hand, this embodiment is to detect a relative positions of reflecting parts by measuring an arrival time difference between reflected lights. A light emitting unit 20 contains a semiconductor laser 66 for outputting a pulse light having a short pulse-width, and a laser drive circuit 65. A light receiving unit 21 contains a light receiving element 61, an A/D convertor circuit 62 with memories, and an averaging circuit 63. The numerals 64 and 67 denote lenses respectively.

In this embodiment, a pulsed detecting light is inputted to the optical line 50, and a time variation in the reflected light intensities is measured, so that the code information corresponding to the relative positions of the reflecting parts can be read. Fig. 7 shows a graph of an example of a measurement result according to this embodiment. The ordinate indicates a reflected light intensity and the abscissa indicates a time. This example



1 is to measure the reflected lights from the identification
code having four reflecting parts including the reference
reflecting part (the nearest reflecting part to the
detecting light emitting side). The reflected light 71 from
5 the reference reflecting part is arrived first, and the
reflected lights 72, 73 and 74 are arrived in order of a
distance close to the reference reflecting part. Assuming
the reflecting parts except the reference reflecting part
can be set only at five points equally separated, the 5 bits
10 identification code can be made by existence of the
reflecting part at the each point. In Fig. 7, the code
information "01101" is indicated.

Next, ^{a second} ~~an~~ ^{of the} ~~embodiment, according to a second~~ invention
will be explained. Fig. 8 is a block diagram of an inner
15 structure of a code reading device 5 and its peripheral
devices in case that this embodiment applies to a control
system of optical lines facility shown in Fig 1. A code
reading device 5 contains a light emitting unit 1020 and a
light receiving unit 1021, and they are controlled by a
20 computer 1022 and a timing control circuit 1023 which form
a control circuit 6.

The light emitting unit 1020 contains a light source
1024 for emitting a light having an adequate spectrum range.
such as white ray, an acoustooptic element 1025 for
controlling an on/off of a light outputted from the light
25 source 1024, and lenses 1026, 1027 placed respectively at



1 an input and an output of the acoustooptic element 1025.
The light emitted from the light source 1024 is inputted to
one end of an optical fiber 40 as a detecting light through
the lens 1026, the acoustooptic element 1025, and the lens
5 1027. The optical fiber 40 is a branch optical line which
connects optical fibers 50 to be measured and the code
reading device 5. The optical fiber 40 is connected to the
optical lines 50 with a connecting means 38. The connecting
means 38 alternatively connects the optical fiber 40 to one
10 of a plurality of the optical lines 50.

The light receiving unit 1021 contains a Fabry-Perot
etalon 1032 as an interference spectroscopy, an etalon
controller 1033 for controlling a space between two plane
boards for a resonance in the etalon 1032, lenses 1030, 1031
15 placed respectively at an input and an output of the etalon
1032, a light receiving element 1034 for converting a light
intensity of the output light from the etalon 1032 to an
electrical signal, a boxcar integrator 1035 for
periodically picking up an output signal from the light
receiving element 1034 based on a signal from a timing
20 control circuit 1023, and an A/D convertor circuit 1036 for
converting an output of the boxcar integrator 1035 to a
digital signal. The etalon 1032 inputs a light from an
optical fiber 41 connected to an optical fiber 40 with a
fiber coupler 37 and analyzes spectra. At this time, the
25 etalon controller 1033 controls a space between resonance



1 planes in the etalon 1032 based on an instruction from a
computer 1022. As the computer 1022 obtains a data from the
A/D convertor circuit 1036 with controlling the etalon
1032, it analyzes a wavelength of the reflected light.

5 Each optical line 50 has unique identification codes 39
written in. The identification code consists of a plurality
of reflecting parts. The each reflecting part reflect a
light having a specific wavelength only. The optical line
has a different combination of specific wavelengths of the
10 reflecting parts each other. Every reflecting part forming
the identification code 39 is a striped pattern formed by
varying the refractive index of the optical line 50 locally.
As a spatial frequency of a variation of the refractive
indices is adequately set, every reflecting part can obtain
15 a unique wavelength of the reflected light. As shown in
Fig. 9A, the reflecting part is the striped pattern where
the refractive index is varied over a specific cycle. Let
the cycle of the striped pattern 1100 (a distance between
the refractive index varying points which adjoin each
20 other) is $\underline{d}$ and a mean refractive index of the optical line
at the reflecting part is $\underline{n}$, the wavelength λ of the
reflected light is represented as $\lambda = 2nd$. Accordingly, as
 $\underline{d}$ and $\underline{n}$ are adequately set, the desired wavelength of the
reflected light can be obtained. The reflecting parts 1100
25 obtained in such a way are set at plural points (in Fig. 9B,
five points) on the optical line 50 as shown in Fig. 9B, and



1 as the wavelengths λ_1 - λ_5 of the reflected lights are set
adequately, the identification code can be formed. The
refractive index can be varied permanently as a UV ray
(Ultra Violet Ray) is partly irradiated to the optical line
5 50. By using this, the reflecting part which reflects a
specific wavelength only can be formed.

The identification code 39 is applied to the optical
lines between the office 1 and the terminal 2, and to the
optical lines between the terminal 2 and the houses of
10 subscribers 3 as shown in Fig. 1. If there is a plurality
of terminals between the office 1 and the houses of
subscribers 3, the identification code is also applied to
the optical lines between the terminals.

Next, a method for reading an identification code 39 in
15 this embodiment will be explained. For instance, by using
five wavelengths λ_1 - λ_5 , a binary number is coded. This
means that existence of a reflected light in the five
wavelengths are corresponded to "1" or "0". Fig. 10A is a
graph of an example of wavelength characteristics of the
reflected lights when the detecting light from the light
20 emitting unit 1020 is given to the optical line 50. The
graph shows a wavelength on the abscissa and a light
intensity on the ordinate. In this example, the reflected
lights at wavelengths of λ_1 , λ_3 and λ_5 can be observed, and
on the other hand, the reflected lights at wavelength of λ_2
25 and λ_4 cannot be observed. Fig. 10B is a chart of an



1 observational result corresponded to the code information.
A five bits code information "10101" is obtained from the
result in Fig 10A.

5 In this embodiment, the optical line which connects the
office 1 and the house of subscribers 3 consists of two
divided optical lines connected with the terminal 2. Since
the identification code is applied to every divided optical
line, they have to be distinguished and confirmed. For this
reason, the boxcar integrator 1035 is used. In other words,
10 the pulsed detecting light is inputted to the optical line
to be measured while the input timing is controlled by the
timing control circuit 1023, and the reflected light from
each identification code is periodically picked up based on
the input timing of the detecting light. Therefore, the
15 reflected lights from identification codes whose locations
are different from each other on the same optical line can
be distinguished. As the computer 1022 distinguishes the
reflected light from each identification code, it obtains
a data of the reflected light intensities in correspondence
with the wavelength, so that the computer gets the
20 interferogram of each identification code. The distinction
of reflected light can be achieved with an optical gate
(optical deflector) instead of the boxcar integrator 1035.

25 Instead of writing the identification code directly in
the optical line, a branch optical line 1101 in which the
identification code 1100 is written can be connected



1 thereto with a fiber coupler 1102 as shown in Fig. 11.

2 In the embodiment described above, the white-light
3 source 1024 is used as the light source, and the Fabry-Perot
4 etalon 1032 is used as the spectroscope in the light
5 receiving unit 1021. Instead of them, when a light source
6 1109 which is a wavelength switching type is used in the
7 light receiving unit 1021 as shown in fig. 12, the
8 spectroscope in the receiving unit 1021 can be omitted. The
9 light source 1109 incorporates a semiconductor laser array
10 1110, a prism 1113, and a condenser lens 1027. The
11 semiconductor laser array 1110 includes a plurality of the
12 semiconductor lasers 1111 for emitting light of different
13 wavelengths, and a lens 1112 which is placed at every
14 semiconductor laser 1111. A control circuit 1114 controls
15 a drive of the semiconductor laser 1111 and a movement of
16 the prism 1113. Then, the light source 1109 can selectively
17 outputs a detecting light having a required wavelength. The
18 wavelength of the reflected light at every reflecting part
19 is selected among the wavelengths emitted from the
20 semiconductor lasers 1111. Accordingly, if the wavelength
21 of the detecting light is subsequently switched and the
22 existence of the reflected light at every wavelength is
23 detected when the identification is conducted, similarly to
24 the embodiment described above, the wavelength of the
25 reflected light for every reflecting part can be obtained.
In this embodiment, in order to periodically pick up the



1 reflected light, the boxcar integrator 1035 is operated
based on the timing signal from the control circuit 1114.
But it is also possible that a light receiving element is
placed at unused end of the optical fiber 41 to detect an
5 input timing of the detecting light, and this detecting
light is used as an operational timing signal for the boxcar
integrator 1035.

Fig. 13 is a perspective view of a structure of another
example of a reflecting part used as an identification code
39. In this example, an optical filter is used as a
10 reflecting part which reflects a specific wavelength only.
A method for forming the identification code will be briefly
explained. Two V-shaped notches 1201, 1202 are formed on a
silicon board 1200, and core fibers 1204 and 1205 of a
double core tape fiber 1203 which are optical lines are
15 buried in respectively. Then, a silicon lid is put over and
is hardened with a resin 1207 to fix the optical fibers 1204
and 1205. Next, as a notch 1208 is formed on the silicon
board 1200 over the silicon lid 1206, the optical fibers
20 1204 and 1205 are cut. Then, a desired monochromatic
reflecting optical filter 1210 is inserted in the notch
1208, so that the reflecting part which reflects a specific
wavelength only is formed on the optical line. The optical
filter 1210 is formed by a dielectric multiple layered film
etc. Using the method with this optical filter, in case
25 that the optical line is either a double core tape fiber

1 like in this example or multicore tape fiber, it is possible
to apply the same identification code to every optical fiber
at the same time.

5 Fig. 14 is a perspective view of an example of an
optical filter placed in a connector. Usually, an optical
line is formed as a plurality of divided optical fibers is
connected by connectors. In this example, as the optical
filter which comprises an identification code is placed on
one side of a connector, an installation of the optical
10 filter becomes easy. The connector includes a male
connector 1220 having a guide pin 1221, and a female
connector 1223 having receiving holes for the guide pin
1221. Each connector 1220, 1223 has a structure that two
silicon chips 1224, 1225 are piled and hardened with an
15 epoxy resin 1226. A number of V-shaped notches equal to or
larger than the number of optical fibers forming a tape
fiber 1227 are placed on the silicon chip 1224, and each
optical fiber is fixed in the V-shaped notch. As the guide
pins 1221 are inserted to the receiving holes 1222, the
20 optical fibers on the side of the male connector 1220 and
the optical fibers on the side of the female connector 1223
are coupled one by one. Before the coupling, a
monochromatic reflecting optical filter 1230 is inserted
between them, so that the identification code can be formed
on the optical line. In this example, the optical filter is
25 made separately from the connectors 1220, 1223. But it is



1 possible to form a dielectric multiple layered film on one
side of the female connector 1223 by vapor-deposition.

Next, ^{a third of the} ~~an embodiment, corresponding to a third invention~~
will be explained. This embodiment is similar to the second
5 invention already explained with Fig. 8-Fig. 14. A point of
difference is to use not only a wavelength of a reflected
light but also a reflected light intensity as an
identification code. This embodiment is also applied to a
control system of optical lines facility as shown in Fig. 1.
10 An inner structure of a code reading device and its
peripheral devices are shown in Fig. 8.

