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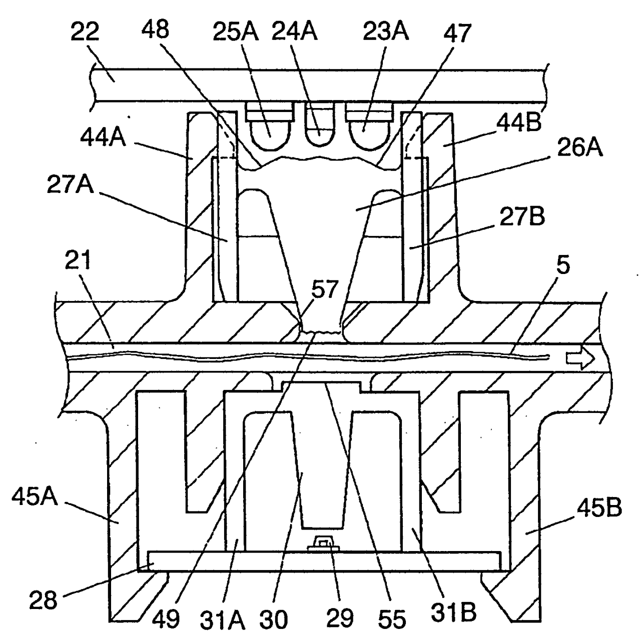
(54) Bill validator

(57) A bill validator having a funnel-like shaped first light-guide disposed between a bill pathway and a plurality of light sources is disclosed. The validator can validate bills with a high accuracy, and a higher resolution ability by condensing light emitted from a plurality of light sources and narrowing a specific measuring point on the bill surface where transmittance and reflectance of the bill are measured.

FIG. 1



EP 1 239 423 A2

Description

Field of the Invention

[0001] The present invention relates to a bill validator for use in various kinds of automated service machines such as automated vending machines, ticket machines or the like.

Background of the Invention

[0002] In recent years, in connection with various kinds of high-priced goods sold by automated vending machines or ticket machines, a bill validator capable of using paper currency in denomination of higher than 1000 yen has been widely used. On the other hand, with the advance of office automation machinery such as copying machine or color printer, crime is going to increase using forged bills made by such a sophisticated machinery. A bill validator must be improved in authenticity to prevent from being committed such crimes.

[0003] In the prior art, a bill validator used in an automated vending machine has a plurality of transmission type light sensing unit comprising a set of light emitting diode (hereafter referred to as LED) and photodiode. Scanning specific measuring points on a bill by light having different wavelengths, the bill validator detects validity by transmittance and of the bill. Examples of such a technology are disclosed in Japanese Patent Publication of Unexamined Applications No.JP S57-62478 or JP H08-7149.

[0004] A conventional bill validator is described as follows with reference to the figures. Fig.13 shows a light sensing unit of a conventional bill validator. In Fig.13, red LED 2 and infrared LED 3 are disposed on a wall surface of bill pathway 1, and photodiode 4 is disposed on an opposite side of wall surfaces of bill pathway 1. When bill 5 to be tested passes in front of photodiode 4, a bill validator of this structure validates the bill by transmittance measured for red LED and infrared LED.

[0005] Fig.14 is a block diagram of a light sensing unit and a validating unit of a conventional bill validator. In Fig. 14, transport system 6 (constructed by belt and roller) is provided along bill pathway 1. A bill detector 7 is disposed at an inlet of transport system 6 to detect a bill inserting, and is connected to controller 8 to detect bill positioning. Red LED 2 and infrared LED 3 disposed on a side of wall of bill pathway are connected to controller 8 to be ignited at a prescribed timing.

[0006] Motor 9 drives transport system 6. Motor 9 is energized by controller 8 through motor driving circuit 10. Synchronous pulse generator 11 to detect motor rotation is connected to motor 9 as well as controller 8. Output signal from photodiode 4 is connected to logarithmic amplifier 12, and output signal of logarithmic amplifier 12 is connected to controller 8 through linear amplifier 13 and analog-digital converter 14 (hereafter referred to as AD converter). Moreover, a reference current of logarithmic amplifier 12 is supplied from controller 8 through digital-analog converter 15 (hereafter referred to as DA converter). In addition to this, a reference value storage circuit 16 and an input value storage circuit 17 are connected to controller 8.

[0007] Next, an operation of a conventional bill validator is described. First, state of every sensor is checked, without bill feeding, for scaling at a starting time of bill validator. When red LED 2 starts, response signal of photodiode 4 against a light emitted from the light source runs to controller 8 through logarithmic amplifier 12, linear amplifier 13 and AD converter 14. Controller 8 calculates difference between AD conversion value and prescribed reference value Xr, then rewrites input value Yr of DA converter 15 using a certain conversion ratio in the course to reduce the difference value. To determine a reference current value for logarithmic amplifier 12, output value of DA converter 15 is regulated to provide output value of AD converter 14 (input value of controller 8) with a prescribed reference value Xr, by varying reference amplifying ratio of logarithmic amplifier 12.

[0008] Similarly, when infrared LED 3 starts, output value of AD converter 14 is provided with a reference value Xir, by varying input value Yir for DA converter 15 to regulate an amplifying ratio of logarithmic amplifier 12.

[0009] After scaling of light sensing unit is finished, a prescribed sensitivity is set for each wavelength of light for each LED by varying input value of DA converter 15 from controller 8, according to an igniting timing of LED 2 and 3.

[0010] After finishing above initial arrangement, when a bill detector 7 detects a feeding of bill 5 at an inlet, motor energized by control circuit 8 drives transport system 6 and carries bill 5 into the light sensing unit. Travel distance of bill 5 can be measured by counting a number of pulses from synchronous pulse generator. Therefore, after bill 5 is transported to a prescribed measuring point from an end of the bill, (1) an AD conversion value Sr of red LED 2, and (2) an AD conversion value Sir of infrared LED 3 are measured. Since difference of disposed position of red LED 2 and infrared LED 3 is corrected by counting a number of pulses generated from synchronous pulse generator these data are measured for an approximate a same point.

[0011] To validate a bill, controller 8 validate values such as AD conversion value Sr for red LED 2, AD conversion value Sir for infrared LED 3 and a difference between Sr - Sir, measured at many points during passage of bill by comparing with a prescribed range of values for valid bill. Moreover, together with output from magnetic sensors, information from other sensors, not shown here, are taken into account to determine total bill validity.

[0012] However, in such a conventional configuration, resolution is hard to improve since measurement in relatively large area of 3 to 5 mm diameter illuminated by light from red LED 2 or infrared LED 3 provide only an averaged transmittance value. In addition to this, skewness of light axis, or error of mounting position of devices such as red LED 2, infrared LED 3 photodiode 4 is hard to correct, and in a case of finding values Sr - Sir on prescribed point of bill 5, measurement results are not always from prescribed point. Problem is that if a bill is heavily creased, accuracy of bill validity becomes poor because area for measurement decreases to a ratio of about half.

Summary of the Invention

[0013] A bill validator, having a light sensing unit to detect bill properties and a validating unit to determine bill authenticity upon signals from the light sensing unit, wherein the light sensing unit comprises followings:

(a1) a plurality of light sources disposed on a side of a bill pathway,
(a2) light sensing devices disposed facing the plurality of light sources on an opposite side of the bill pathway, and
(a3) a funnel-like shaped first light-guide housed in between the plurality of light sources and the bill pathway, which condense light emitted from the plurality of light sources, then emit the light to the bill pathway.

Brief Description of the Drawings

[0014]

Fig. 1 is a cross-sectional view taken in a direction of bill transportation of a light sensing unit of a bill validator used in the first exemplary embodiment of the present invention.
Fig. 2 is a perspective view of a light sensing unit used in the first exemplary embodiment of the present invention.
Fig. 3 is a cross-sectional view taken in a direction perpendicular to a bill transportation of a light sensing unit used in the first exemplary embodiment of the present invention.
Fig. 4 is a block diagram of light sensing unit and validating unit used in the first exemplary embodiment of the present invention.
Fig. 5 is a schematic view of a light transmitting a light-guide used in the first exemplary embodiment of the present invention.
Fig. 6 is a schematic view of a light transmitting a light-guide having an inclined plane of refraction used in the first exemplary embodiment of the present invention.
Fig. 7 is a schematic view of a shape of a light-guide having cylindrical shaped plane of refraction used in the first exemplary embodiment of the present invention.
Fig. 8 is a schematic view of a light transmitting a light-guide having cylindrical shaped plane of refraction used in the first exemplary embodiment of the present invention.
Fig. 9 is a schematic view of a light transmitting a light-guide having finely rugged plane used in the first exemplary embodiment of the present invention.
Fig. 10 is a schematic view of a hollow shaped light-guide used in the first exemplary embodiment of the present invention.
Figs. 11A, 11B and 11C are schematic views of fitting method of a light-guide used in the first exemplary embodiment of the present invention.
Fig. 12 is a cross-sectional view taken in a direction of bill transportation of a light sensing unit of a bill validator used in the second exemplary embodiment of the present invention.
Fig. 13 is a cross-sectional view taken in a direction of bill transportation of a light sensing unit of a conventional bill validator.
Fig. 14 is a block diagram of a light sensing unit and a validating unit of a conventional bill validator.

