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A request for correction by exchanging figures 4A and 4C has been filed pursuant to Rule 88 EPC. A decision on the request will be taken during the proceedings before the Examining Division (Guidelines for Examination in the EPO, A-V, 2.2).

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## (54) Method and apparatus for sorting discrete materials and manufactured products.

(57) A sorting method and apparatus is provided in which a flow of particles or objects to be sorted is accelerated by being caused to descend an inclined chute after which the stream or streams discharged from the chute are scanned transversely from one or both sides and while in free fall by one or several linescan cameras. The chute may be arranged to divide the flow into separate side by side streams. In a particular arrangement, two cameras scan the streams successively at respective different levels. The linescan data captured by the cameras is then processed to derive signals for operating downstream sorting means.

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# METHOD AND APPARATUS FOR SORTING DISCRETE MATERIALS AND MANUFACTURED PRODUCTS

This invention relates to a method and apparatus employed to detect and eject a particular object or objects from a plurality of similar or dissimilar objects. More particularly, the objects to be separated are detected on the basis of size, e.g. length, width, area or perimeter; reflected radiation, e.g. light; or transmitted radiation through the objects.

This invention is particularly suitable for sorting or grading, and rejecting, a variety of materials, e.g. broken or chipped pharmaceutical tablets, under or oversized capsules, broken almonds, peanuts with glass or shell, dehydrated vegetable with discolouration blemishes, incorrectly manufactured metal washers and many others.

An object of this invention is to provide a reliable method of presenting a stream of objects being sorted. Another object is to provide an arrangement of sensing elements (cameras) to enable detection of a single or several features (e.g. area and discolouration and the position of discolouration) simultaneously. A further object is to provide accurate means of ejection of rejected objects.

It is known (e.g. Automated Visual Inspection, B. G. Batchelor et al or Patent Application GB 8822183.3) that linescan CCD cameras can be used for sorting articles, e.g. on a belt, using either reflected or transmitted light. The use of linescan cameras for measurement of a single dimension only is also well documented. In order to effect two-dimensional measurements, e.g. of length and width or of an area, matrix cameras are normally employed. This technique presents difficulties in speed of image frame capture, normally twenty five frames per second, and the complex processing required to extract the object data from the image frame. Both of these limit significantly the number of inspections which can be performed in a given time. Linescan cameras offer higher speed and higher resolution but scanning takes place only in one dimension, typically width.

According to one aspect of the present invention, the product or flow of objects to be sorted is first accelerated to produce separation and then caused to fall under gravity, preferably in a plurality of separate side by side streams, and data for determining whether individual particles or objects should be accepted or rejected, according to preset criteria, is obtained by at least one linescan camera the direction of scan of which is across the falling stream or streams.

To accelerate the flow and divide it into a plurality of side by side streams, an inclined chute may be employed that optionally has a multiplicity of side by side channels amongst which the flow is distributed. According to the data that it is required to capture, two linescan cameras may be employed in cascade, i.e. viewing the objects falling in the streams at two successive levels as they fall, and/or there may be viewing cameras, singly or in pairs, back and front of the streams.

According to another aspect of the invention, data is obtained from objects in a falling stream by scanning with at least one, and preferably at least two, linescan cameras employing transmitted or reflected radiation, the data is processed by processing means pre-programmed with selected parameter limits which the objects should obey, and reject signals are issued by the processing means to ejection means downstream of the site of the scanning operation for ejecting from the falling stream any objects that do not obey the selected limits.

Arrangements according to the invention will now be described in more detail by way of example, with reference to the accompanying diagrammatic drawings, in which:-

Figures 1A, 1B and 1C are respectively, a diagrammatic end elevation, side elevation and plan of a sorting apparatus embodying the invention,

Figures 2A, 2B and 2C are similar diagrammatic views showing a modification of the sorting apparatus of Figures 1A-C,

Figure 3 is a diagram representing an object falling successively through the scanning lines of two linescan cameras,

Figures 4A, 4B and 4C are again diagrammatic views similar to Figures 1A C and showing a further modification,

Figures 5A and 5B are, respectively, a diagrammatic side elevation and plan of a four camera arrangement, and

Figure 6 is a diagrammatic side elevation showing a complete sorting system in more detail.