An identification code 39 consists of a plurality of
reflecting parts. The each reflecting part reflect a light
having a specific wavelength only. Each optical line has a
different combination of specific wavelengths and
15 reflectance. Using the reflectance also as an
identification code is different from the second invention.
Every reflecting part forming the identification code 39
contains striped pattern where refractive indices are
varied locally on the optical line 50. As a spatial
20 frequency of a variation of the refractive indices or a
value of the refractive index is adequately set, every
reflecting part can obtain a unique wavelength of the
reflected light and the reflectance. As shown in Fig. 9A,
the reflecting part contains striped pattern where the
25 refractive indices are varied over a specific cycle. Let a



1 cycle of the striped pattern 1100 (i.e. a distance between
the refractive index varying points which adjoin each
other) is $\underline{d}$ and a mean refractive index of the optical line
at the reflecting part is $\underline{n}$, the wavelength λ of the
5 reflected light is represented as $\lambda=2nd$. Accordingly, as
 $\underline{d}$ and $\underline{n}$ are adequately set, the desired wavelength of the
reflected light can be obtained. The desired reflectance
can be obtained by conducting the number of stripes and the
difference of the refractive indices at striped pattern.
10 The reflecting part 1100 obtained in such a way is set at
plural parts (In Fig. 9B, five parts) on the optical line 50
as shown in Fig. 9B, and as the wavelengths $\lambda_1-\lambda_5$ and the
reflectances of the reflected lights are adequately set,
the identification code can be formed. The refractive index
15 can be varied as a UV ray (Ultra Violet Ray) is partly
irradiated to the optical line. By using this, the
reflecting part which reflects a light with a specific
wavelength and reflectance only can be formed.

20 The identification code 39 is applied to the optical
lines between the office 1 and the terminal 2, and to the
optical lines between the terminal 2 and the houses of
subscribers 3 as shown in Fig. 1. If there is a plurality
of terminals between the office 1 and the houses of
subscribers 3, the identification code is also applied to
the optical lines between the terminals.

25 Next, a method for reading an identification code in



1 this embodiment will be explained. For instance, using six
 wavelengths λ_0 - λ_5 , a 4 notation number is coded. This means
 that if λ_0 is a reflected wavelength at a reference
 reflecting part, and based on the reflected light intensity
 5 at the reference reflecting part, the other reflected
 lights with wavelengths λ_1 - λ_5 are corresponded to one of
 "0"- "3". Fig. 15A is a graph of an example of wavelength
 characteristics of the reflected lights when the detecting
 light from a light emitting unit 20 is given to the optical
 10 line 50. The graph shows a wavelength on the abscissa and
 a light intensity on the ordinate. In this example, the
 reflected lights at wavelengths λ_1 - λ_5 are respectively
 corresponding to the reflected light intensities
 "a,0,3a,0,2a". Fig. 15B is a chart of an observational
 15 result corresponded to a code information. The code
 information "10302" is obtained from the result in Fig. 15B.

In this embodiment, similar to the embodiment according
 to the second invention, the identification code on every
 divided optical line can be distinguished by the boxcar
 20 integrator 1035.

The identification code can be written in a branch
 optical line as shown in Fig. 11.

Further, it is possible to apply the embodiments
 already described with Fig. 12-Fig. 14.

25 Next, ^{a fourth} ~~any~~ ^{of the} ~~embodiment according to a fourth~~ invention is
 also applied to a control system of optical lines facility



1 as shown in Fig. 1. An inner structure of a code reading
device and its peripheral devices are shown in Fig. 8. In
this embodiment, an identification code 39 includes a
reflecting part where the reflectance depend on
5 wavelengths. The reflecting part contains striped pattern
where the refractive indices are locally varied. As a
spatial frequency of a variation of the refractive indices
or a value of a refractive index is adequately set, the
reflected light spectrum can be obtained. The reflected
10 light spectrum is a content of the identification code 39.
The identification code 39 is applied to the optical line
between the office 1 and the terminal 2, and to the optical
line between the terminal 2 and the houses of subscribers 3
as shown in Fig. 1. If there is a plurality of terminals
15 between the office 1 and the houses of subscribers 3, the
identification code is also applied to the optical lines
between terminals.

Fig. 16A-Fig. 16C show a method for writing reflecting
parts which form an identification code 39. Every figure
shows that as a UV ray (Ultra Violet Ray) is locally
20 irradiated to the optical line 50 to vary a refractive index
of the irradiated part, the reflecting part having a desired
reflected light spectrum is formed. Fig. 16A shows a method
for recording with a hologram. The UV ray 2062 is
irradiated to the hologram 2061, and the diffracted lights
25 by a hologram pattern recorded on the hologram 2061 are



1 projected to the optical line 50. The refractive index is
locally varied corresponding to a pattern formed by the
diffracted lights, so that the reflecting part 2064
containing stripes of varied refractive index is formed on
5 the optical line 50. The pattern made by the diffracted
lights is freely set by changing a hologram pattern. Fig.
16B shows a method for forming a reflecting part 2074 having
the striped pattern with the refractive index varied by
condensing the UV ray 2072 with a lens 2073, and projecting
10 a mask pattern 2071 having specific intervals and
transmissivity of stripes to the optical line 50. Fig. 16C
shows another method for forming a reflecting part having
the striped pattern with the refractive index varied. This
method comprises a control process of a UV ray intensity by
15 forming a slit image with the UV ray 2083 on an optical line
50 using a slit 2081 and a lens 2082 and a control process
of a movement of the slit image. While the UV ray intensity
is adequately varied, the slit image is moved along the
optical line 50 with a control of its speed to form the
20 reflecting part. These method for writing the
identification code can be applied to the embodiments
according to the second and third invention described above
and to an embodiment according to a fifth invention
described thereafter.

25 Next, a method for reading an identification code 39 of
this embodiment will be explained. Fig. 17A is a graph of



1 an example of a reflected light spectrum at an
identification code 39 when the detecting light from a light
emitted unit 1020 is given to the optical line 50. In this
graph, the abscissa indicates a wavelength and the ordinate
5 indicates a light intensity. A threshold level 2092 is
adequately set to the reflected light spectra 2091, and a
binary code is applied to each wavelength based on whether
the light intensity at each of wavelengths $\lambda_1 - \lambda_n$ is larger
or smaller than the threshold level 2092. Fig. 17B shows a
10 corresponding chart between the wavelengths and binary
cords. In the chart, when the light intensity is larger
than the threshold level 2092, "1" is given, and when the
light intensity is smaller than the threshold level 2092,
"0" is given. In such a way, the reflected light spectra
15 can be easily coded to a binary digit. It is possible that
the method for setting a threshold level 2092 is to set a
light intensity at a specific wavelength of a reflected
light as a threshold level 2092 other than the method for
setting a threshold level in advance.

20 In this embodiment, similar to the ^{second}embodiment, ~~according~~
~~to the second invention~~, the identification code on every
divided optical line can be periodically picked up by the
boxcar integrator 1035.

25 The identification code can be written to a branch
optical line as shown in Fig. 11.

Further, it is possible to apply the embodiments



1 already described with Fig. 12-Fig. 14.

Next, ^{a fifth of the} ~~an~~ embodiment, ~~according to a fifth~~ invention will
be explained. Fig. 18 is a block diagram of an inner
structure of a code reading device 5 and its peripheral
5 devices in case that this embodiment applies to a control
system of optical lines facility shown in Fig. 1.

The light emitting unit 3020 contains a light source
3109 and its drive control circuit 3114. The light source
3109 incorporates a semiconductor laser array 3110, a prism
3113, and a condenser lens 3027. The semiconductor laser
10 array 3110 contains a plurality of semiconductor lasers
3111 which emit lights of different wavelengths, and a lens
3112 which is placed at every semiconductor laser 3111. The
drive control circuit 3114 selectively controls a drive of
the semiconductor laser 3111 and a movement of the prism
15 3113, so that the light source 3109 can selectively put
a detecting light having a required wavelength. An optical
fiber 40 is a branch optical line which connects optical
fibers 50 to be measured and a code reading device 5, and is
connected to the optical fibers 50 to be measured with a
20 connecting means 38. The connecting means 38 selectively
connects the optical fiber 40 to one of the optical lines 50
to be measured.

A light receiving unit 3021 contains a light receiving
element 3034 for converting an inputted light to an
25 electrical signal, and an A/D convertor circuit 3035 with



1 memories for converting a signal from the light receiving
element 3034 to a digital value, and an averaging circuit
3036 for averaging the digital value from the A/D convertor
circuit 3035. An optical fiber 41 is connected to the
5 optical fiber 40 with an optical fiber coupler 37, and one
end is led to the light receiving unit 3021. The A/D
convertor circuit 3035 stores a time variation in signals
from the light receiving element 3034 based on the emitting
timing of the detecting light from the drive control circuit
10 3114 and converts an analog data to a digital data in an
appropriate interval. Accordingly, a period from time when
the light emitting unit 3020 emits the detecting light to
time when the reflected light comes back can be detected.

15 Since the reading unit 5 is constructed in this way, a
computer 3022 can identify a specific wavelength of every
reflecting part which forms an identification code 39 and
a relative position thereof, using a combination of the
wavelength of a detecting light and the time when the
reflected light at the identification code 39 arrives.

20 Each optical line 50 has unique identification codes 39
written in. The identification code 39 consists of a
plurality of reflecting parts. Each reflecting part
reflects a light having a specific wavelength only. Each
optical line has a different combination of specific
wavelengths and relative positions of reflecting parts.
25 Every reflecting part forming the identification code 39



1 contains striped pattern where refractive indices are
varied locally on the optical line 50. As a spatial
frequency of a variation of the refractive indices etc. are
adequately set, every reflecting part can obtain a unique
5 wavelength of the reflected light. As shown in Fig. 9A, the
reflecting part contains striped pattern where the
refractive indices are varied over a specific cycle. Let a
cycle of the striped pattern 1100 (i.e. a distance between
refractive index varying points which adjoin each other) is
10 $\underline{d}$ and a mean refractive index of the optical line at the
reflecting part is $\underline{n}$, the wavelength λ of the reflected
light is represented as $\lambda = 2nd$. Accordingly, $\underline{d}$ and $\underline{n}$ are
adequately set, so that the desired wavelength of the
reflected light can be obtained. The reflecting part 1100
15 obtained in such a way is set at plural parts (In Fig. 9B,
5 parts) on the optical line 50 as shown in Fig. 9B, and as
the wavelengths $\lambda_1 - \lambda_5$ of the reflected lights and relative
positions of the reflecting parts are set adequately, the
identification code can be formed. The refractive index can
20 be varied as a UV ray (Ultra Violet Ray) is locally
irradiated to the optical line 50. By using this, the
reflecting part which reflects a specific wavelength only
is formed.

25 The identification code 39 is applied to the optical
lines between the office 1 and the terminal 2, and to the
optical lines between the terminal 2 and the houses of



1 subscribers 3 as shown in Fig. 1. If there is a plurality
of terminals between the office 1 and the houses of
subscribers 3, the identification code is also applied to
the optical lines between the terminals.

5 Next, a method for reading an identification code 39 of
this embodiment will be explained. For instance, n notation
number is coded with n kinds of wavelengths $\lambda_1 - \lambda_n$ as
wavelengths of reflected lights. This means that numbers
1 to n are assigned to every wavelength. Then, a reflecting
10 part having a wavelength characteristic selected from these
wavelengths is applied to m points of the optical line 50.
Accordingly, the n notation number of m figure can be coded
with the specific wavelengths of the reflecting parts and
their relative positions. Since the code reading device 5
15 can detect the wavelength of the detecting light and the
arrival time of the reflected light, the code can be read.
Fig. 19 shows a combination chart of wavelengths and the
relative positions of the reflecting parts. This chart
indicates that the wavelength λ_2 is formed first, λ_1 is a
second, λ_3 is a third and so on, and as reading this and
20 converting it to a code, "213..." is made.

25 In the embodiment above, the A/D convertor circuit 3035
is driven based on the timing signal from the drive control
circuit 3114, but it is possible that with the light
receiving element placed at unused end of the optical fiber
41, the input timing of the detecting light is detected, and



1 this detected signal is used as an operational timing signal for the A/D convertor circuit 3035.

The identification code can be written in a branch optical line as shown in Fig. 11.

5 Further, it is possible to apply the embodiments already explained with Fig. 13-Fig. 14.

Next, ^{a sixth} ~~an~~ embodiment ^{of the} ~~according to a sixth invention~~ will be explained. In this embodiment, a code reading device shown in Fig. 6 is applied to the system shown in Fig. 1.