Description of the Preferred Embodiments.

[0015] The present invention is explained by following preferred embodiments with reference to Fig. 1 through Fig. 12

First Exemplary Embodiment

[0016] Fig. 1 is a cross-sectional view of a light sensing unit of the first exemplary embodiment. In Fig. 1, first board 22 is disposed on one side of bill pathway 21 of a bill validator. First board 22 carries on surface a plurality of chip formed light sources, red LED 23A, infrared LED 24A and blue LED 25A. Infrared LED 24A is arranged in the center. The validator can test the validity of a bill with high accuracy because the bill is measured for transmittance by a plurality of light sources, red LED 23A, infrared LED 24A and blue LED 25A each having different light wave length. Additionally, surface mount LED having low height can produce a down-sized machine.

[0017] Funnel-like shaped first light-guide 26A is disposed between bill pathway 21 and first board 22. In order to condense emitted light, first light-guide 26A and 26B (shown in Fig. 2) of this invention have such a shaping, for example, a funnel or wedge like shaping that bottom side cross-section facing bill pathway 21 is smaller than top surface cross-section facing first board 22. First light-guide 26A formed from transparent resin has incorporated with fitting-frame 27A and 27B to secure to bill pathway 21. First light-guide 26A and 26B are set in place by locking fitting-frames 27A and 27B, and fitting-hooks 44A and 44B respectively which are incorporated with an upper surface of bill pathway 21.

[0018] Second board 28 is disposed under a lower surface of bill pathway. Second board 28 carries surface-mount photodiode 29 as a light sensing device. Surface-mount photodiode used here allows an apparatus to be down-sized with its low height.

[0019] Additionally, funnel-like shaped second light-guide 30 formed from transparent resin is disposed, facing photodiode 29, between bill pathway 21 and second board 28. In order to condense light into photodiode 29, second light-guide 30 of this invention have such a shaping, for example, a funnel or wedge like shaping that top surface cross-section against bill pathway 21 is larger than bottom side cross-section facing second board 28.

[0020] Second light-guide 30 is incorporated with fitting-frame 31A and 31B to be fixed to bill pathway 21. Second light-guide 30 is set in place by locking second board 28 to fitting-hooks 45A and 45B which are incorporated with surface of bill pathway 21. Fitting-frames 31A and 31B are sandwiched between bill pathway 21 and second board 28.

[0021] Fig. 2 is a perspective view of a light sensing unit of the first exemplary embodiment. First board 22 carries on its surface aforementioned red LED 23A, infrared LED 24A and blue LED 25A being arranged in a line parallel to a bill transportation direction. In addition to this, another one line of red LED, infrared LED and blue LED are provided parallel to the bill transportation direction.

[0022] Therefore, a plurality of measurement lines parallel to a bill transportation direction can be arranged in high density, which can improve a bill validity ability.

[0023] Like first light-guide 26A housed facing aforementioned LED of 23A, 24A and 25A, another first light-guide 26B is housed facing LED of 23B, 24B and 25B. First light-guide 26B is housed parallel to the bill transportation direction but in different position from first light-guide 26A because capacity for bill validity is improved by placing a plurality of measurement lines parallel to bill transportation direction in higher density.

[0024] Additionally, first light-guide 26A and 26B are coupled by same fitting-frame 27A and 27B. A plurality of light-guide are assembled into one structure using a common fitting-frame, which provide an improved quality as surface of light-guides are prevented from finger touch during assembly.

[0025] Second light-guide 30 having a form of tapering to a photodiode 29 or, as aforementioned, a funnel-like shaped, is housed facing light emitting side of first light-guides 26A and 26B.

[0026] Fig. 3 is a cross-sectional view of a light sensing unit of the first exemplary embodiment from perpendicular view point of Fig. 1. Barrier 46 to block through-light is provided on wall surface of bill pathway 21, between both first light-guides of 26A and 26B, to prevent mutual light interfere from both light sources of LED's line of 23A-24A-25A, and LED's line of 23B-24B-25B.

[0027] Fig. 4 is a block diagram of light sensing unit and validating unit for bill validator of this invention and conventional art.

In Fig. 4, transport system 32 (comprising belt and roller) for carrying bill 5 is provided along bill pathway 21. Bill detector 33 is disposed at an inlet of transport system 32, and is connected to controller 34 to detect bill positioning.

[0028] Red LED's 23A and 23B, infrared LED's 24A and 24B, and blue LED's 25A and 25B are connected to controller 34 to ignite them sequentially at a prescribed timing.

[0029] Motor 35 drives transport system 32. Motor 35 is energized by controller 34 through motor driving circuit 36. Synchronous pulse generator 37 to detect rotation of the motor is connected to motor 35 as well as controller 34.

[0030] Output signal of photodiode 29 fed into logarithmic amplifier 38 is amplified in logarithmic value output, which flows through in the order of linear amplifier 39, then analog-digital converter 40 (hereafter referred to as AD converter) and finally to controller 34. In addition to this, reference current for logarithmic amplifier 38 is supplied from control 34 through digital-analogue converter 41 (hereafter referred to as DA converter).

[0031] Usually, one chip microprocessor having many I/O ports is adopted for controller 34.

[0032] Next, an operation of bill validator of the the first exemplary embodiment of this invention is described. First, stage of every sensor is checked at starting time of bill validator when bill is not supplied. When red LED 23A starts, light emission runs to bill pathway through first light-guide 26A, then runs to photodiode 29 through second light-guide 30. Output signal from photodiode 29 is fed to controller 34 through logarithmic amplifier 38, linear amplifier 39 and AD converter 40. In controller 34, calculating difference between AD conversion value of this input voltage and reference value Xr1 which is prescribed and stored beforehand in reference value storage circuit 42, input value Yr1 for DA converter 41 is changed using a certain ratio to provide a smaller difference value.

[0033] To determine a reference current value for logarithmic amplifier 38, output signal of DA converter 41 repeats to change reference amplifying ratio of logarithmic amplifier 38, to provide output signal of AD converter 40 (input value of control circuit 34) with the same value as prescribed beforehand. Amended input value Yr1 is stored in relevant input value storage circuit 43.

[0034] Next, starting infrared LED 24A, like aforementioned way, varying input value Yir1 of DA converter 41 when infrared LED 24A is on, arranging amplifying ratio of logarithmic amplifier 38, provide output value of AD converter 40 with same value of reference value Xir1 of infrared diode 24A. Amended input value Yir1 is stored in relevant input value storage circuit 43.

[0035] Next, starting blue LED 25A, like aforementioned way, varying input value Yir1 of DA converter 41 when blue LED 25A is on, arranging amplifying ratio of logarithmic amplifier 38, provide output value of AD converter 40 with same value of reference value Xb1 of blue diode 25A. Amended input value Yb1 is stored in relevant input value storage circuit 43.

[0036] Similarly, obtained input value Yr2 for red LED 23B, input value Yir2 for infrared LED 24B and input value Yb2 for blue LED 25B are stored in respective input value storage circuit 43.

[0037] Initialization work is being finished in above, next, at starting time of each LED, controller 34 reads out relevant input values from input value storage circuit 43, varying respective relevant input value, suitable sensitivity for each spot and each light wave length is determined.

[0038] After finishing above initialization, when a bill detector 33 detects a fed bill 5 at inlet of light sensing unit, motor energized by controller 34 drives transport system 32 and carries bill 5 into the light sensing unit.

[0039] Travel distance of bill 5 can be measured by control 34 by counting number of pulse from synchronous pulse generator 37. Therefore, after transported beforehand prescribed distance from end of the bill, AD conversion value Sr1 for red LED 23A, AD conversion value Sir1 for infrared LED 24A and AD conversion value Sb1 for blue LED 25A are determined.