Referring firstly to Figures 1A-C, objects are fed in a controlled manner by a feeder **11** on to an inclined chute 12. This chute typically, but not essentially, provides a multiplicity of side by side channels 13 into which the objects are directed. A separate stream of objects is allowed to slide within each channel under gravity. As the objects fall from the lower ends of the channels all the streams corresponding to the number of channels are viewed by one or more cameras of the linescan CCD type and each stream will be monitored by a respective sector of the or each linescan CCD camera. The processing of the linescan information is generally in accordance with patent application GB 8822183.3 and will depend on the camera arrangement and on features required to be recognised.

For recognition of approximate shape or approximate size a single camera 14 viewing transmitted light from a light source 15 is employed, as illustrated in Figures 1A-C. An assumption about the speed of fall must be made.

Where accurate size (length, width, area or perimeter) is required as a sorting parameter, two cameras are employed in a cascade (i.e. one viewing after the other) arrangement (Figures 2A-C). Providing the two cameras are viewing parallel lines a known distance S apart, and the relative timing of the two cameras is also known, the velocity of the object can be calculated. Once the speed of travel is known the length of any object can also be calculated. By virtue of the linescan camera, each object is scanned, in a single line, typically 2000 times per second but this could be faster or slower as required. Illustration of an object (e.g. a tablet) falling past the cascade arrangement of cameras is given in Figure 3. The object's velocity is determined as V = S/(TA-TB) where

TA - is the time when the object just enters into the view of camera A.

TB - is the time when the object just enters into the view of camera B.

S - distance between camera A viewing line and camera B viewing line.

V - velocity of object.

For bichromatic detection of colour a similar arrangement to Figures 2A-C may be employed. In this configuration, a colour filter of one spectral characteristic is employed in front of one camera and a filter of a different spectral characteristic is employed in front of the other camera. Thus only a certain colour will produce a combination of signal strengths at each of the two cameras corresponding to that colour.

For objects, e.g. opaque peanuts or vegetable dices, where viewing from more than one direction is required two cameras can be employed in front and back viewing modes (Figures 4A-C) with two corresponding light sources. For maximum vision all round, up to four cameras may be employed in a configuration illustrated in Figures 5A and 5B, in which the cameras are shown disposed in pairs back and front approximately at the four corners of a notional rectangle lying in the horizontal plane with two of its sides parallel to the plane of the streams of objects being scanned.

Each of the systems described includes apparatus for ejecting from the flow of product those objects that are rejects according to the criteria applied in the scanning operation. The arrangement of the apparatus is illustrated more specifically in Figure 6. Taking the particular case of sorting almonds, the almonds are fed along the vibratory conveyor 11 where an even spread of product is achieved. The rate of feed is controllable. The almonds are guided into the individual channels on the chute 12 where the product is constrained from moving from one channel to another and is aligned longitudinally. The chute 12 allows the almonds to accelerate under gravity thus separating individual nuts from each other. On leaving the lower end of the chute 12, a particular almond first comes into view of the opposed cameras 14.

The viewing area is illuminated by lights 15, preferably producing uniform strips of light. At some distance underneath the lower end of the chute 12 there is an apical separating barrier 16 and the product streaming from the channels of the chute will pass down on the right side of this barrier, as viewed in Figure 6, if allowed to fall undisturbed, on to an accepted product conveyor 20. Between the lower end of the chute 12 and the apex of the barrier 16, and at a level below the site at which the falling almonds are scanned by the cameras, there is a horizontal bank of pneumatic reject nozzles 17, one to each of the individual product streams from the channels of the chute.

The signals produced by both cameras are compared, by an electronic processor 18, against a preset threshold (software program 19) and if the object or part of an object in view is darker than the threshold a signal to energise a pneumatic valve to activate the reject nozzle for the particular channel will be given by the processor. The reject nozzle then blows that object out of the stream of normal product, to fall on the left hand side of the barrier 16 into a reject product receptacle 21.

