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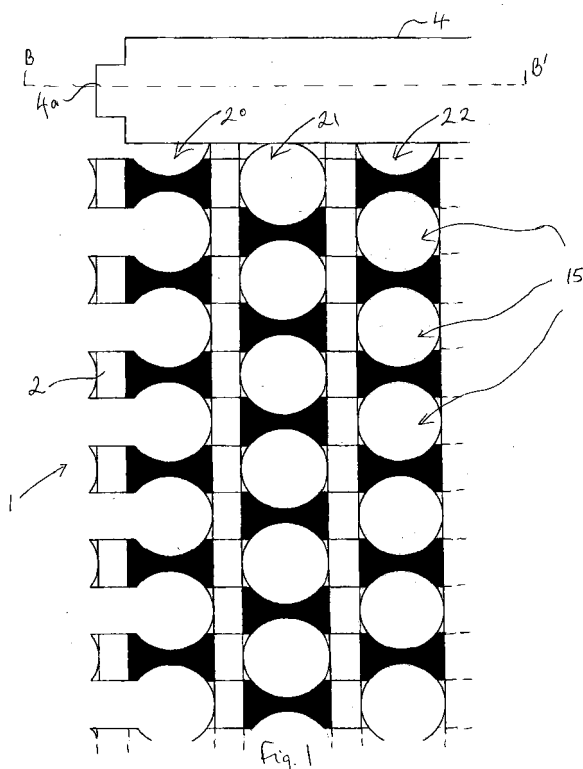
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(54) **Grading screen**

(57) A grading screen (1) comprising a multiplicity of substantially parallel crossbars (3) and a multiplicity of link elements (2) bridging across pairs of successive crossbars so as to define an endless grading screen having a multiplicity of openings (15) defined therein. Each opening in the grading screen is defined by two pairs of opposed link elements. The connecting portion

of each link element is waisted (12) so that the openings in the grid screen are of generally circular form. The openings may, for example, be of circular or near-circular form, or may even be of hexagonal or near-hexagonal form. A grading screen having rectangular openings is also described, in which additional plastics rods (30) are used to sub-divide the openings defined by the link elements, so as to form smaller openings.



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Description

[0001] The present invention relates to a new grading screen suitable for incorporation in grading machinery. Such grading screens may be used in, for example, mobile machinery for grading produce, or in stationary machinery provided in packing or processing plants. In particular, though not exclusively, the invention relates to a new grading screen for use in grading harvested agricultural produce such as, for example, potatoes.

[0002] GB 1 527 096 discloses a grading screen comprising a plurality of T-shaped elements which are assembled together on supporting wires to form a grading screen having generally rectangular screen openings for grading potatoes and the like. GB-A-2 143 751 and WO95/00260 also disclose similar grading screens which use I-shaped plastic elements supported on metal wires or rods to form generally rectangular screen openings.

[0003] While such grading screens are often used for grading potatoes, it is known that better grading i.e. more accurate grading can be achieved using a grading screen having hexagonal screen openings for grading the potatoes. Grading screens having hexagonal screen openings are commonly used in the USA, for example, for grading potatoes. Such screens are normally of woven wire or metal netting form in which the wire is woven in a pattern which defines the hexagonal openings. Due to wear, corrosion, deformation and deterioration through use, such grading screens have a relatively short life as compared with grading screens of the afore-described type employing discrete plastic elements.

[0004] It is an object of the invention to overcome one or more of the foregoing disadvantages.

[0005] According to the present invention we provide a grading screen comprising a multiplicity of substantially parallel crossbars and a multiplicity of link elements bridging across pairs of having a multiplicity of openings defined therein, wherein each said link element comprises two integral end portions of generally hollow tubular form via which the link element is hingedly connected to respective ones of a said pair of the crossbars, and an integral connecting portion extending between said integral end portions, and the link elements are arranged on the crossbars in rows parallel to the crossbars, each crossbar having hingedly connected thereto in alternating relationship the link elements in two adjacent ones of said rows whereby each said opening in the grading screen is defined by two pairs of opposed link elements, and wherein the connecting portion of each said link element is substantially waisted so that the openings in the grid screen are of generally circular form.