10 Each optical line 50 has unique identification codes 39 written in. The identification code 39 consists of a plurality of bending loss parts. A combination of relative positions of the bending loss parts is changed for each optical line. Every bending loss part forming the
 15 identification code 39 is a bending part on the optical line 50, and a concrete example of a jig is shown in Fig. 20. The jig 4080 consists a receiving member 4081 with V-shaped notches and a weight member 4082. In the receiving member 4081, concavities are formed at the V-shaped notches corresponding to a required identification code. Here, the
 20 concavities 4083-4086 are formed in the first, third, fourth, and seventh notch. On the weight member, projections 4087-4090 are formed at the position corresponding to the concavities on the receiving member 4081. The optical line 50 is meandered and inserted in the
 25 V-shaped notches on the receiving member 4081 and weighted



1 over with the weight member 4082, so that the bending loss
parts are formed at the first, third, fourth, and seventh V-
shaped notch. At the code reading device 5, a pulsed
5 detecting light is inputted to the optical line 50, and a
time variation in backscattering light intensities is
measured, so that a code information corresponding to a
relative position of each bending loss part is read.

The identification code 39 is applied to the optical
lines between the office 1 and the terminal 2, and to the
10 optical lines between the terminal 2 and the houses of
subscribers 3 as shown in Fig. 1. If there is a plurality
of terminals between the office 1 and the houses of
subscribers 3, the identification code is also applied to
the optical lines between the terminals.

15 Next, a method for reading an identification code 39 in
this embodiment will be explained. When a detecting light
is inputted to the optical line 50 having the identification
code formed with the four bending loss parts as shown in
Fig. 20. The light receiving unit 21 collaborates with the
20 computer 22 to obtain a characteristic of a time variation
in the backscattering light intensities as shown in Fig.
21A. This means that at the each bending loss part, the
backscattering light intensity rapidly decreases based on
the irradiation loss. Fig. 21B shows a result of the
differentiated characteristics. In this graph, peaks 4095,
25 4096, 4097 and 4098 are corresponding to the first, third,



1 fourth and seventh bending loss part formed in the V-shaped
notches. Assuming that the first bending loss part is a
reference bending loss part and an existence of the bending
loss part in 7 V-shaped notches except the notch for the
5 first bending loss part is coded, the characteristics shown
in Fig. 21B can be replaced with a seven bits code shown in
Fig. 21C. The content of the code information is set freely
as selecting a number of the bending loss parts or positions
of the bending loss parts.

10 In this embodiment, the optical line which connects the
office 1 and the houses 3 of subscribers consists of two
divided optical lines connected with the terminal 2. Since
the identification code is applied to every divided optical
line, they have to be distinguished and confirmed. In order
15 to do that, as an operation of the A/D convertor circuit 62
with memories is periodically controlled by timing control
circuit 23, a variation of the light intensities is
periodically picked up based on the input timing of the
detecting light. Therefore, the variation of the light
intensities at different points of the identification code
20 on the same optical line can be distinguished. Picking up
the backscattering light can be achieved with an optical
gate (optical deflector). As shown in Fig. 11, the
identification code can be written in a branch optical line.

25 Next, an embodiment according to a seventh invention
will be explained. In this embodiment, a code reading



1 device shown in Fig. 22 is applied to the system shown in
Fig. 1. In this embodiment, optical lines between the
office 1 and terminal 2 are gathered to be a multicore
optical line, and further the multicore optical lines are
5 gathered to be an optical fiber 9. The identification of
the optical line described thereafter is related to an
identification of a multicore optical line. In this case,
each mono-optical line inside of the multicore optical line
is called a core optical fiber.

10 Fig. 22 shows a block diagram of an inner structure of
a code reading device 5 and its peripheral devices. A code
reading device 5 consists of a light emitting unit 5020 and
a light receiving unit 5021, and they are controlled by a
computer 5022 and a timing control circuit 5023 which form
15 a control circuit 6.

20 The light emitting unit 5020 contains a light source
5024 for emitting a light having an adequate spectrum range
such as white ray, an acoustooptic element 5025 for
controlling an on/off of a light outputted from the light
source 5024, and lenses 5026, 5027 placed respectively at
an input and an output of the acoustooptic element 5025.
The light emitted from the light source 5024 is inputted to
one end of an optical fiber 40 as a detecting light through
the lens 5026, the acoustooptic element 5025, and the lens
5027. The optical fiber 40 is a branch optical line which
25 connects one of the multicore optical lines 50 to be



1 measured and the code reading device 5. The optical fiber
40 is connected to the multicore optical line 50 with a
connecting means 38. In this embodiment the optical fiber
40 is also a multicore optical fiber having a number of
5 cores equal to the number of core fibers of optical line 50.
The connecting means 38 alternatively connects the
multicore optical fiber 40 to one of a plurality of the
multicore optical lines 50 to be measured.

10 A light receiving unit 5021 contains a number of light
receiving elements 5031 equal to the number of core fibers
of the multicore optical line for converting an inputted
light to an electrical signal, and an A/D convertor circuit
3035 for converting a signal from the light receiving
15 element 5031 to a digital value and transmitting the digital
value to a computer 5022, and a lens 5033 placed in front of
every light receiving element 5031. The light receiving
element 5031 receives a light from an optical fiber 41
connected to an optical fiber 40 with a fiber coupler 37 and
converts the light to an electrical signal. The optical
20 fiber 41 is also a multicore optical fiber having a number
of optical core fibers equal to the number of core fibers of
a multicore optical line 50 that is the number of core
fibers of the optical fiber 40. Each core optical fiber of
the optical fiber 41 is led to the light receiving element
5031. Accordingly, the existence of the reflected light at
25 every core optical fiber can be detected. The light



1 receiving elements 5031 are controlled by the timing
control circuit 5023, and the light receiving element is
operated subsequently from the left hand of the figure, so
that the reflected light at the each core optical fiber is
5 subsequently provided to the A/D convertor circuit 5032.

Unique identification codes 39 are written in each
optical line 50. The identification code is formed by
placing reflecting parts selectively on core optical fibers
of the multicore optical line and changing a combination of
10 the existence of the reflecting part at the core optical
fibers for every multicore optical line. Fig. 23 shows an
example of the identification code at the multicore tape
optical line. Each core optical fiber 5061 of the multicore
tape optical line 5060 is exposed to be a part on which the
identification code will be made. The reflecting part 5063
15 is selectively made at this part. The reflecting parts 5063
can be formed as the refractive indices are varied by
irradiating to the core optical lines 5061 with a UV ray
(Ultraviolet Ray). The reflecting parts 5063 can be also
formed by cutting the core optical fibers and inserting an
20 optical filter into the cutting part. In the Fig. 23,
identification code part 5063 remains being exposed for
easy explanation. This part will be fixed by a board like
a silicon chip to maintain a mechanical strength in
practice.

25 Next, a method for reading an identification code 39



1 will be explained. Here, a multicore optical line is 8-core
tape optical fiber. As the detecting light is inputted to
the all (eight) core optical fibers of the tape optical
fiber to be read, the receiving unit 5021 receives only a
5 reflected light from the core optical fiber having a
reflected part. These reflected light is detected at the
light receiving element 5031 corresponding to the core
optical fiber one by one, and the signal is inputted to the
computer 5022 through the A/D convertor circuit 5032. Fig.
10 24 shows a chart of a detection result. All core optical
fibers are numbered 1-8. By the existence of the reflecting
part at the each numbered core optical fiber, the detection
of the reflected light is made. When the reflected light is
detected, a code "1" is given and when the reflected light
15 is not detected, a code "0" is given, so that the 8 bits code
information is obtained from the detecting result.

Further, as shown in Fig. 11, the identification code
can be written to a branch optical line.

INDUSTRIAL APPLICABILITY

20 In accordance with the identifying method of the
present invention,

① each optical line has a different combination of
positions of a plurality of reflecting parts forming an
identification code, and the relative positions are
detected,

25 ② each optical line has a different combination of



1 reflective wavelengths of a plurality of reflecting parts
forming an identification code, and the wavelengths of the
reflected lights are measured,

5 ③ each optical line has a different combination of
reflective wavelengths and reflectances of a plurality of
reflecting parts forming an identification code, and the
wavelengths and light intensities of the reflected lights
are measured,

10 ④ each optical line has a different reflective
wavelength characteristic of reflecting parts forming an
identification code, and spectra of the reflected lights
are measured,

15 ⑤ each optical line has a different combination of
reflective wavelengths and relative positions of a
plurality of reflecting parts forming an identification
code, and the wavelengths and the relative positions of the
reflecting parts are measured based on reflected lights
from the identification code,

20 ⑥ each optical line has a different combination of
relative positions of a plurality of bending loss parts, and
the relative positions are detected,

25 so that the optical line can be easily and accurately
identified. Accordingly, the invention is effective to the
confirmation of connections in case that a switching is
operated at the terminal.

In case that the optical line is a multicore type,



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1 reflecting parts can be selectively applied to core optical
lines to form an identification code. For all core optical
lines, as an existence of a reflected light is measured, the
multicore optical line can be easily and accurately
5 identified.

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THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. A method for identifying an optical line, comprising the steps of:
forming a plurality of reflecting parts on an optical line along a longitudinal
5 direction of the optical line;
inputting detection light to the optical line;
detecting detection light reflected from the reflected parts; and
identifying the optical line based on a specific combination of specific
characteristics of the reflected light.
10
2. A method for identifying an optical line according to claim 1, comprising the
steps of:
forming the plurality of the reflecting parts on the optical line as an identification
code, the optical line having a specific combination of relative positions of the reflecting
15 parts; and
detecting the relative positions of the reflecting parts based on the reflected light
to thereby identify the optical line.
3. A method for identifying an optical line according to claim 1, comprising the
20 steps of:
forming the plurality of the reflecting parts on the optical line as an identification
code, each reflecting part reflecting light having a specific wavelength, and the optical
line having a specific combination of the specific reflecting wavelengths; and
detecting wavelengths of the reflected light to thereby identify the optical line.
25
4. A method for identifying an optical line according to claim 1, comprising the
steps of:
forming the plurality of the reflecting parts on the optical line as an identification
code, each reflecting part reflecting a light having a specific wavelength, and the optical
30 line having a specific combination of the specific reflecting wavelengths and reflectance;
and
detecting wavelengths and reflectance of the reflected light to thereby identify



the optical line.

5. A method for identifying an optical line according to claim 1, comprising the steps of:

5 forming the plurality of the reflecting parts on the optical line as an identification code, each reflecting part reflecting light having a specific wavelength, and the optical line having a specific combination of the specific reflecting wavelengths and relative positions; and

10 detecting wavelengths and relative positions of the reflected light to thereby identify the optical line.

6. A method for identifying an optical line according to claim 1, comprising the steps of:

15 forming the reflecting part on the optical line as an identification code, the reflecting part on the optical line having a specific reflectance characteristic depending on a wavelength; and

detecting reflected light spectra coming back from the reflecting parts when the detection light is inputted to the optical line to thereby identify the optical line.

20 7. A method for identifying an optical line, comprising the steps of:

connecting a branch optical line to the optical line;

forming a plurality of reflecting parts on the branch optical line along a longitudinal direction of said branch optical line;

inputting detection light to the optical line;

25 detecting detection light reflected from the reflected parts; and

identifying the optical line based on a specific combination of specific characteristics of the reflected light.

8. A method for identifying an optical line according to claim 7, comprising the steps of:

30 forming the plurality of the reflecting parts on the branch optical line of the optical line as an identification code, the branch optical line having a specific



combination of relative positions of the reflecting parts; and

detecting the relative positions of the reflecting parts based on the reflected light to thereby identify the optical line.

- 5 9. A method for identifying an optical line according to claim 7, comprising the steps of:

forming the plurality of the reflecting parts on the branch optical line of the optical line as an identification code, each reflecting part reflecting light having a specific wavelength, and the branch optical line having a specific combination of the

- 10 specific reflecting wavelengths;

detecting wavelengths of the reflected light to thereby identify the optical line.