[0040] Difference in disposing position of LED's on first board 22 has no influence on specific radiation spot because light emitted from red LED 23A, light emitted from infrared LED 24A and light emitted from blue LED 25A are all radiated on a same specific spot through first light-guide 26A.

Additionally, since bill transporting speed in current bill validator is, for example, 150 mm/s, if each LED ignites at time interval of not more than 1 ms, the bill travels not more than 0.15 mm during the interval. When opening width of light-guide 26A facing against bill pathway 21 is approx. 2 mm, effect on positioning caused by bill transportation becomes not more than 7.5 %, which brings a marked improvement in resolution and poisoning accuracy for each wavelength of light.

[0041] Photodiode 29 detects also light emitted from another line of LEDs 23B-24B-25B, through first light-guide 26B and second light-guide 30, to process AD conversion value for different point of the bill in the same circuit.

[0042] To validate a bill totally, as is known in the art, control 34 validates whether values of Sr1, Sir1, Sr1 - Sir1 measured at many points during passage of bill are within a prescribed range of values. Moreover, information from other sensors such as magnetic sensor must also be taken into account for total determination of bill authenticity.

[0043] Additionally, a configuration disposed in this invention comprises a function of validating a plurality of line of scanning for a bill by a plurality of light sources by receiving with smaller number of light sensing device. Therefore, by reducing circuit devices such as logarithmic amplifier connected to light receiving devices and surface mounting area for circuit parts on a board, device can be totally down-sized.

[0044] In the aforementioned the first exemplary embodiment, 2 lines of LEDs comprising 3 kinds of LEDs each detects adjacent 2 lines of area on a bill using 2 first light-guides 26A and 26B. Similarly, cases of using not more than 2 kind of LEDs or not less than 4 kinds of LEDs are also available. Or, needless to say, in some cases of products of having 1 first light-guide 26 or not less than 3 can be manufactured. In case of 1 first light-guide, similar effects can be expected with conventional photodiode even if second light-guide 30 is not used. As is described in Claim 4 of this invention, first light-guide or second light-guide is a molded component filled with transparent material having a funnel-like shape, which can be well manufactured in a mass-production system though having a complex surface form.

[0045] In Fig. 1, planes of refraction 47 and 48 inclined against light of incidence is provided in places facing red LED 23A and blue LED 25A of first light-guide 26A. Moreover, end surface 49 of first light-guide 26A facing bill pathway 21 has a mirror finish formed of continuous fine rugged surface. Effects of such surface form are described as follows.

[0046] Fig. 5 shows courses of light 56 sent out from red LED 23A when light-guide 26A has no plane of refraction 47. It shows large quantity of light losses such as transmission loss in light runs to left-hand-side wall of first light-guide 26A, and many off-light runs to left side in Fig. 5 and being not enter window portion 55 of second light-guide 30.

[0047] Moreover, light receiving wall surface 57 of bill pathway 21, in this figure, is provided with black colored to absorb light or rugged finished to prevent through-light by reflection from wall surfaces 57. Fig. 6 shows courses of light 56 sent out from red LED 23A when light-guide 26A has an inclined plane of refraction 47 to induce the light to emitting side of light-guide 26A.

[0048] Courses of light passing left hand side wall of light-guide 26A disappears by providing plane of refraction 47. It shows also less light pass off to left side and do not enter window portion 55 of second light-guide 30. The same is for blue LED 25A.

[0049] Fig. 7 shows an example of shape when first light-guide 26A is provided with 3 cylindrical planes 50 instead of large plane of refraction 47. Fig. 8 shows courses of light 56 sent out from red LED 23A when the cylindrical planes 50 are installed. It shows, in this case, reduced loss by light condensed further. However, as light condenses to a limited point in a testing area partially, it has a fault of difficulty to provide an even quantity of light within the testing area. In such a case light shall necessarily be scattered using fine rugged planes or the like, as described later,

[0050] Fig. 9 shows a course where light 56 emitted from red LED 23A passes through when, with a plane of refraction 47, a light emission side terminal plane of first light-guide 26A is finished with a mirror surface having a shape of continuous fine, rugged spots. More quantity of light enter a window portion 55 of second light-guide 30 than in the case of Fig. 6, and a distribution of light quantity within a measuring area and a scattered direction of light incident into second light-guide 30 is observed.

[0051] Whole width of first light-guide 26A is provided with a shape of fine rugged surface shown in Fig. 9 having fine mountain shapes with a vertical angle of 140 degrees and a uniform cross-section arranged in 0.4 mm pitch. Similar effects are expected in so-called micro-prism surface having continuous fine quadrangular pyramid shaped convex plane or irregular rugged surface provided by shot peening or selection etching if it comprises little transmission loss and suitable scattering light.

[0052] Additionally, a hollow shaped components having opening for both light emitting and incoming ends, and finished with mirror surface or high reflecting materials provide with similar effects though, as to first light-guide 26A and 26B or second light-guide 30, a case of manufacturing using transparent materials is described.

[0053] Fig. 10 shows second light-guide 30R hollow-shaped with plastic material of high reflectance. Similar effects are expected in a molded component provided with plastic materials including much amount of light reflecting filler such as titanium oxide, or a light-guide having a metal luster in inner surface formed from resin plating such as electroless nickel plating. In this case, an injection molding provides a light-guide with a thinner thickness with less deformation comprising effects of steady product properties.

[0054] Upon fitting first light-guide 26A and 26B facing bill pathway 21, optically important portion such as terminal surfaces or side surfaces can be free from dirt or cloud due to finger touch by using fitting frame 27A and 27B. In addition to this, fitting method of a fitting frame 27A and 27B is shown in Figs. 11A, 11B and 11C.

[0055] That is, in case of push-in structure of fitting frame 27A and 27B along guide-ribs 51A and 51B, it is important that fitting frames 27A and 27B are higher than fitting hook 44A and 44B or guide-ribs 51A and 51B. This structure capable of pushing into an end holding fitting-frame 27A and 27B following an arrow mark provides an easy and secure assembling, accordingly. As guide-ribs are lower than fitting-frames, first light-guide can be secured on side walls of bill pathway without being obstructed by guide-ribs when holding upper end of fitting-frames and push into fitting-ribs.

Second Exemplary Embodiment

[0056] Next, light sensing unit of embodiment 2 of the invention is described. Fig. 12 shows a cross-sectional view of an sensing unit of the second exemplary embodiment .

In Fig. 12, on one side of wall surfaces of bill pathway 21, first board 61 is mounted on which surface mount LED's, red LED 23A and infrared LED 24A, and second photodiode 62 are disposed. First light-guide 63 is disposed between bill pathway 21 and first board 61. First light-guide 63 formed from light transparent materials is assembled into one structure with;

(1) first funnel-like shaped portion 64 facing red LED 23A and infrared LED 24B,
(2) second funnel-like shaped portion 65 facing second photodiode 62, and
(3) fitting-frames 66A and 66B to be secured on bill pathway 21.

First light-guide 63 is secured to bill pathway 21 by coupling fitting frames 66A and 66B, and fitting hooks 67A and 67B incorporated to bill pathway 21. On another side of wall surfaces of bill pathway 21, second board 68 is mounted on which first photodiode 69 is disposed. Second light-guide 70 having funnel-like shape formed from light transparent materials, facing first photodiode 69, is disposed between bill pathway 21 and second board 68. Second light-guide 70 has fitting frames 71A and 71B built into one structure to assemble with bill pathway. Second light guide 70 is secured between bill pathway 21 and second board 68 with fitting frames 71A and 71B being sandwiched by coupling second board 68 with fitting hooks 72A and 72B incorporated to wall surfaces of bill pathway 21

[0057] Next, an operation of such a configuration in the second exemplary embodiment of the invention is described. As is same as the first exemplary embodiment, the configuration can detect light transmittance of a bill as follows:

(1) light emitted from red LED 23A and infrared LED 24A is sent out to bill 5 through first funnel-like portion 64 of first light-guide 63, and
(2) light transmit through bill 5 is received by first photodiode 69 through second light-guide 70. At this time, as a light reflecting from a surface of bill 5 is sent to second photodiode 62 through second funnel-like portion 65 of first light-guide 63, level of reflecting light can be measured if second photodiode 62 and first photodiode 69 are connected to a same circuit. In this case, light transmittance and reflectance of a bill is measured for a same area of a bill at the same time, which can provide an effectual means to validate a colorful bill having a distinguishing reflection spectrum.