[0006] It will be appreciated that the term "generally circular" is intended to refer to any shape which largely approximates the shape of a circle, namely any shape having a generally uniform diameter. Preferably, the openings in the grid screen are all of substantially uni-

form size and shape. The ratio of the largest diameter to the smallest diameter of each said screen opening is less than $\sqrt{2}$ (which is the value of this ratio for a square shape), and is preferably less than 1.4. Most preferably the ratio of the largest diameter to the smallest diameter of each said screen opening is in the range of 1.0 to 1.2, and may advantageously be substantially equal to 1.0. It will be appreciated that circular screen openings will provide particularly good grading accuracy when grading potatoes or the like.

[0007] The connecting portions of the link elements may each comprise at least one curvilinear edge, in plan view, defining at least a portion of the circumference of a circle. Alternatively, each connecting portion may comprise a plurality of linear edges arranged so that the openings defined in the grading screen approximate a many-sided polygon, for example a hexagon.

[0008] Each said connecting portion preferably tapers inwardly, in the plane of the grading screen, from each of its end regions where it is integrally joined to the end portions of the link element. Each said connecting portion preferably tapers inwardly, from said end regions, towards a midpoint along the length of the connecting portion. Each said connecting portion may, for example, taper inwardly from each of its end regions in curvilinear fashion whereby the screen openings are of substantially circular, or near-circular, form. Alternatively each connecting portion may taper linearly in from each said end region, so that the connecting portion is of generally bow-tie shape, whereby the generally circular grading screen openings are of substantially hexagonal, or near-hexagonal, form.

[0009] The cross-sectional diameter of each of the two generally hollow tubular end portions of each link element may vary along the length of the axis of each end portion. The generally tubular outer surface of each end portion may be radiused in order that the side profile of each said end portion defines a portion of the circumference of a circle.

[0010] According to another aspect of the present invention we provide a grading screen comprising a multiplicity of substantially parallel crossbars and a multiplicity of link elements bridging across pairs of successive crossbars so as to define an endless grading screen having a multiplicity of openings defined therein, wherein each said link element comprises two integral end portions of generally hollow tubular form via which the link element is hingedly connected to respective ones of a said pair of the crossbars, and an integral connecting portion extending between said integral end portions, and the link elements are arranged on the crossbars in rows parallel to the crossbars, and wherein the grading screen further includes a multiplicity of rods arranged substantially parallel to and in alternating relationship with said parallel crossbars and which are threaded through complementary bores provided therefor in the connecting portions of said link elements so as to sub-divide each said opening defined in the grad-

ing screen, thereby creating smaller openings in the grading screen, and wherein the diameter of each said rod is less than the diameter of each said crossbar.

[0011] Preferably, the grading screen further includes two endless drive belts into which opposite ends of the crossbars are bonded, and each said rod spans substantially the full width of the grading screen, between the drive belts, with the ends of the rods being free (i.e. not connected to the drive belts in any way).

[0012] Preferred embodiments of the invention will now be described by way of example only and with reference to the accompanying drawings in which:

Fig.1 is a plan view of a portion of a grading screen according to one embodiment of the invention;

Fig.2(a) is a plan view of one link element of the screen of Fig.1;

Fig.2(b) is an end view of the link element of Fig.1;

Fig.2(c) is a cross-sectional view on the line A-A' in Fig.2 (a);

Fig.3 is a cross-sectional view on the line B-B' in Fig.1;

Fig.4 is an end perspective view of a modified version of the link element of Fig.2(a).

Fig.5(a) is a plan view of one link element of a grading screen according to an alternative embodiment of the invention;

Fig.5(b) is an end view of the link element of Fig.6 (a);

Fig.5(c) is a cross-sectional view on the line C-C' in Fig.6(a);

Fig.6 is a plan view of a portion of a grading screen according to an alternative embodiment of the invention;

Fig.7 is an end view of another modified version of the link element of Fig.2(a);

Fig.8 is a plan view of a portion of a grading screen formed using a link elements like that of Fig.7;

Fig.9 is a plan view of a portion of a grading screen according to another embodiment of the invention; and

Fig.10 is an end view of a link element of the grading screen of Fig.9.

[0013] Fig.1 shows a portion of an endless grading screen 1 for a grader for grading potatoes. The screen 1 comprises a large number of link elements 2 mounted on crossbars 3 whose ends are bonded into two drive belts 4 (only one shown in Fig.1) via which drive is transmitted from motor driven drive rollers in the grader (not shown) to the grading screen. The drive belt 4 has an end connector portion 4a for connecting to a complementary connecting portion at its other end, so as to form an endless belt, in known fashion. Fig.3 illustrates the rod ends bonded into the belts 4. Our earlier International Patent Application, W094/21108, describes a conveyor web structure in which the rod ends are bonded into the belts in this manner.