10. A method for identifying an optical line according to claim 7, comprising the steps of:

- 15 forming the plurality of the reflecting parts on the branch optical line of the optical line as an identification code, each reflecting part reflecting a light having a specific wavelength, and the branch optical line having a specific combination of the specific reflecting wavelengths and reflectance; and

- 20 detecting wavelengths and reflectance of the reflected light to thereby identify the optical line.

11. A method for identifying an optical line according to claim 7, comprising the steps of:

- 25 forming the plurality of the reflecting parts on the branch optical line of the optical line as an identification code, the reflecting part reflecting light having a specific wavelength, the branch optical line having a specific combination of the specific reflecting wavelengths and relative positions; and

detecting wavelengths and relative positions of the reflected light to thereby identify the optical line.

30

12. A method for identifying an optical line according to claim 7, comprising the steps of:



forming the reflecting part on the branch optical line of the optical line as an identification code, the reflecting part on the branch optical line having a specific reflectance characteristic of a wavelength; and

5 detecting reflected light spectra coming back from the reflecting parts when the detection light is inputted to the optical line to thereby identify the optical line.

13. A method for identification of an optical line according to any one of claims 1 to 12, characterized by:

10 detecting the information of the reflected light coming back from the reflecting part at a timing in dependence on the position thereof when a pulsed detection light is inputted to the optical line.

14. A method for identification of an optical line according to any one of claims 1 to 12, characterized in that:

15 the reflecting part comprise a striped pattern which is formed by varying the refractive index of the optical line or branch optical line locally.

15. A method for identification of an optical line according to any one of claims 1 to 12, characterized in that:

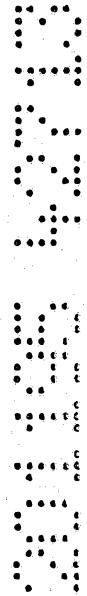
20 the reflecting part is an optical filter inserted into the optical line or branch optical line.

16. A method for identification of an optical line according to any one of claims 1 to 12, characterized in that:

25 the optical line consists of a plurality of divided optical fibers,
a connecting part with an optical connector is provided between the divided optical lines, and
an optical filter as the reflecting part is formed at the optical connector.

30 17. A method for identifying a multi-core optical line which has a plurality of core optical lines, comprising the steps of:

forming reflecting parts on the core optical lines of the multi-core optical line



selectively as an identification code,

the multi-core optical line having a specific combination of existences of the reflecting parts and characteristics of reflections;

detecting reflected light when detecting light is inputted to the multi-core optical
5 line;

identifying the multi-core optical line based on a result of the detecting step.

18. A method for identification of an optical line according to claim 1, 2, 7 or 8, characterized in that:

10 an optical-path difference of the reflected lights from the reflecting parts is measured by interferometer, and the relative positions of the reflecting parts are detected based on a result of the measurement.

19. A method for identification of an optical line according to claim 1, 2, 7 or 8, characterized in that:

15 the reflecting part is a notch formed on the optical line or branch optical line.

20. A method for identifying an optical line in a group of optical lines, comprising the steps of:

20 forming a plurality of bending loss parts on the each optical line as an identification code, the each optical line has a specific combination of relative positions of the plurality;

detecting the relative positions of the plurality based on a backscattering when a detecting light is inputted to the optical line; and

25 identifying the optical line based on a result of the detecting step.

21. A method for identifying an optical line, comprising the steps of:

connecting a branch optical line on the optical line,

placing a plurality of bending loss parts on the branch optical line as an
30 identification code, the each branch optical line has a specific combination of relative positions of the plurality;

detecting the relative positions of the plurality based on a backscattering when



a detecting light is inputted to the optical line; and
identifying the optical line based on a result of the detecting step.

22. A method for identifying an optical line substantially as hereinbefore described
5 with reference to the accompanying drawings.

10

15 DATED this 20th day of November, 1995

SUMITOMO ELECTRIC INDUSTRIES, LTD. and
NIPPON TELEGRAPH & TELEPHONE CORPORATION

By their Patent Attorneys

20 DAVIES COLLISON CAVE

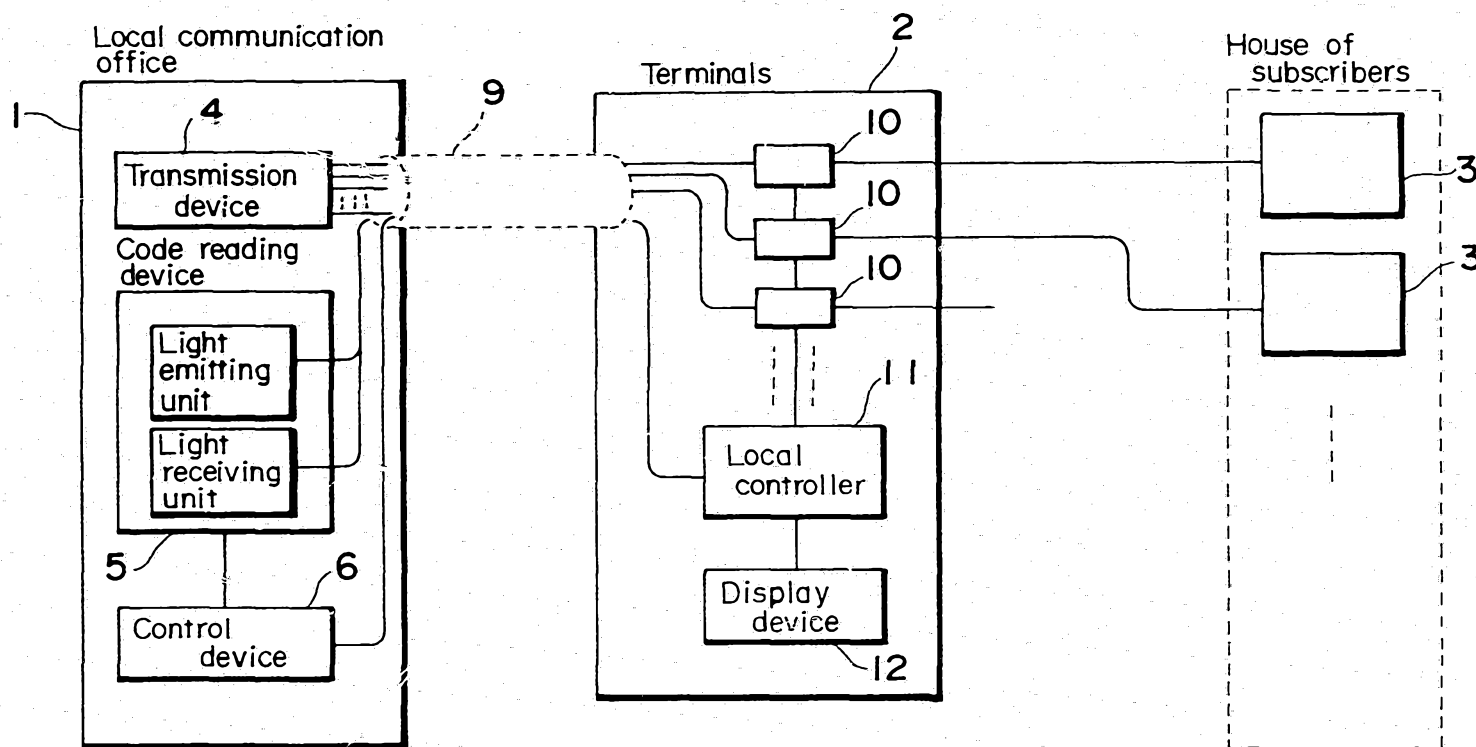


1 ABSTRACT

5 The present invention is to provide a method for identifying an optical line easily and accurately regardless of the optical line length. A plurality of reflecting parts is placed on the optical line, and a combination of relative positions of the reflecting parts is changed for every optical line to form an identification code, and the relative positions of the reflecting parts are
10 detected based on reflected lights when a detecting light is inputted to the optical line, so that the optical line is identified based on a result. Concretely, when the detecting light is inputted to one end of the optical line, the light is reflected at the plurality of the reflecting parts which form the identification code and comes back the
15 input end. A combination of the relative positions etc. of the reflecting parts is changed for every optical line. To detect the relative positions of the reflecting parts which form the identification code, either the optical path difference of the reflected lights from the reflecting
20 parts is measured or the time difference between the reflected lights come back from the reflecting parts is measured. Then, based on the result, the optical line can be identified.