[0058] As mentioned above, a bill validator, disclosed in this invention, comprises a funnel-like shaped first light-guide to send a condensed light emitted from a plurality of light sources to a bill pathway side, which can improve a resolution capability by reducing an area for measurement of transmittance and reflectance. Moreover, as light from a plurality of light sources goes to the same area, the validator comprises a function of detecting a plurality of scanning lines on a bill using a plurality of light sources by condensing light to lesser quantity of light receiving device than quantity of light source or scanning line. Therefore, device can be down-sized by cutting down for circuit element components such as logarithmic amplifier connected to light receiving devices and reducing area for mounting circuit elements.

Claims

1. A bill validator comprising:

(a) a light sensing unit to detect bill properties including:

(a1) a plurality of light sources disposed on a side of a bill pathway;
(a2) a light sensing device disposed facing said plurality of light sources on an opposite side of said bill pathway; and
(a3) a funnel-like shaped first light-guide housed in between said plurality of light sources and said bill pathway, said light-guide condenses light emitted from said plurality of light sources, then said light-guide emits the light to said bill pathway; and

(b) a validating unit to determine bill authenticity based on signals from said light sensing unit.

2. The bill validator of claim 1, wherein each of said plurality of light sources has different wavelengths of light.

3. The bill validator of claim 1, wherein each of said plurality of light sources includes a surface mount light emitting diode.

4. The bill validator of claim 1, further comprising:

(c) a plurality of said first light-guides arranged in a direction perpendicular to said bill transportation direction along said bill pathway;
(d) a plurality of said light sources arranged facing each of said plurality of first light-guides;
(e) a barrier separation to prevent through-light between said first light-guides;
(f) a second light-guide disposed between said light sensing device and said bill pathway,

wherein said second light-guide has a funnel-like shape, opens to said bill pathway facing said plurality of first light-guides and tapers to said light sensing device.

5. The bill validator of claim 1 and 4, wherein said light sensing device includes surface mount photodiode.

6. The bill validator of claim 1 and 4, wherein said plurality of light sources are arranged in a direction of bill transportation.

7. The bill validator of claim 4, wherein at least one of said first light-guide and said second light-guide having a funnel-like shape includes molded component formed from transparent resin materials.

8. The bill validator of claim 4, wherein at least one of said first light-guide and said second light-guide comprises a funnel-like shape, and inside surface is formed from light reflecting materials.

9. The bill validator of claim 7, wherein at least one of said first light-guide and said second light-guide further comprises a fitting frame in one end of said light-guide.

10. The bill validator of claim 9, further comprising:

fitting frames to couple with said plurality of light-guides,

wherein a plurality of said first light-guides are arranged in perpendicular to a bill transporting direction.

11. The bill validator of claim 9, further comprising:

guide-ribs for positioning having a height of lower than said fitting frame provided on side walls of said bill pathway; and
fitting-hooks provided in one end of said guide-ribs.

12. The bill validator of claim 7, wherein an end surface of said first light-guide facing said plurality of light sources comprises an inclined plane of refraction against incident light.

13. The bill validator of claim 12, wherein said plane of refraction is formed from a cylindrical convex plane.

14. The bill validator of claim 6, wherein an end surface of said first light-guide facing said bill pathway comprises a mirror surface finish having a shape of continuous rugged surface.

15. The bill validator of claim 4, further comprising:

a first light receiving device arranged on an identical side of said plurality of light sources facing said bill pathway; and
a second light receiving device arranged on an

opposite side of said plurality of light sources facing said bill pathway.

16. A bill validator comprising:

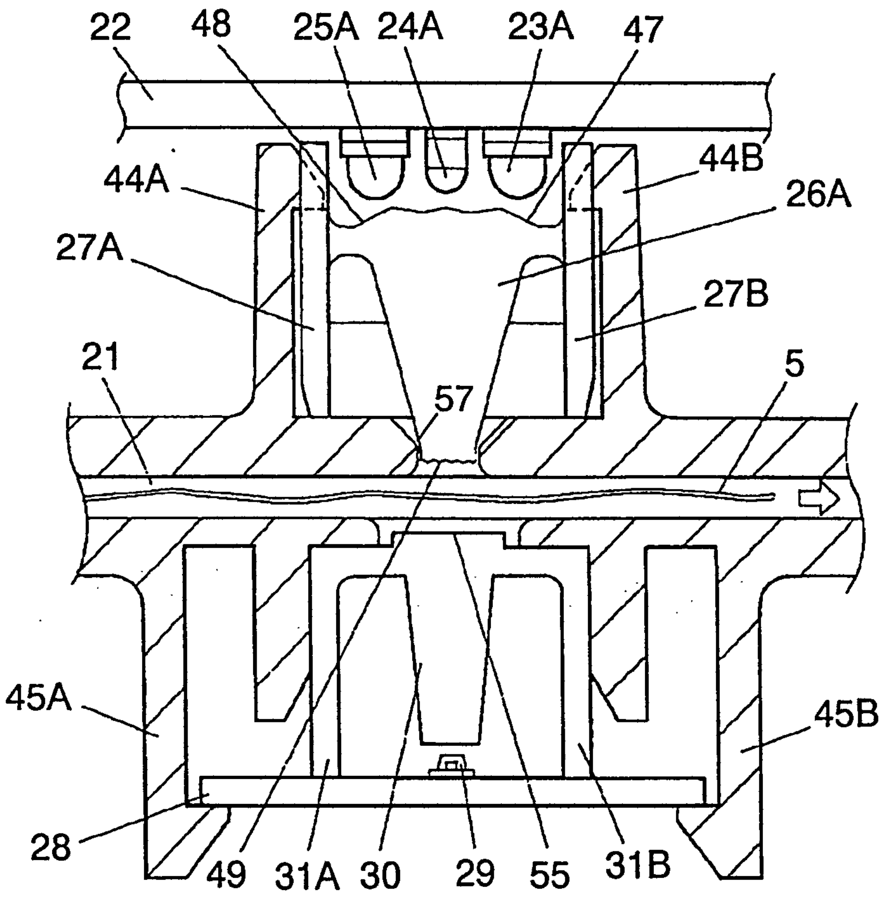
(a) a light sensing unit to detect bill properties including:

(a1) a plurality of light sources disposed on a side of a bill pathway;
(a2) a light sensing device disposed against said plurality of light sources on the opposite side of said bill pathway; and
(g) a funnel-like shaped second light-guide housed in between said light sensing devices and said bill pathway, wherein said second light-guide is tapered against said light sensing device and opened against said bill pathway; and

(b) a validating unit to determine bill authenticity based on signals from said light sensing unit.

17. The bill validator of claim 1, wherein said bill pathway includes black colored wall surfaces.

FIG. 1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48
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47
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29
55
31B