[0014] As shown in more detail in Figs.2(a)-(c), the link elements 2 each have two end portions or cross-pieces 5,6 of generally tubular form which each have a bore 7,8 extending therethrough via which the link elements are hingedly mounted on the crossbars 3, before the ends of the crossbars 3 are bonded into the belts 4. The bore diameter of the cross-pieces is such that the cross-pieces are a loose clearance fit around the cross-bars. Each link element 2 also has a connecting portion 9 extending between the cross-pieces 5,6. The cross-pieces 5,6 and connecting portion 9 are formed integrally in the link element 2 which is made of a plastics material. In Fig.1 the connecting portions 9 of the link elements 2 are shown blocked in black.

[0015] As seen clearly in Fig.1 and Fig.2(a), the connecting portion 9 in each link element 2 extends inwardly, from each end where it is integrally joined to each cross-piece 5,6, in the plane of the grading screen and perpendicularly to the crossbars 3 for a very short distance Z before tapering inwardly in curvilinear fashion, in the plane of the grading screen 1, towards the midpoint X along the length of the connecting portion, so as to form a waist 12 in the connecting portion 9. The taper is such that each edge 10,11 of the connecting portion 9 defines an arc of equal radius of curvature R.

[0016] The cross-pieces 5,6 each comprise a tubular member 5a,6a with a respective projecting end member 5b,6b projecting outwardly therefrom. Each projecting end 5b,6b is shaped so as to have a radius of curvature R, the projecting ends thus having a concave form in plan view as seen in Fig.6.. The radius of curvature R of the projecting ends 5b,6b of the cross-pieces 5,6 is the same radius of curvature R as the edges 10,11 of the connecting portion 9 of the link element.

[0017] By assembling the link elements 2 on the crossbars 1 as shown in Fig.1, so that they form rows 20,21,22 of link elements parallel to the crossbars 3, with the link elements in adjacent rows being alternately spaced, the link elements form a grading screen having a plurality of evenly spaced, uniformly sized screen openings 15 of perfectly circular form, or at least substantially circular form i.e. having a substantially uniform diameter. The total length L of each connecting portion 9 is equal to twice the radius of curvature R of the connecting portion 9 in the plane of the grading screen 1. As shown in Fig.2(b) the connecting portion 9, as well as the afore-said projecting end 5b,6b of each end portion 5,6, are of generally planar form, having uniform thickness Y in the plane perpendicular to the grading screen 1. In the embodiment illustrated (which is not to scale), the radius of curvature R is 23.8mm and the axial length S of each cross-piece 5,6 is 27.8 ± 0.2 mm. The thickness Y is 4mm, the diameter D of the tubular member 5a,6a each cross-piece 5,6 is 16.4mm, and the diameter B of each bore 7,8 is 9.2mm. The distance T between the axes of the cross-pieces 5,6 is thus 64mm.

[0018] As shown in Fig.2(c) the edges 10,11 of the connecting portion 9 are rounded across the thickness

Y of the connecting portion. This tends to minimise damage which could be caused to the potatoes as they come into contact with the connecting portions 9 of the link elements 2.

[0019] The radiused projecting end members 5b,6b are not, though, ideal. Due to the nature of the movement of the endless grading screen in use thereof, and in particular the bending of the grid screen when the belts 4 bend around the drive rollers, or when the grading screen bends around other rollers which may be present in its path (for example to produce steps in the grading screen, as described in our International Patent Application W095/00260), the link elements 2 in one row will move out of the plane of the link elements in an adjacent row (as the grading screen bends). This will cause the generally circular openings previously defined in the flat plane of the grading screen by the link elements to be distorted/change shape at least to some extent, which could potentially have an adverse effect on the grading accuracy.