Fig. 1



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Fig. 2

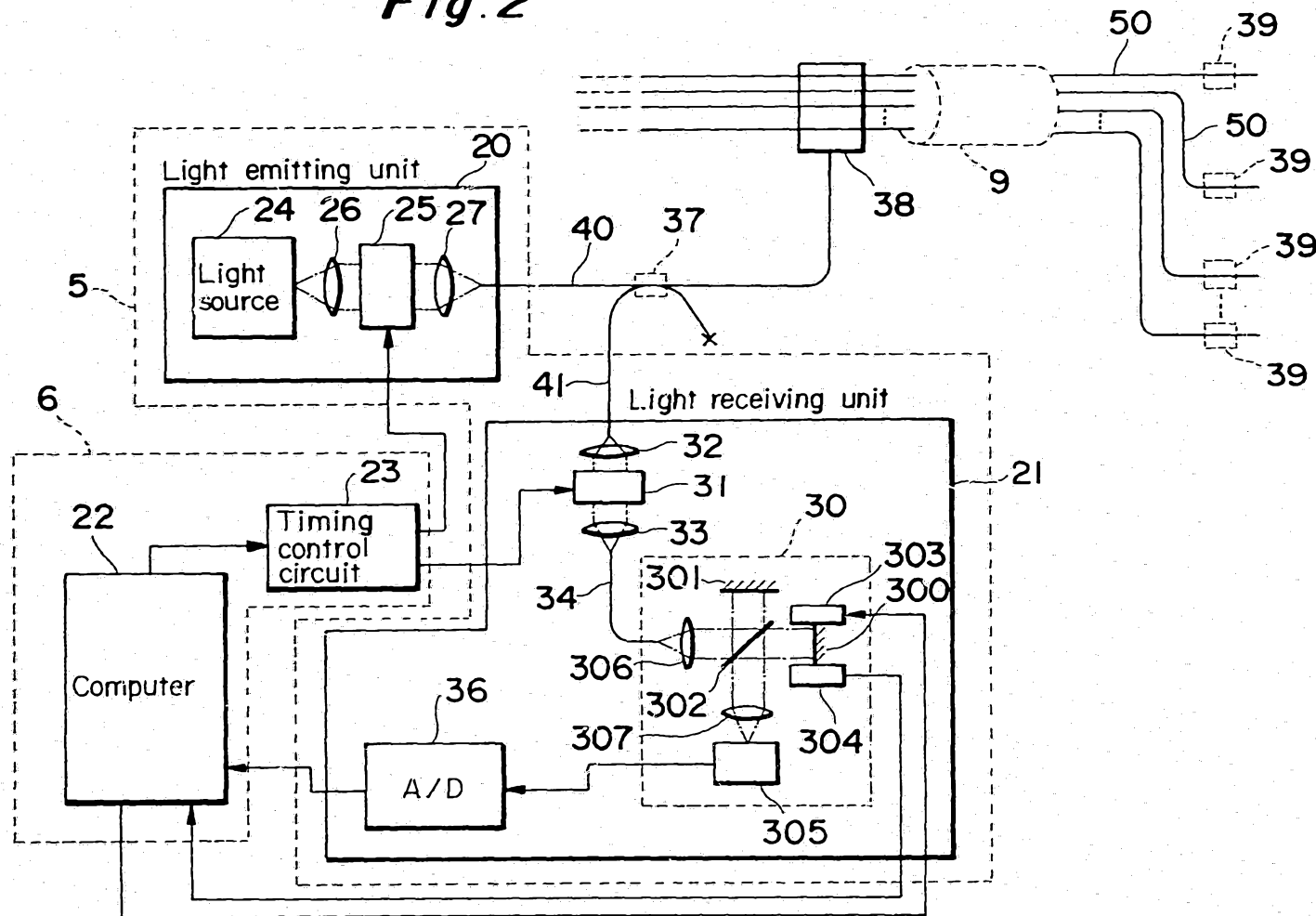


Fig. 3

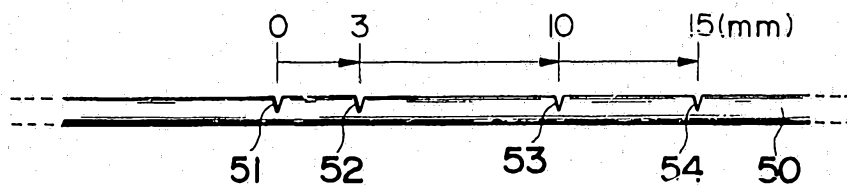


Fig. 5

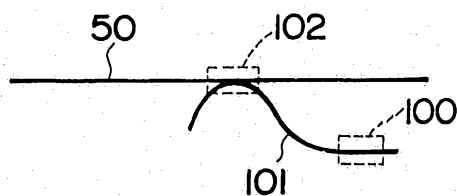


Fig. 7

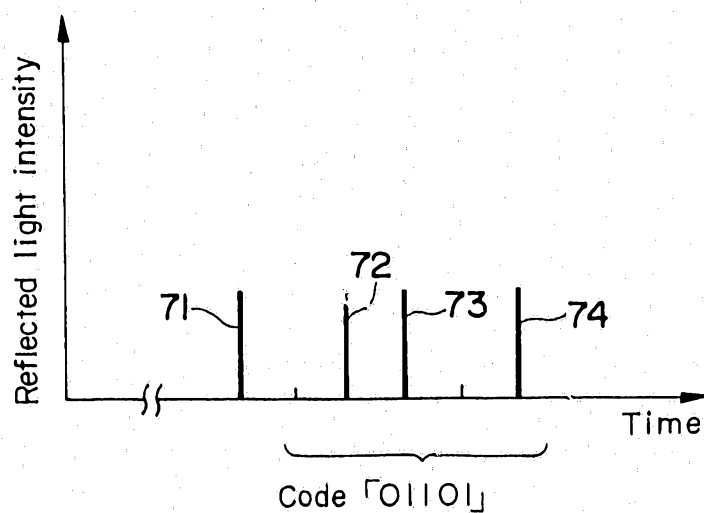
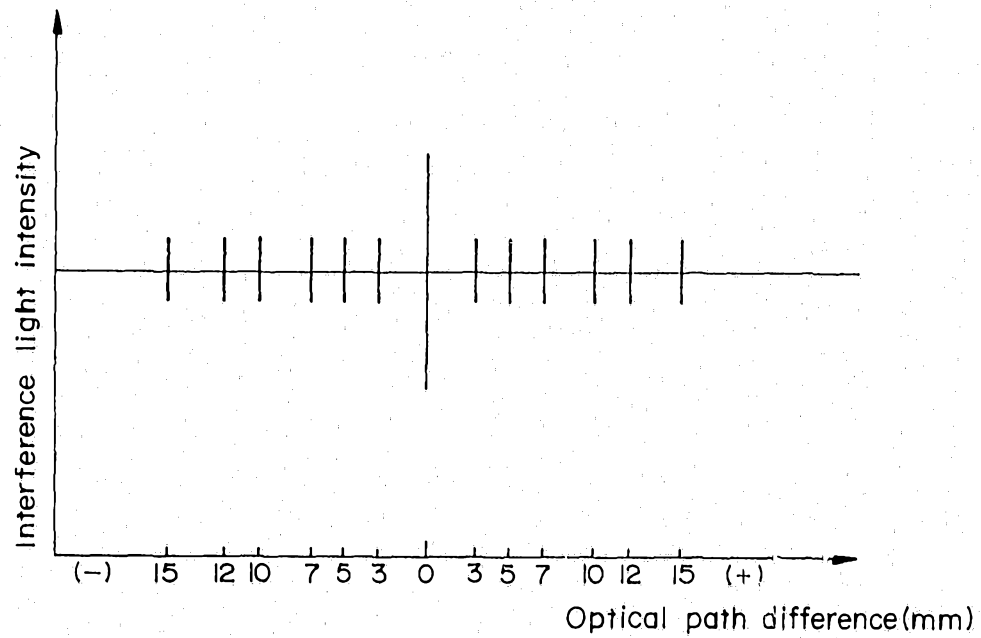


Fig. 4A**Fig. 4B**

Optical path difference	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Code	0	0	1	0	1	0	1	0	0	1	0	1	0	0	1