FIG. 2

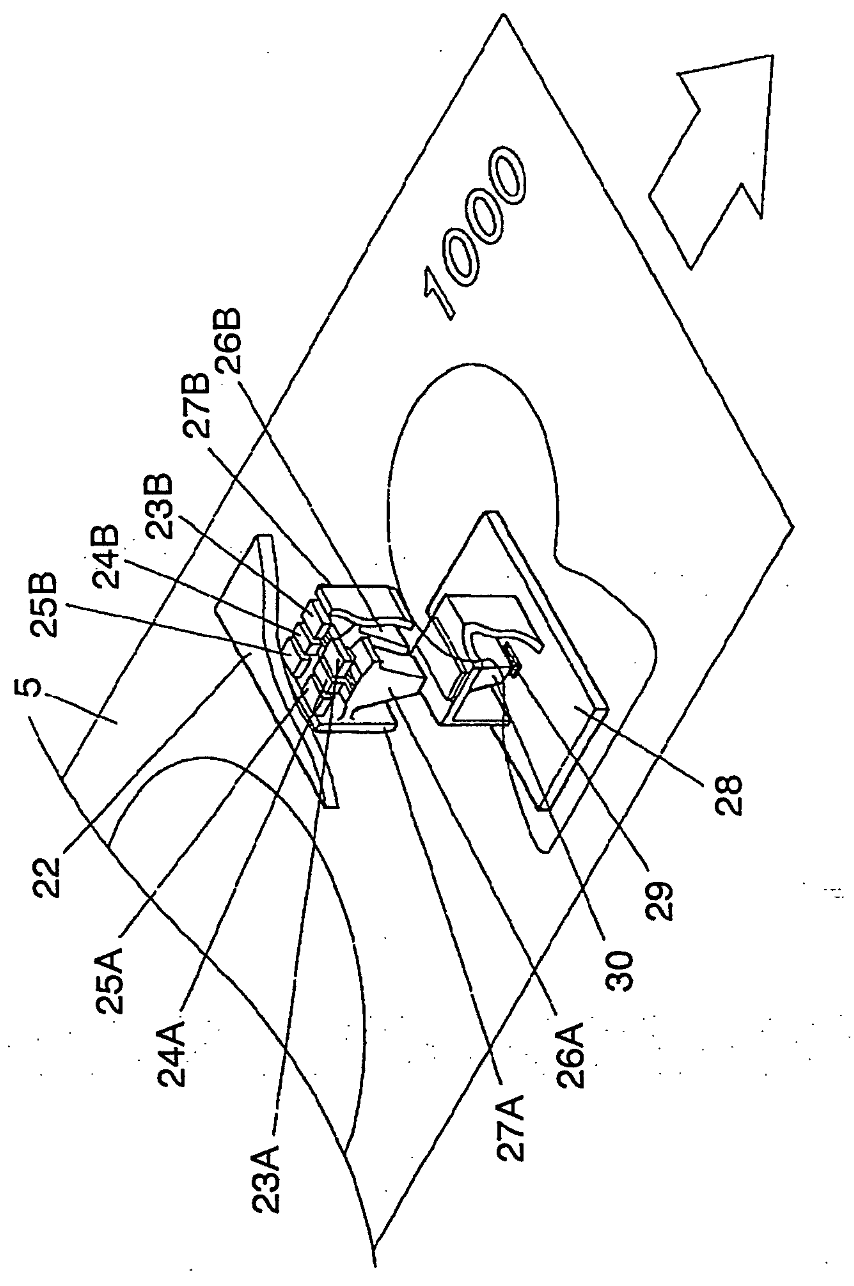


FIG. 3

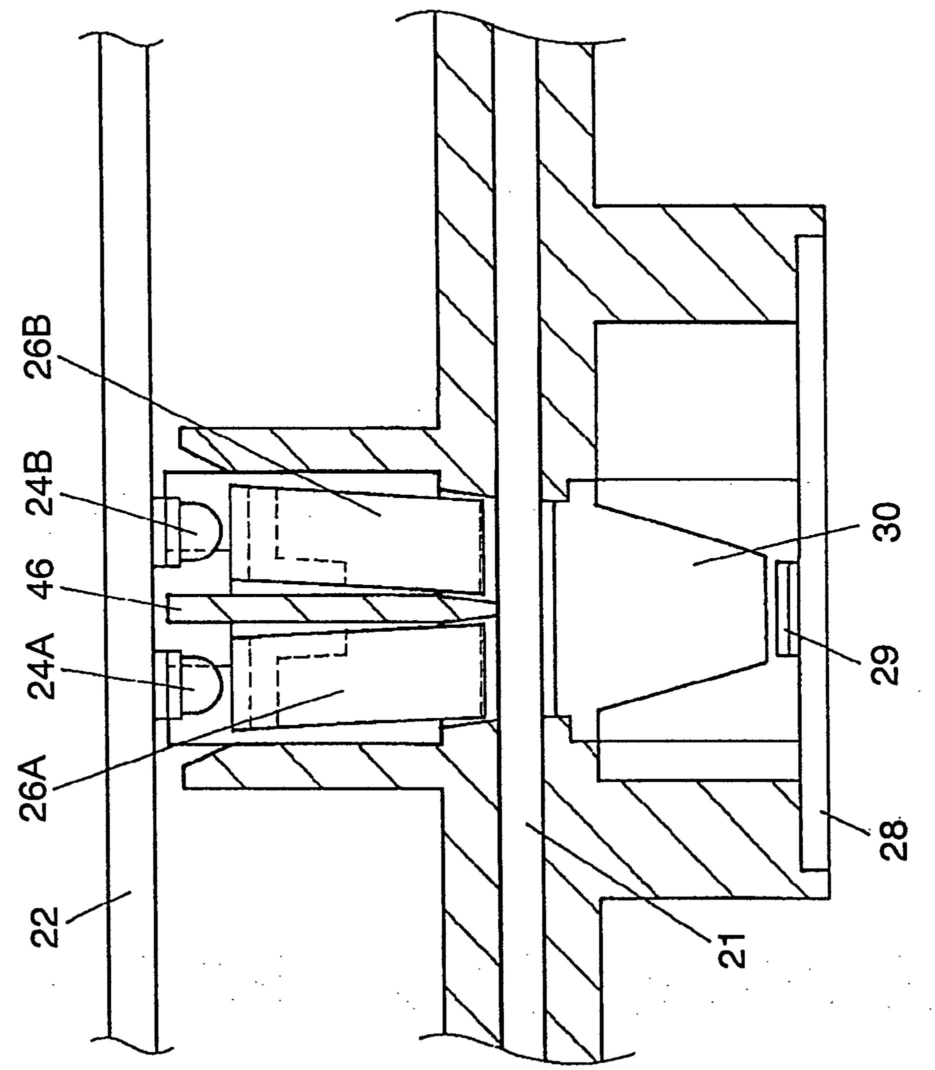
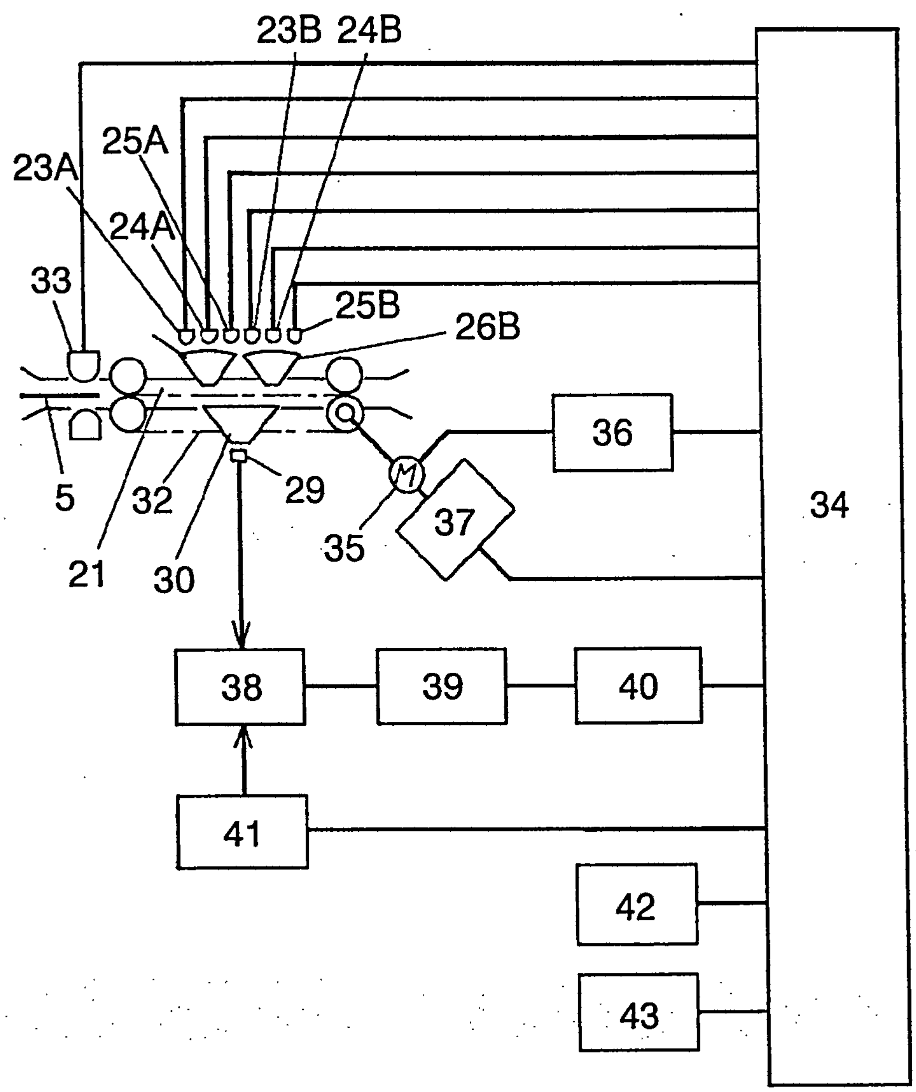


FIG. 4


23B 24B
25A
23A
24A
33
25B
26B
36
5
32
29
34
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41
42
43