Further, one camera 14 integrates the total area of the object obtained by repeated scanning and when scaled by time T (inversely proportional to velocity: V = S/T) an accurate area is calculated by the processor 18. This area is compared with acceptance limits preset in the program 19 and if it is outside these limits a reject signal will again be issued to the pneumatic valve so that air under pressure is supplied to the respective reject nozzle 17.

## Claims

1. A method of sorting a travelling flow of particulate product or discrete objects, wherein the product or flow of objects to be sorted is first accelerated to produce separation and then caused to fall under gravity, preferably in a plurality of separate side by side streams, and data for determining whether individual particles or objects should be accepted or rejected, according to preset criteria, is obtained by at least one linescan camera the direction of scan of which is across the

falling stream or streams.

2. A method according to Claim 1, wherein the product or flow of objects is accelerated and separated into side by side streams, by being directed down an inclined chute, and the falling streams are scanned transversely of the streams by one or more linescan cameras after they are discharged off the lower end of the chute.

3. A method according to Claim 1 or Claim 2, wherein two linescan cameras are employed in cascade, i.e. respectively scanning the falling stream or streams at two successive levels.

4. A method according to Claim 2, wherein the falling streams are scanned from both sides of the plane of the streams by two linescan cameras, or two pairs of linescan cameras, disposed at opposite sides of said plane.

5. A method according to Claim 4, wherein two pairs of linescan cameras are employed, the four cameras being disposed, when considered in plan, at the corners of a quadrilateral.

6. A method according to any preceding claim, wherein the scanning data obtained by the, preferably at least two, linescan cameras, employing transmitted or reflected radiation, is processed by processing means that is preprogrammed with selected parameter limits which the particles or objects in the falling stream or streams should obey, and reject signals are issued by the processing means to ejection means downstream of the site of the scanning operation for ejecting from the falling stream any objects that do not obey the selected limits.

7. Apparatus for sorting a travelling flow of particulate product or discrete objects, comprising an inclined chute, feeding means for feeding the flow of product or objects to the upper end of the chute whereafter the flow is accelerated as it descends the chute to be discharged at the lower end thereof as a falling stream or streams, at least one linescan camera mounted to scan across the falling stream or streams below the level of the lower end of the chute, sorting means operating upon the falling stream or streams at a level below the level of scanning to sort the product or objects into at least two separated flows, and control means responsive to the scanning data captured by the linescan camera or cameras to generate control signals for activating the sorting means.

8. Apparatus according to Claim 7, wherein the chute is arranged to divide the descending flow into side by side separate streams.

9. Apparatus according to Claim 7 or Claim 8, wherein two linescan cameras are provided arranged to scan across the falling stream or streams at respective different levels.

10. Apparatus according to Claim 8, wherein two linescan cameras, or two pairs of linescan cameras, are provided mounted to scan the falling streams from opposite sides of the plane of the streams.

Fig. 1A.

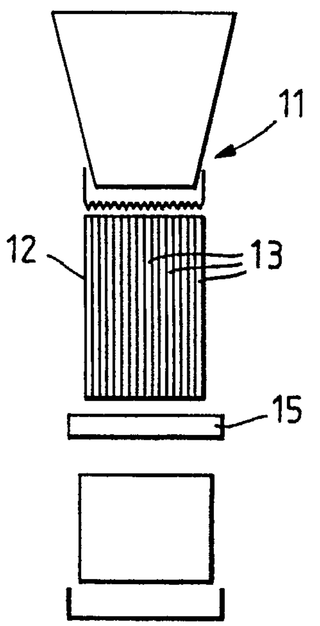


Fig. 1B.