Fig. 6

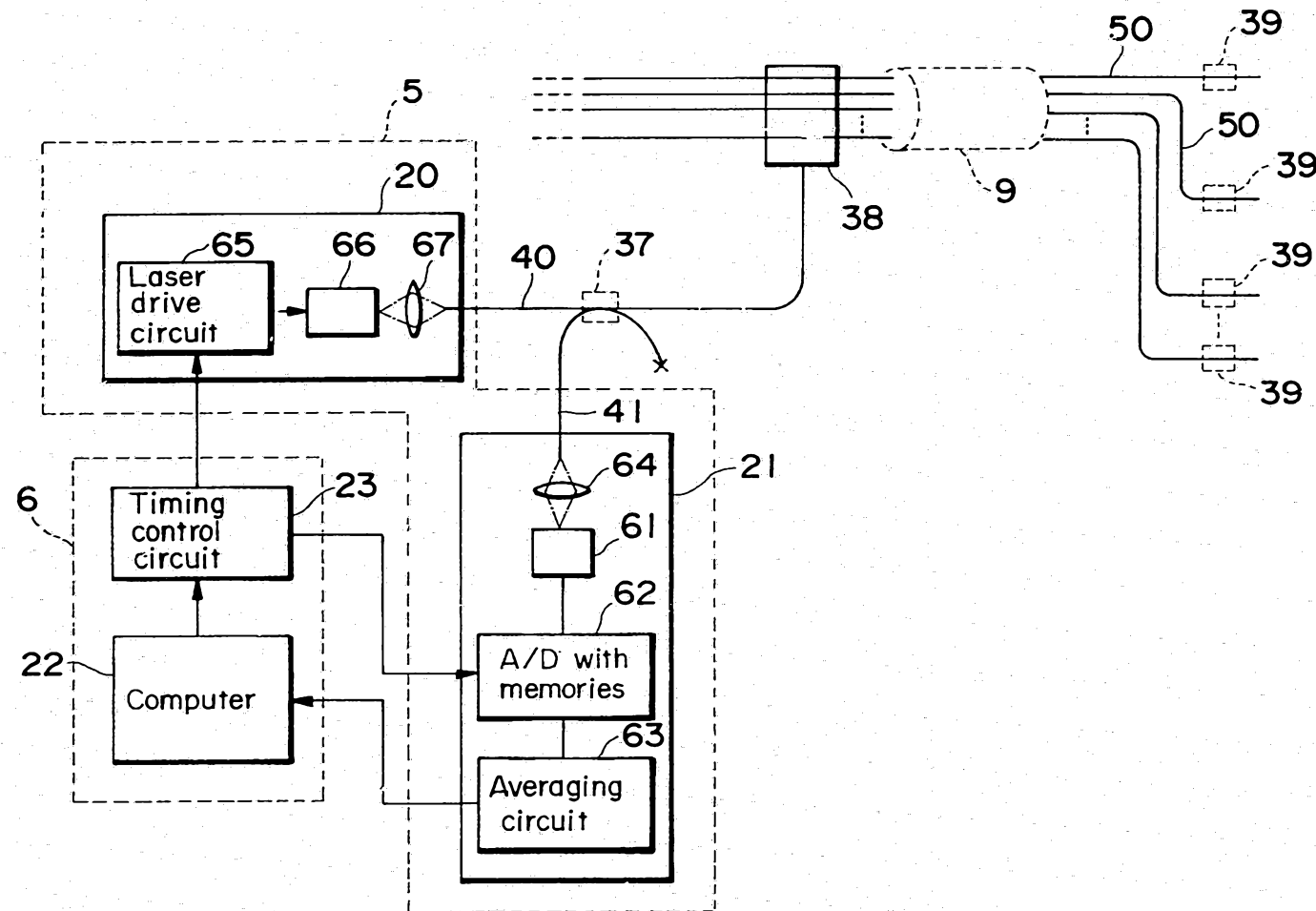


Fig. 8

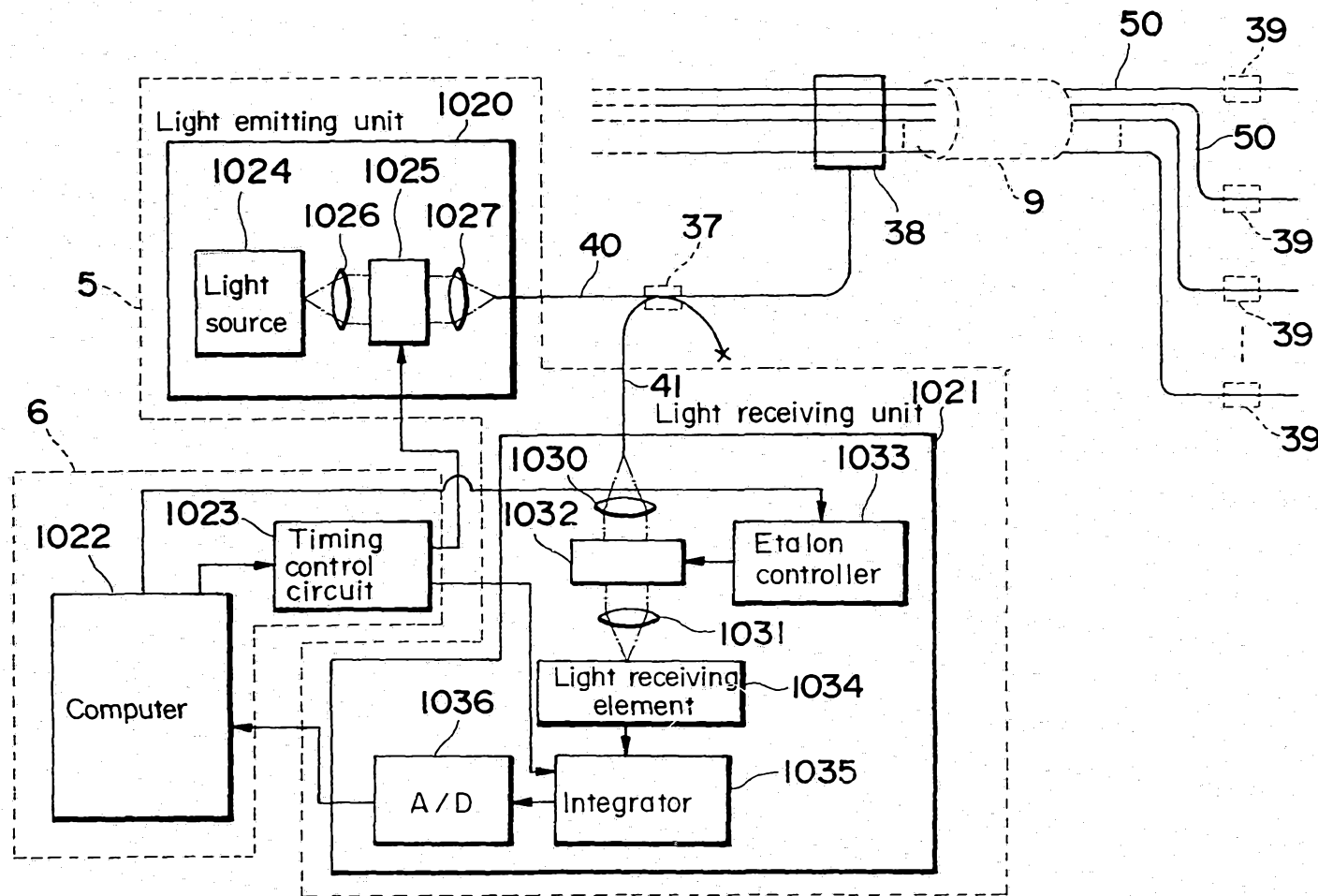


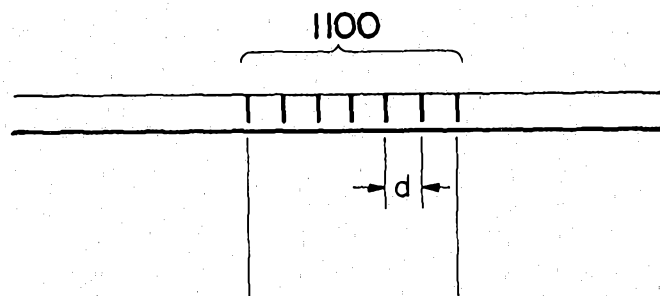
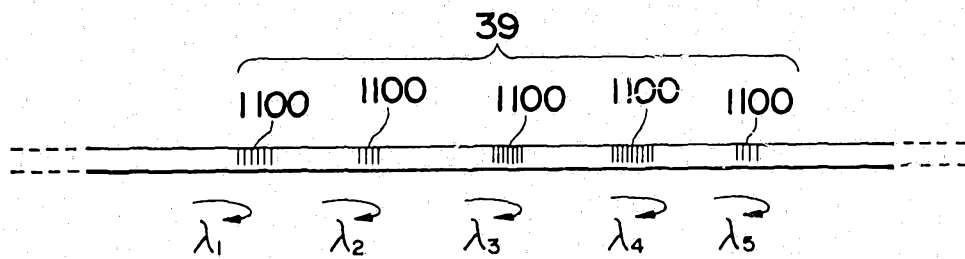
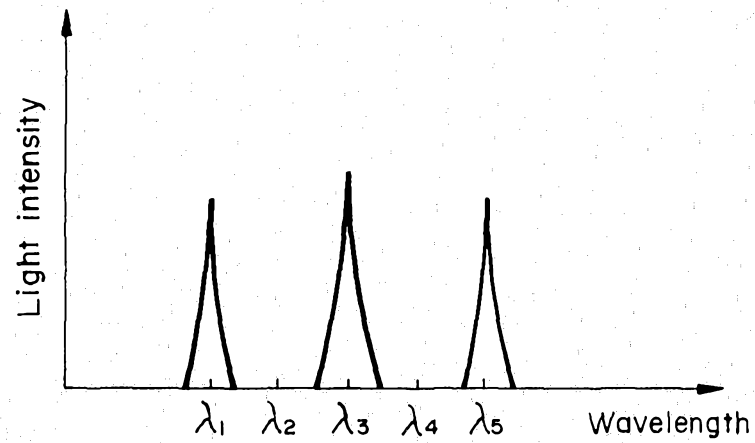
Fig. 9A**Fig. 9B**

Fig. 10A**Fig. 10B**

Wavelength	λ_1	λ_2	λ_3	λ_4	λ_5
Code	1	0	1	0	1

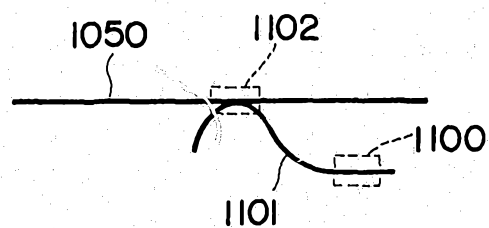
Fig. 11

Fig. 12

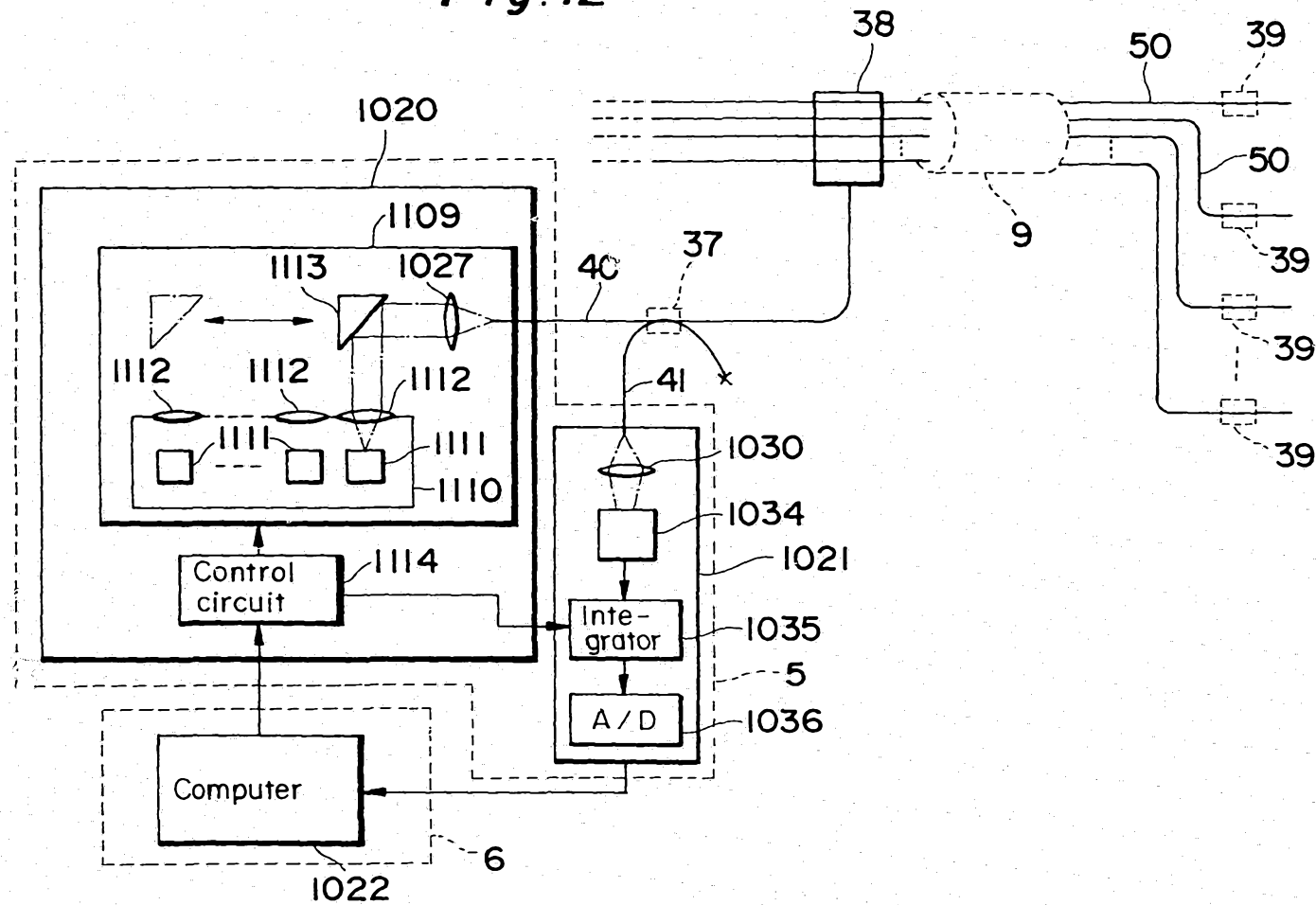
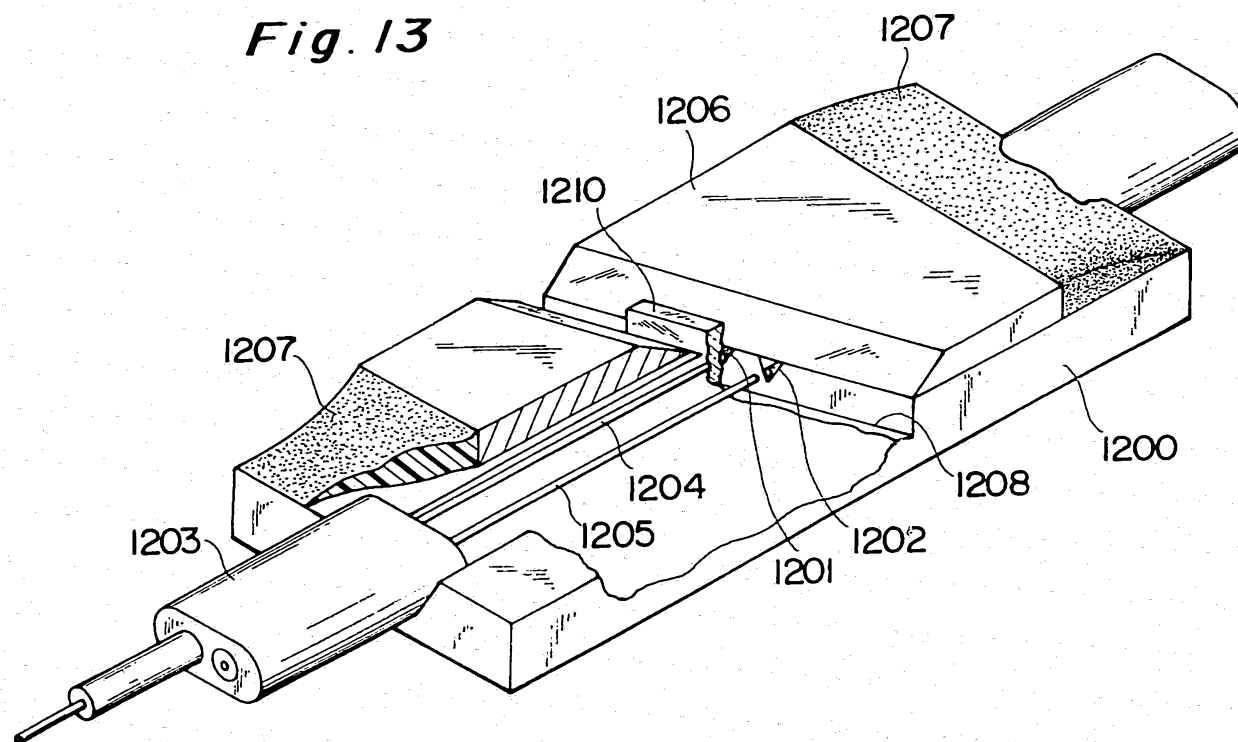