FIG. 5

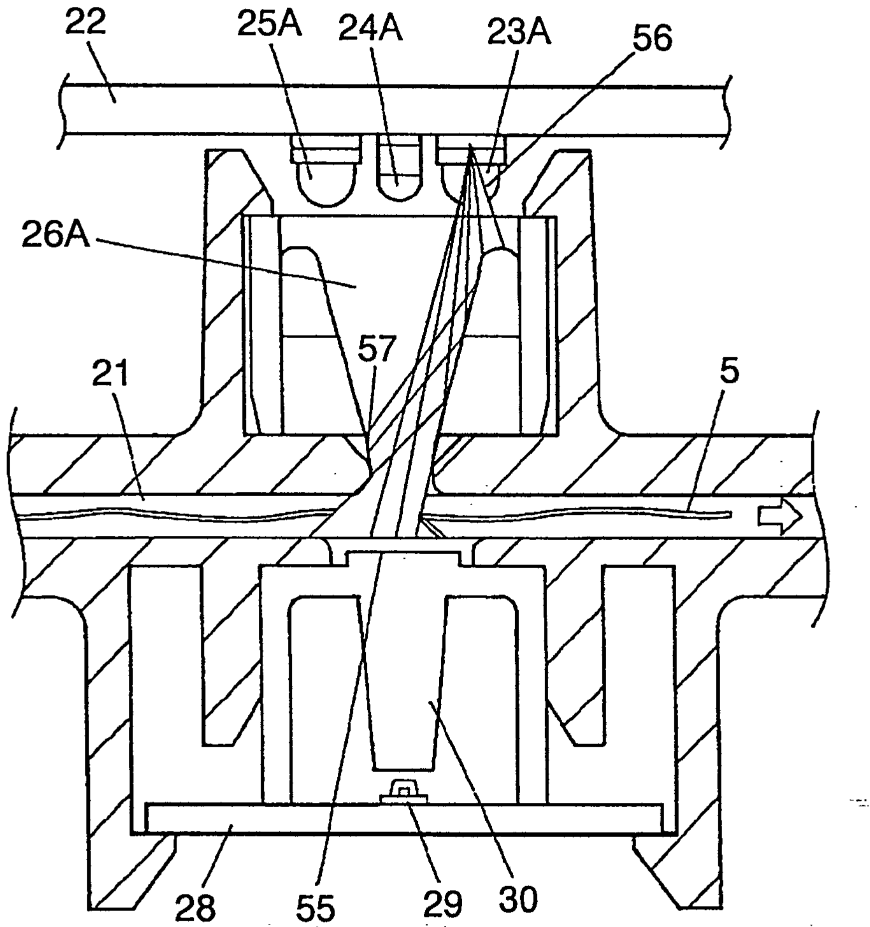

FIG. 6

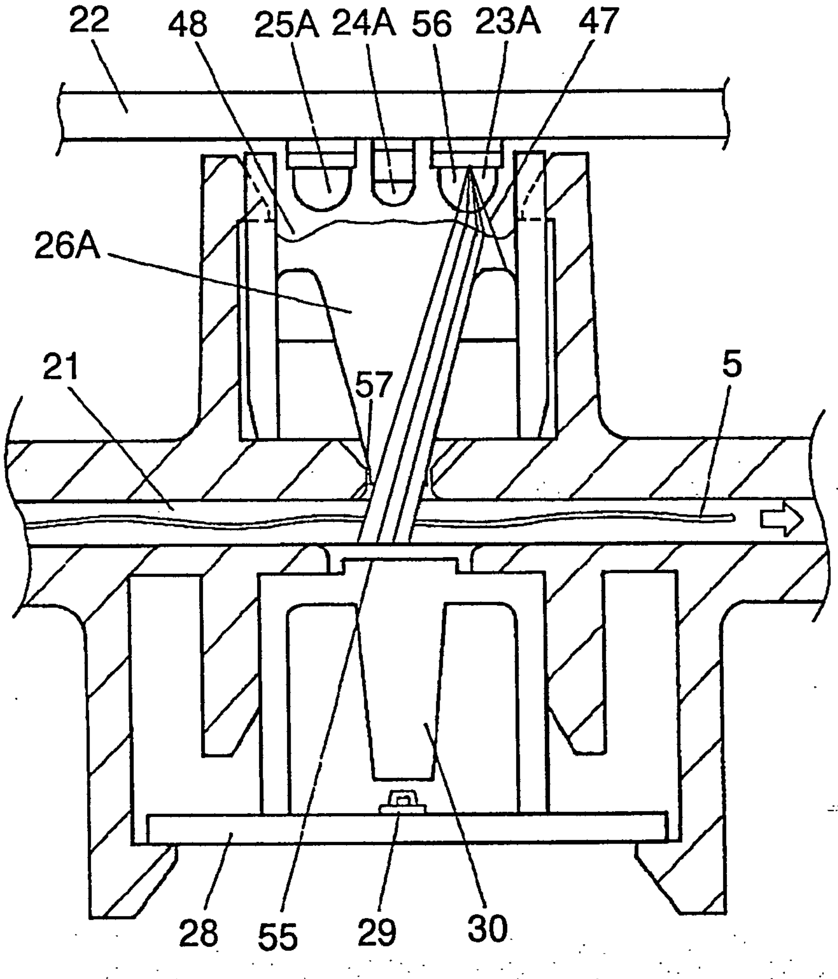

FIG. 7

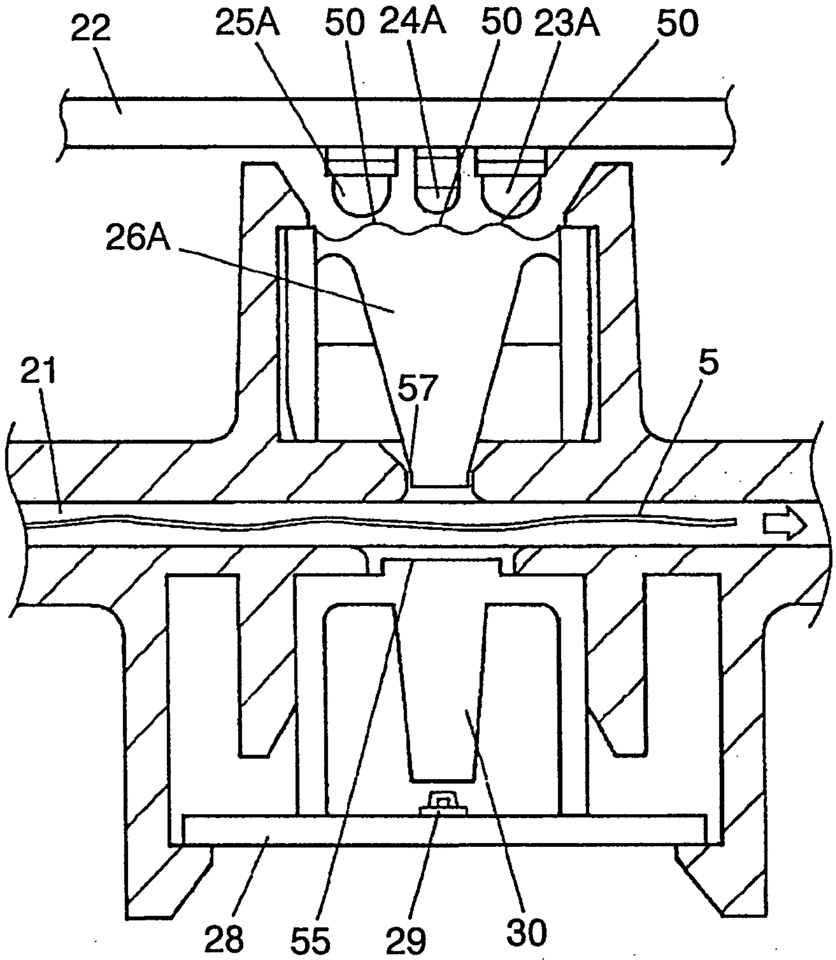

FIG. 8

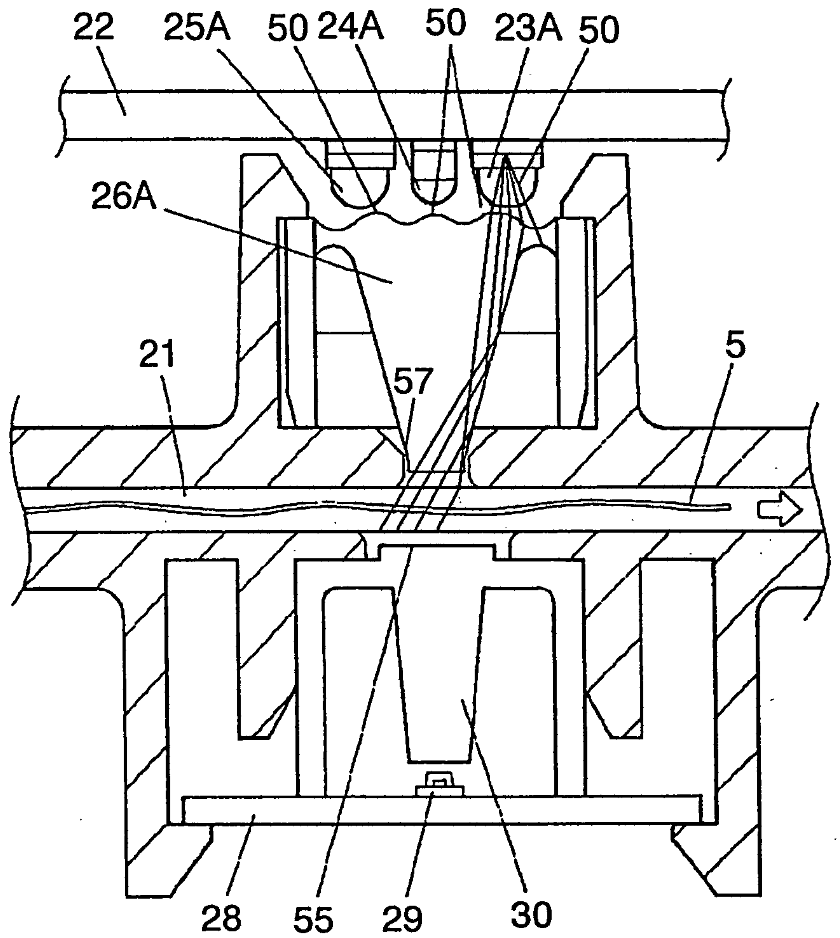