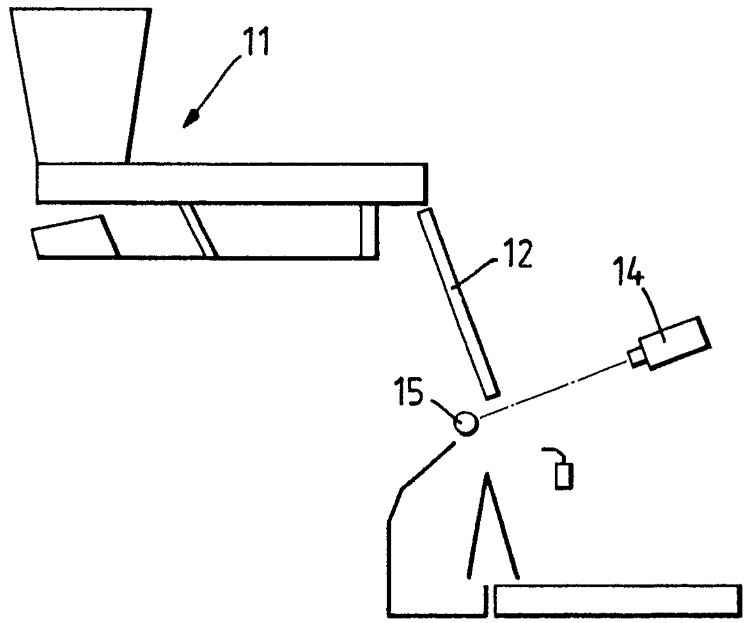


Fig. 1C.

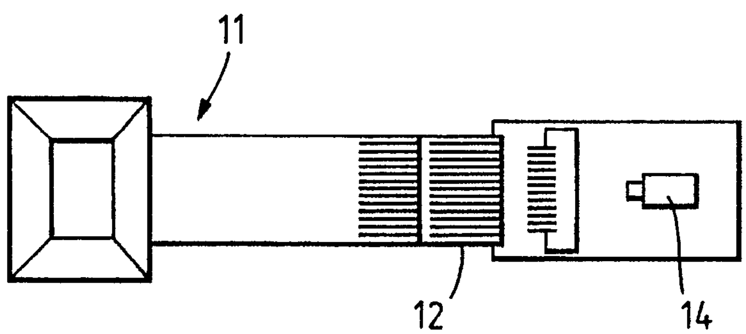

Fig.2A.

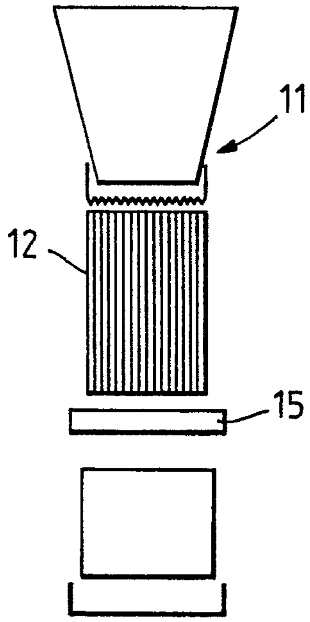


Fig.2B.

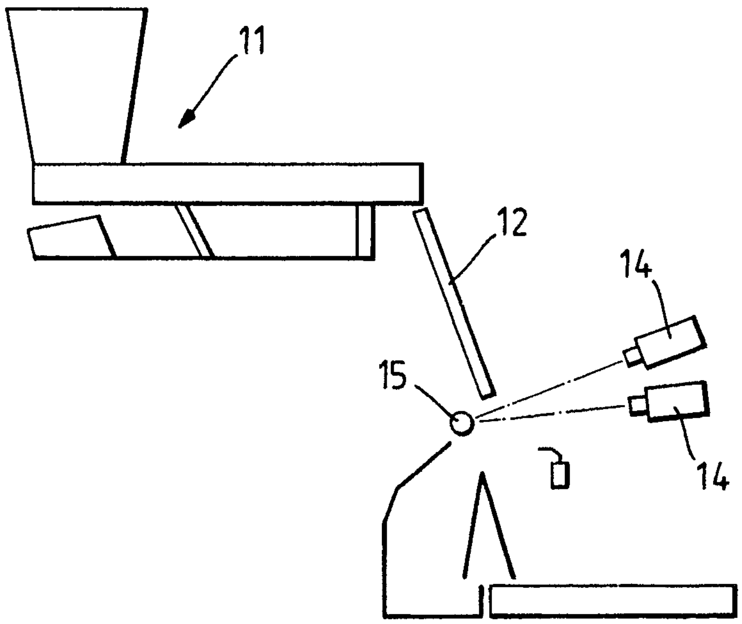


Fig.2C.