Fig. 13



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Fig. 14

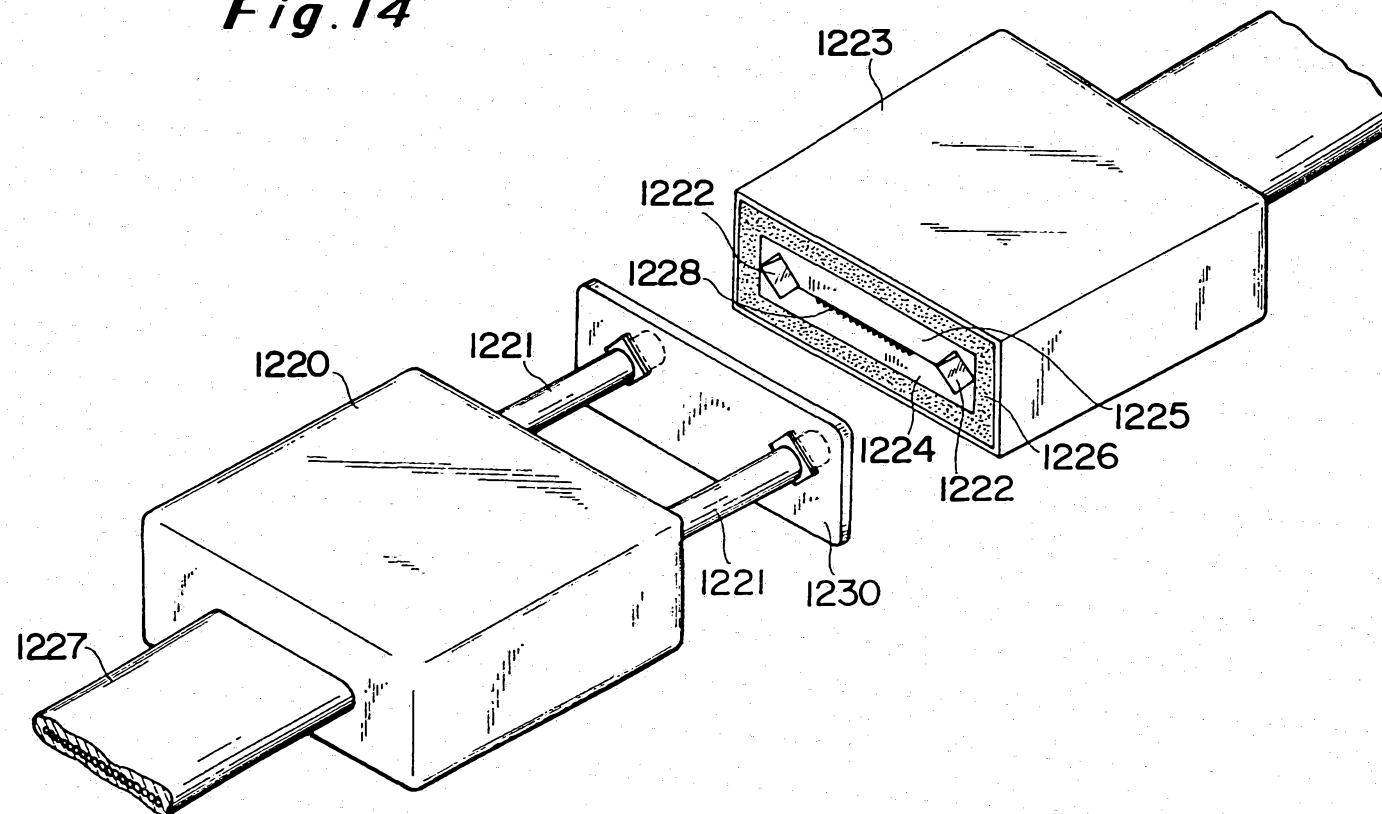
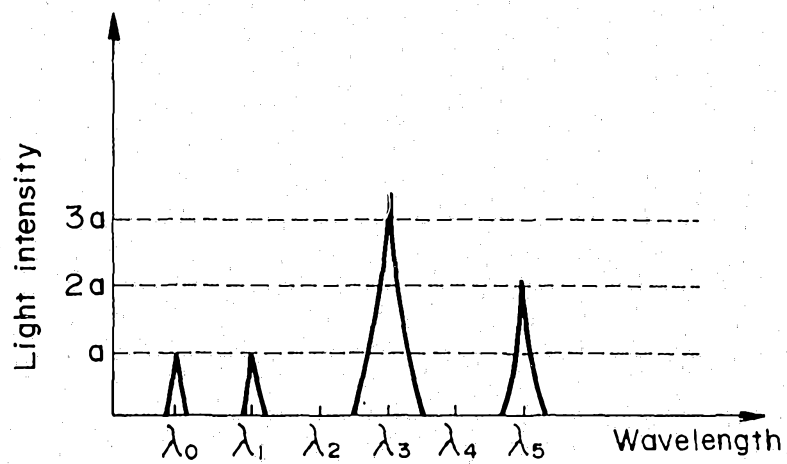


Fig. 15A**Fig. 15B**

Wavelength	λ_1	λ_2	λ_3	λ_4	λ_5
Code	1	0	3	0	2

Fig. 16A

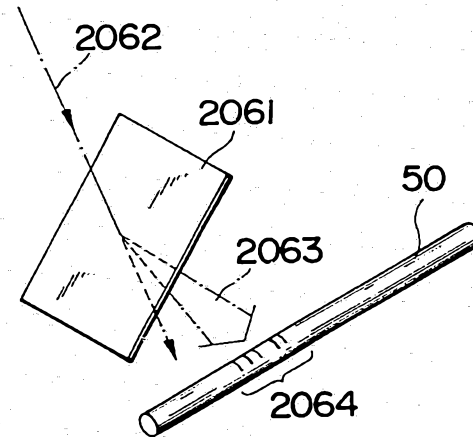


Fig. 16B

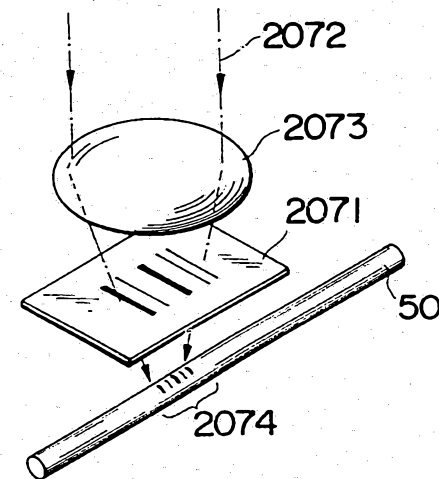


Fig. 16C

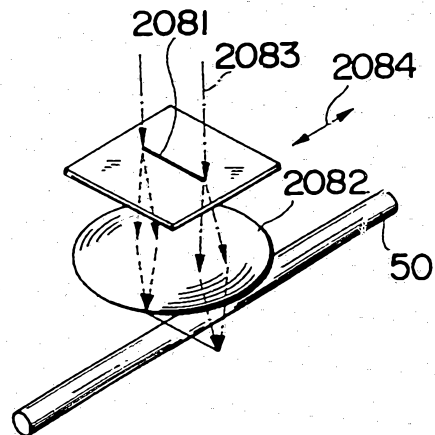
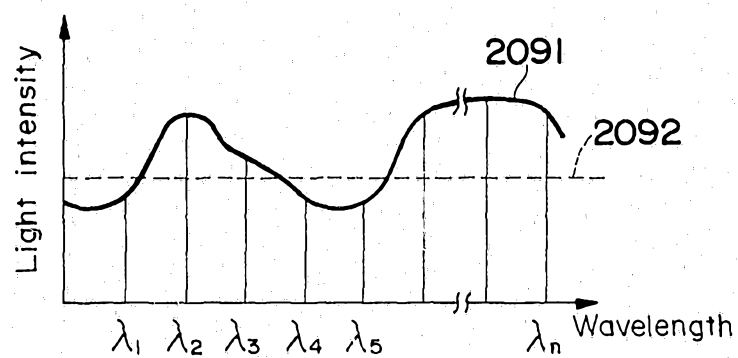


Fig. 17A**Fig. 17B**

Wavelength	λ_1	λ_2	λ_3	λ_4	λ_5		-----	λ_n
Code	0	1	1	0	0		-----	1

Fig. 18

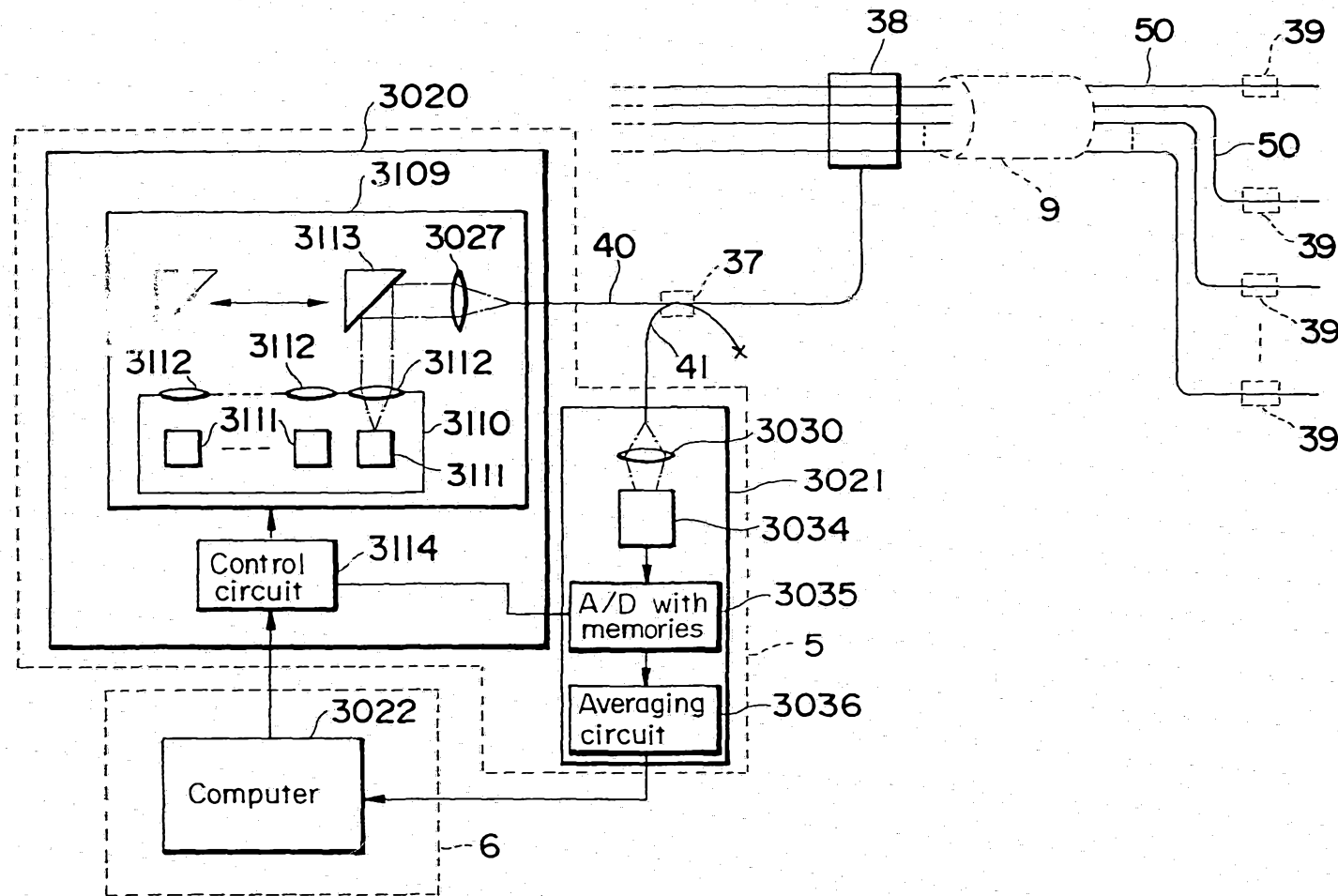
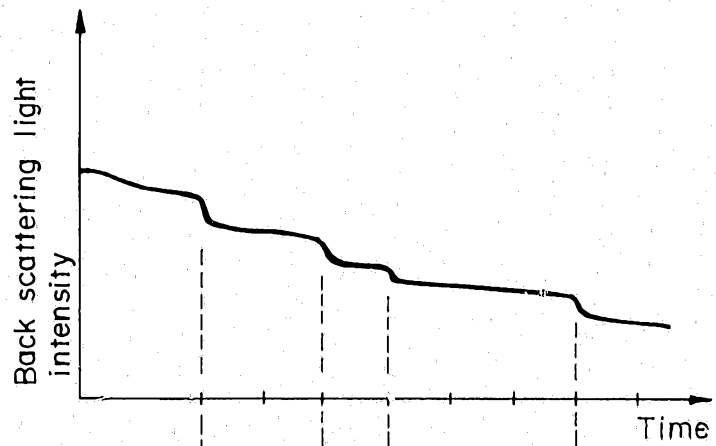
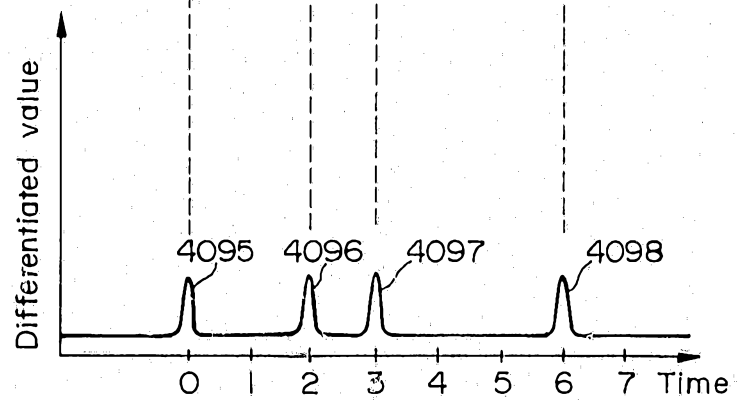