FIG. 9

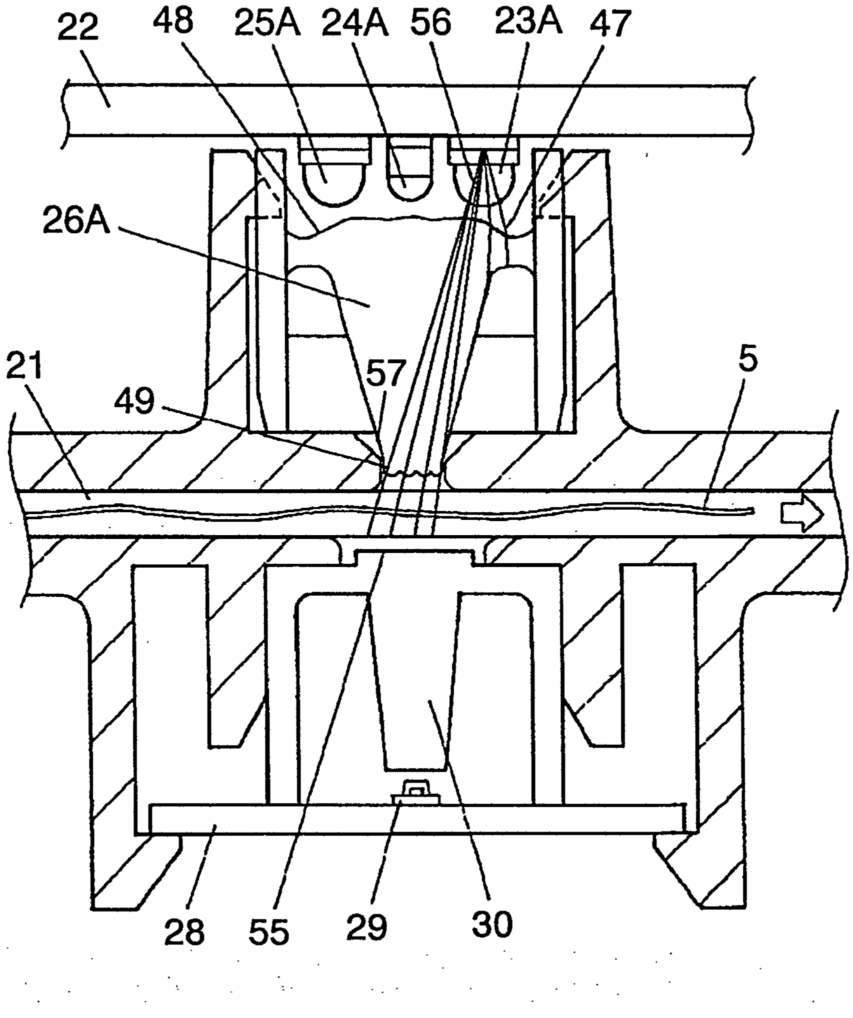

FIG. 10

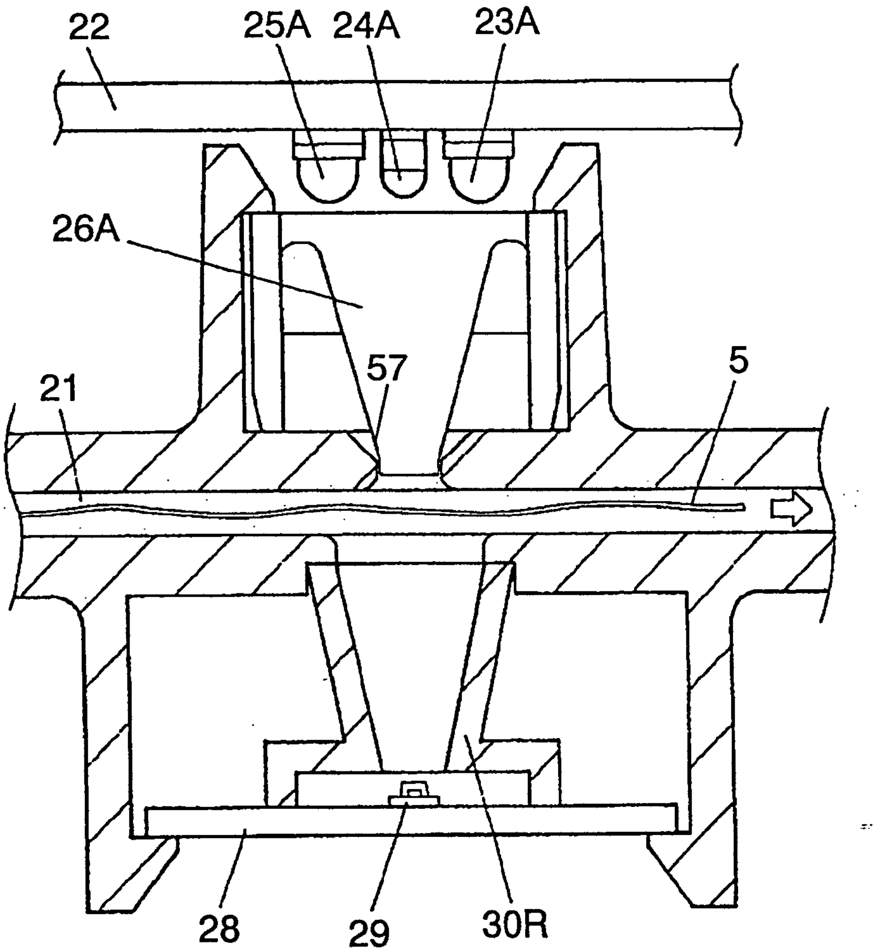

FIG. 11A

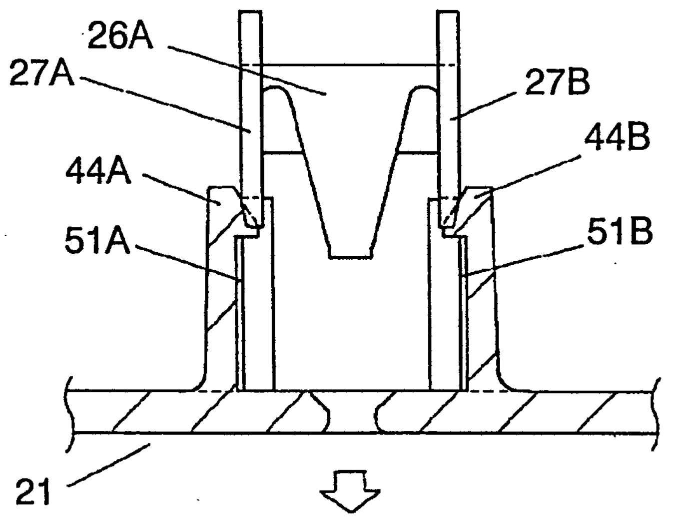

FIG. 11B