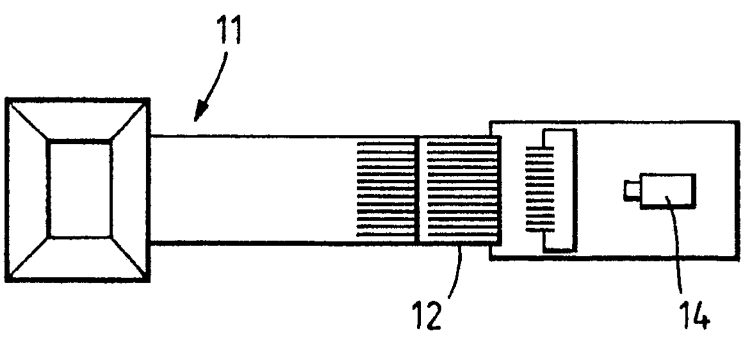

Fig.3.

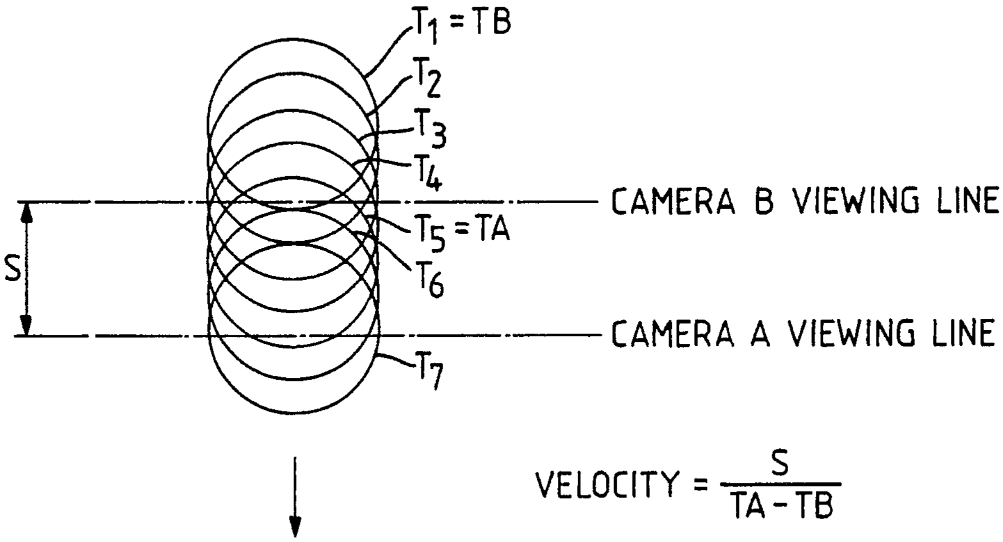
T1 =TB
T2
T3
T4
CAMERA B VIEWING LINE
T5 =TA
T6
S
CAMERA A VIEWING LINE
T7
VELOCITY = S / TA - TB

Fig.6.