Fig. 19

Wavelength	Corresponding code	Position of reflecting point					
		1	2	3	-----	m-1	m
λ_1	1		○				
λ_2	2	○					
λ_3	3			○			
⋮	⋮						
λ_{n-1}	n-1						
λ_n	n						

Reading code		2	1	3	-----
--------------	--	---	---	---	-------

Fig. 21A**Fig. 21B****Fig. 21C**

Position of bending loss	1	2	3	4	5	6	7
Code	0	1	1	0	0	1	0

Fig.22

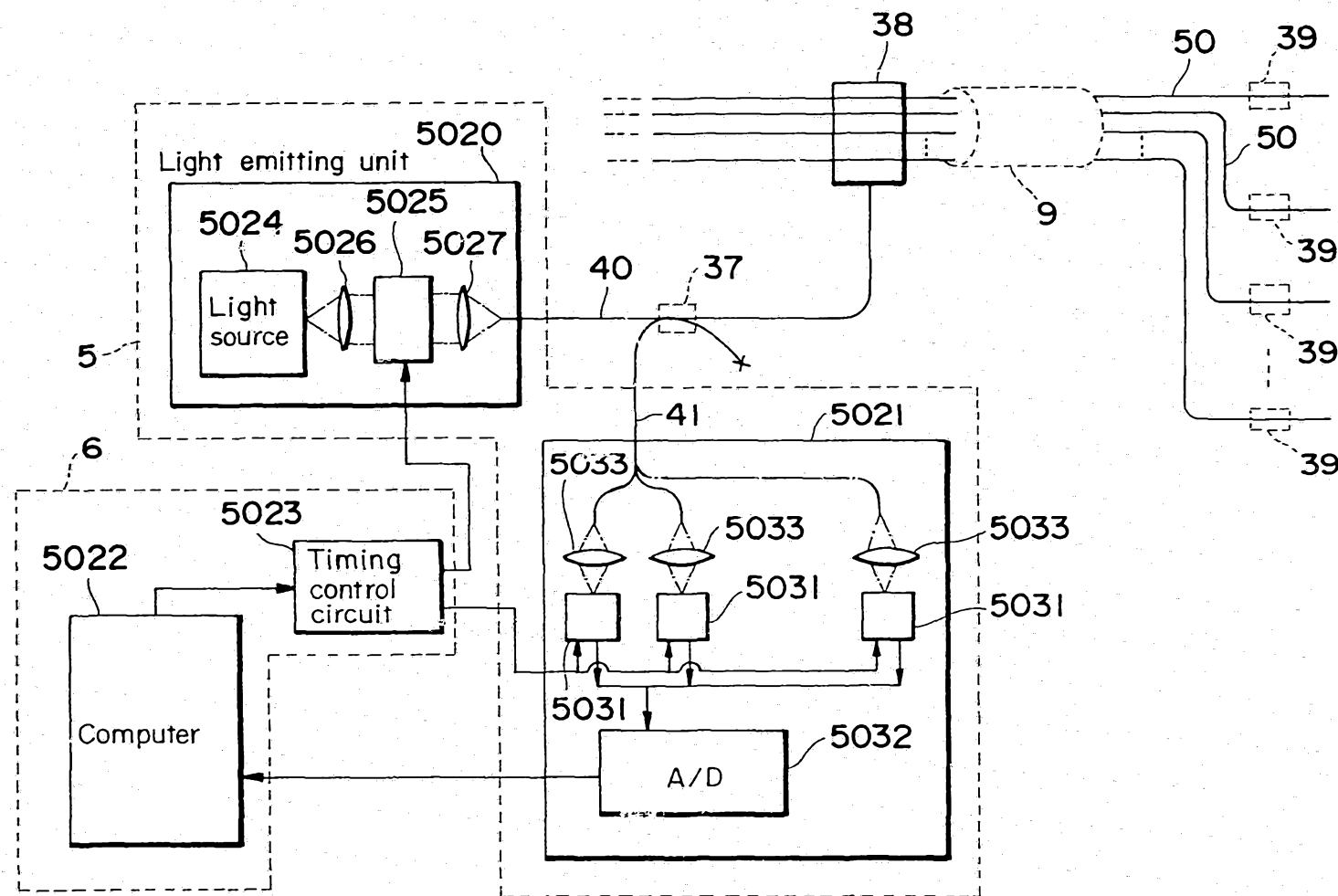
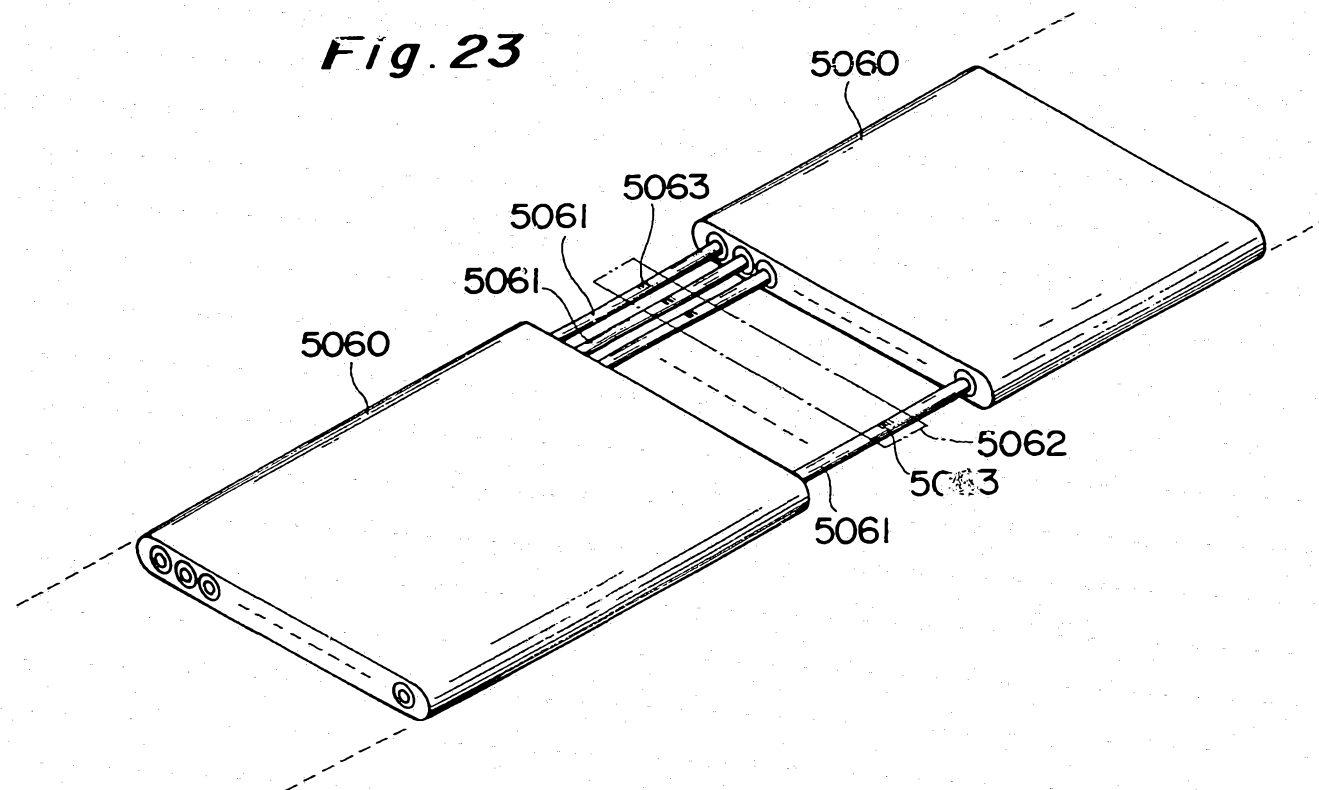


Fig. 23



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Fig. 24

Code number	1	2	3	4	5	6	7	8
Existence of reflecting part	YES	NO	YES	YES	NO	YES	NO	YES
Code	1	0	1	1	0	1	0	1

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP93/00567

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl⁵ G01M11/00, G02B6/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Int. Cl⁵ G01M11/00-11/02, G02B6/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho 1926 - 1993

Kokai Jitsuyo Shinan Koho 1971 - 1993

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP, A, 2-230105 (The Furukawa Electric Co., Ltd., Tokyo Electric Power Co., Inc.), September 12, 1990 (12. 09. 90), Line 6, column 1 to line 1, column 2, Fig. 1 & EP, A1, 390,341	1, 7
A	JP, A, 2-230106 (The Furukawa Electric Co., Ltd., Tokyo Electric Power Co., Inc.), September 12, 1990 (12. 09. 90), Line 6, column 1 to line 2, column 2, Fig. 1 & EP, A1, 390,341.	1, 7
A	JP, A, 2-20803 (Kansai Telecom Technology K.K., Mitsubishi Densen Kogyo K.K.), January 24, 1990 (24. 01. 90), Line 5, column 1 to line 17, column 2, Figs. 1, 4 (Family: none)	20, 21

☒ Further documents are listed in the continuation of Box C.☐ See patent family annex.

* Special categories of cited documents:

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"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

July 13, 1993 (13. 07. 93)

Date of mailing of the international search report

August 3, 1993 (03. 08. 93)

Name and mailing address of the ISA/

Japanese Patent Office

Facsimile No.

Authorized officer

Telephone No.

A. 発明の属する分野の分類 (国際特許分類 (IPC))

Int. Cl¹ G01M11/00, G02B6/00

B. 調査を行った分野

調査を行った最小限資料 (国際特許分類 (IPC))

Int. Cl¹ G01M11/00-11/02, G02B6/00

最小限資料以外の資料で調査を行った分野に含まれるもの

日本国実用新案公報 1926-1993年

日本国公開実用新案公報 1971-1993年

国際調査で使用了電子データベース (データベースの名称、調査に使用した用語)

C. 関連すると認められる文献

引用文献の カテゴリー*	引用文献名 及び一部の箇所が関連するときは、その関連する箇所の表示	関連する 請求の範囲の番号
A	JP, A, 2-230105 (古河電気工業株式会社, 東京電力株式会社), 12. 9月, 1990 (12. 09. 90), 第1欄第6行-第2欄第1行, 第1図 & EP, A1, 390,341	1, 7
A	JP, A, 2-230106 (古河電気工業株式会社, 東京電力株式会社), 12. 9月, 1990 (12. 09. 90),	1, 7

☒ C欄の続きにも文献が列挙されている。☐ パテントファミリーに関する別紙を参照。

* 引用文献のカテゴリー

- 「A」特に関連のある文献ではなく、一般的技術水準を示すもの
「E」先行文献ではあるが、国際出願日以後に公表されたもの
「L」優先権主張に疑義を提起する文献又は他の文献の発行日若しくは他の特別な理由を確立するために引用する文献 (理由を付す)
「O」口頭による開示、使用、展示等に言及する文献
「P」国際出願日前で、かつ優先権の主張の基礎となる出願の日の後に公表された文献

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「Y」特に関連のある文献であって、当該文献と他の1以上の文献との、当業者にとって自明である組合せによって進歩性がないと考えられるもの
「&」同一パテントファミリー文献

国際調査を完了した日

13. 07. 93

国際調査報告の発送日

03.08.93

名称及びあて先

日本国特許庁 (ISA/JP)
郵便番号100
東京都千代田区霞が関三丁目4番3号

特許庁審査官 (権限のある職員)

加藤 隆夫

2 G 8 2 0 4

電話番号 03-3581-1101 内線 3226

C (続き). 関連すると認められる文献

引用文献の カテゴリー*	引用文献名 及び一部の箇所が関連するときは、その関連する箇所の表示	関連する 請求の範囲の番号
A	第1欄第6行-第2欄第2行, 第1図 & EP, A1, 390,341 JP, A, 2-20803 (株式会社 関西テレコムテクノロジー, 三菱電線工業株式会社), 24. 1月, 1990 (24. 01. 90), 第1欄第5行-第2欄第17行, 第1図, 第4図 (ファミリーなし)	20, 21