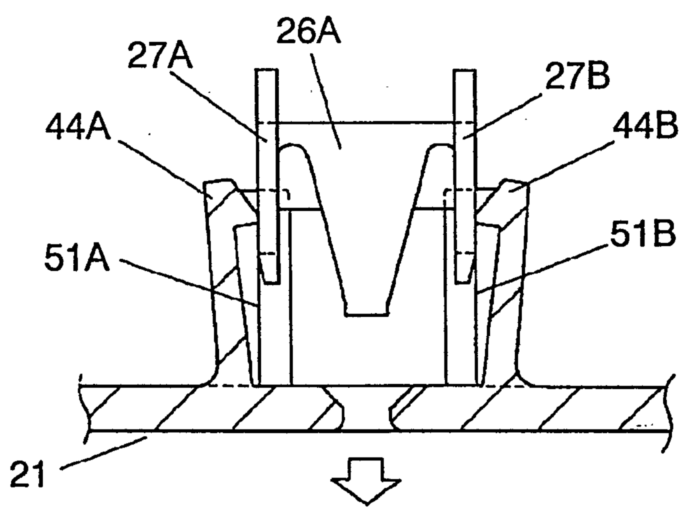

FIG. 11C

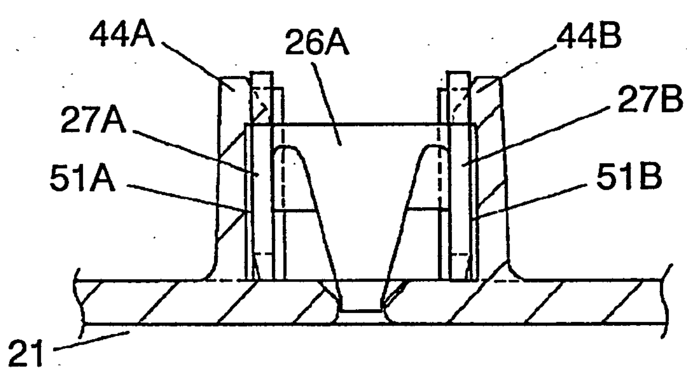

FIG. 12

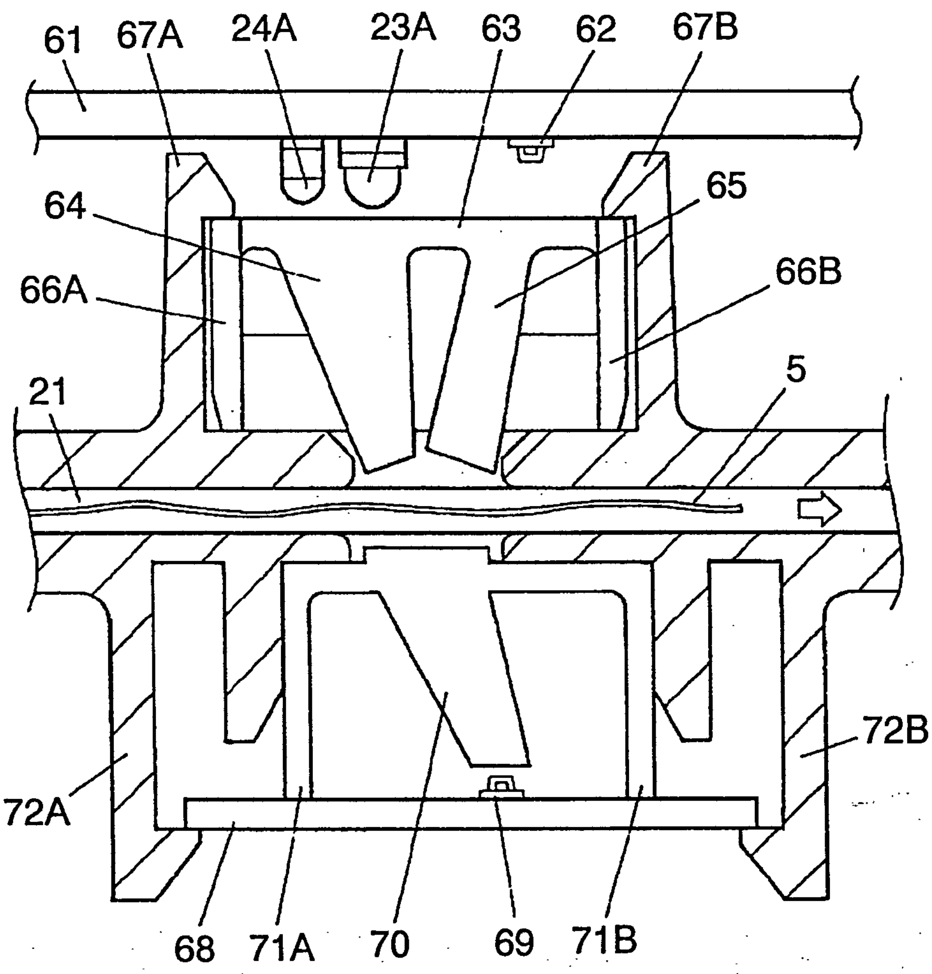

FIG. 13

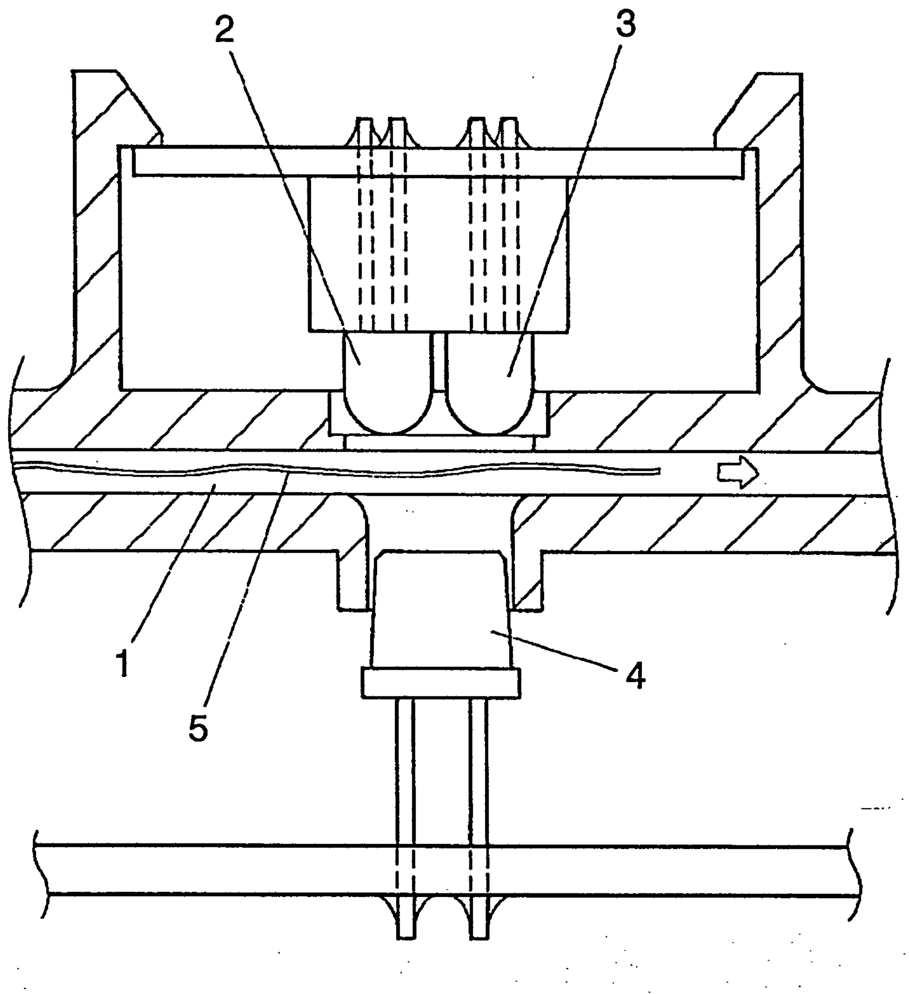

FIG. 14