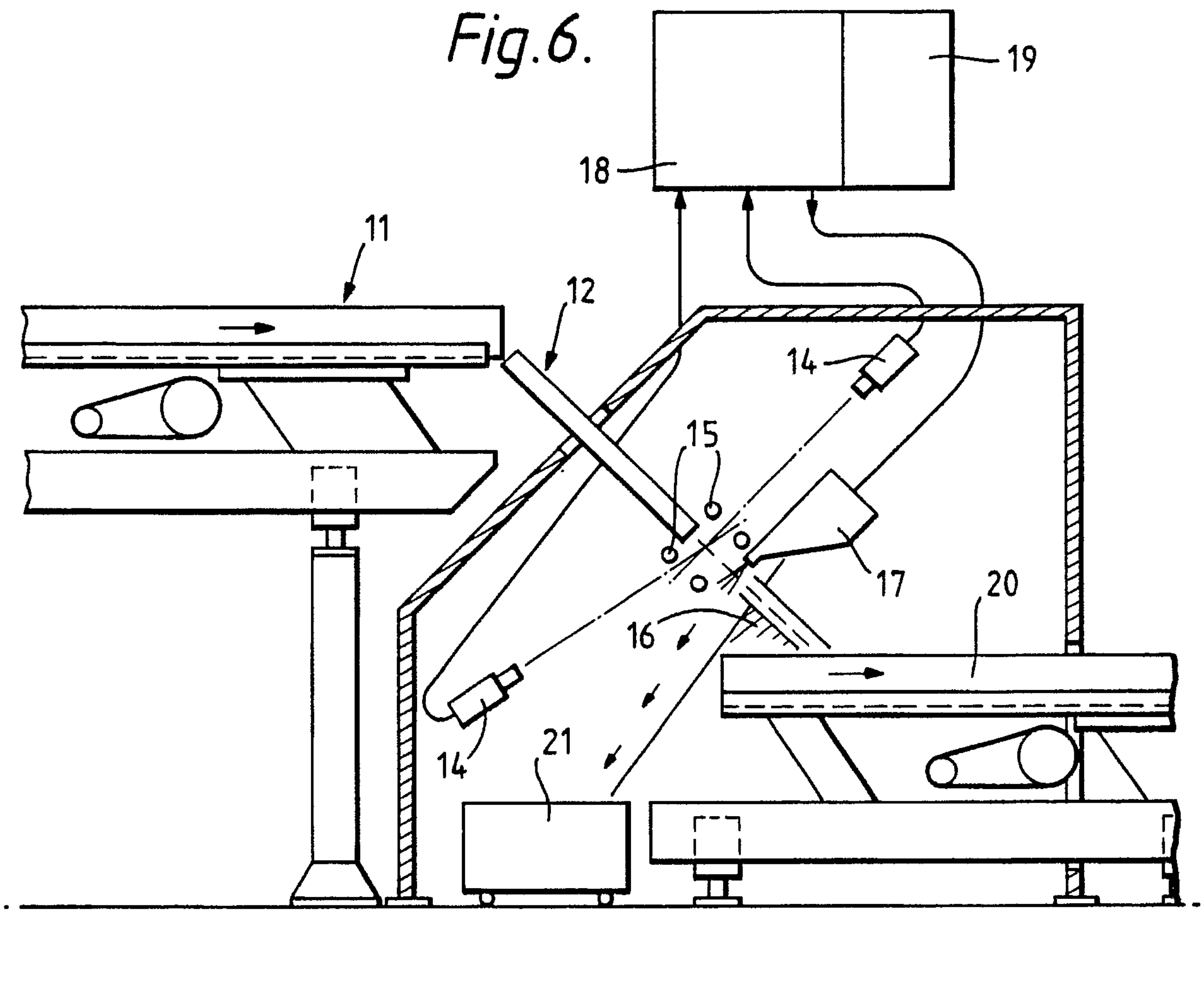
19
18
11
12
14
15
17
20
16
14
21

Fig.4C.

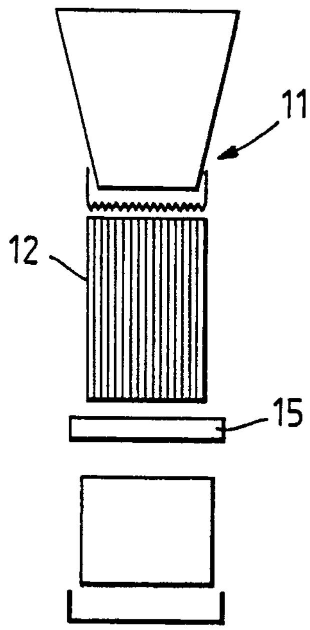


Fig.4B.

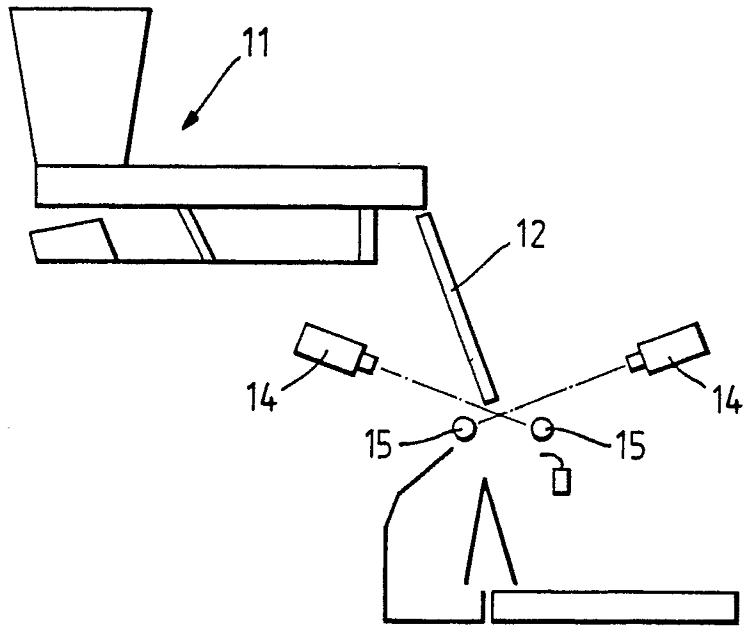


Fig.4A.

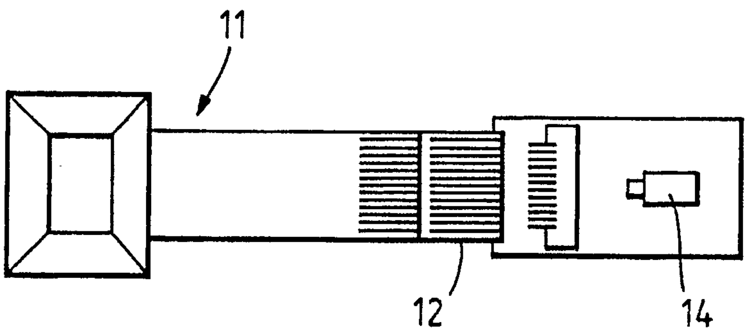

Fig. 5A.

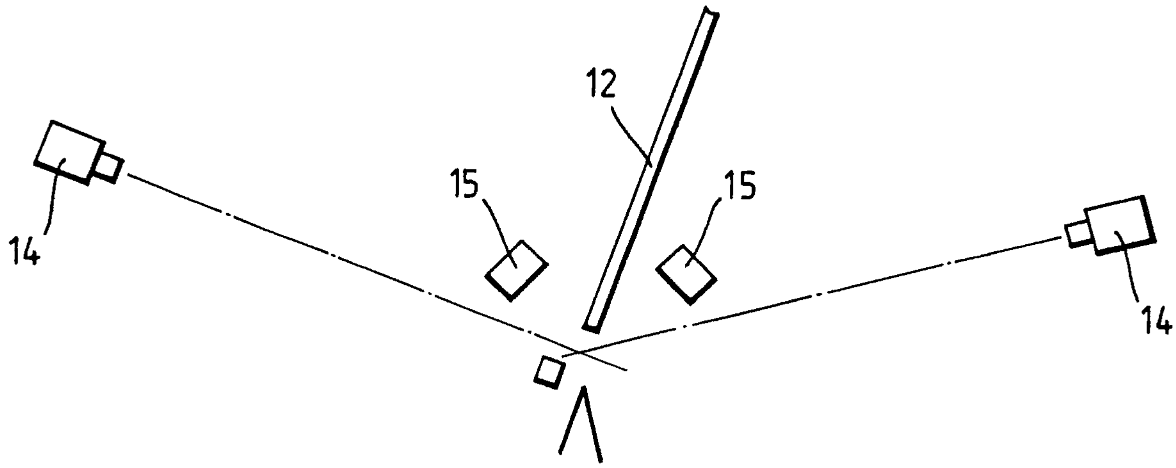


Fig. 5B.