[0020] A preferred alternative link element design which overcomes this problem is illustrated in Fig.4. Fig. 4 shows a link element 2 which differs from that of Fig. 2(a) in that the integral end portions 5,6 are each of a generally hollow tubular form in which the cross-sectional diameter varies along the axial length of the end portion. In particular, each end portion 5,6 tapers inwardly, in curvilinear fashion, from the two ends thereof towards the midpoint along the axial length S of the end portion so that the outer surface of each end portion is radiused, having a radius R. In this manner the side profile of each end portion will define a portion of the circumference of each circular opening 15 defined in the grading screen by the link elements. The connecting portion 9 in this link element is similar to that of Fig.2(a), but differs in that the edges 10,11 are each formed as a single arc, in plan view of the element 2, having radius R (i.e. the same radius R as the outer surface 23 of each end portion 5,6 of the element 2). In the embodiment of Fig.4 (not to scale) the axial length S of each end portion 5,6 is 27.8 ± 0.2 mm, the maximum cross-sectional diameter of each end portion 5,6 (at the axial ends thereof) is 25mm while the minimum cross-sectional diameter (halfway along the axial length S) is 16.4mm, and the value of R is 23.8mm. The plan view of the grading screen formed by these link elements will be identical to Fig.1. However, it will be appreciated that as the inclination of the link elements in one column of the screen move relative to the link elements in an adjacent column, each circular screen opening 15 will maintain its circular shape when the end portions 5,6, rotate on the cross-bars 3.

[0021] Another alternative embodiment of the invention is illustrated in Figs. 5(a)-(c) and Fig.6, in which the connecting portion 9 of each link element 2 is of generally bow-tie shape as shown in Fig.5(a). Each connecting portion is tapered inwardly, in the plane of the grading screen, in a linear manner, rather than curvilinearly

as in the previously described embodiments. Similarly to the link element of Fig.2(a) the ends of the connecting portion 9, where it is joined to the cross-pieces 5,6, extend inwardly perpendicularly to the crossbars 3 for a short distance Z, before beginning to taper towards the waist 12. As can be seen from Fig.6 (in which the connecting portions 9 of the link elements 2 have been blocked in in black) this shape of connecting portion 9 produces generally hexagonally shaped screen openings 15 in the grading screen 1. In the embodiment illustrated (which is not to scale), the dimensions are as follows: the total length U of the connecting portion 9 is 80.4mm; the distance T between the axes of the cross-pieces 5,6 is 64mm; the length V of the connecting portion 9 is 47.6mm; the axial length S of each cross-piece 5,6 is 31.5 ± 0.2 mm; the thickness Y of the connecting portion 9 is 4mm; the diameter D of each cross-piece 5,6 is 16.4mm, and the diameter B of each bore 7,8 is 9.2mm. The distance Z from each end of the connecting portion to where it begins to taper is 3.5mm and the distance W to which the connecting portion tapers in from the ends of the cross-pieces 5,6 is 11.8mm. These dimensions are chosen so as to provide substantially hexagonal screen openings 15 (as shown in Fig.6) in which the length of any diameter which extends between two opposite parallel sides of the opening is one and seven eighths of an inch (47.6mm). It will be appreciated that in this particular embodiment the ratio of the largest diameter a to the smallest diameter b (which is equal to the length V of the connecting portion 9) is approximately 1.2 (see Fig.6).

[0022] Although the grading screen of Fig.4 may not offer the same accuracy of grading provided by the screen of Fig.1, the hexagonal openings offer a good approximation of circular openings, and thus offer some improvement in grading accuracy as compared with the old style rectangular grid openings, although not providing the full benefit offered by a grading screen with circular or near-circular openings.

[0023] It will be appreciated that further modifications are possible to the above-described embodiments without departing from the scope of the invention. For example, the link elements 2 could be made out of rubber, or a synthetic rubber material, or even metal, rather than plastics material. Other generally circular shapes of screen opening 15 are also possible which would provide at least some of the benefit of the invention in terms of grading capabilities. For example, the screen openings could be more oval-shaped than perfectly circular, or could be substantially octagonally-shaped, or have the shape of another polygon having a higher number of sides than eight, thus also providing a good approximation of a circle. It is envisaged that any generally circular shape in which the ratio of the largest diameter to the smallest diameter is less than, or substantially equal to, 1.2 will provide the best results.

[0024] Fig.7 shows a modified version of the link element 2 of Fig.2(a) for use in a grading screen according

to another possible embodiment of the invention. In Fig. 7 the link element differs to that of Fig. 2 only in that the end portions 5,6, do not have the projecting ends 5b,6b of Fig. 2(a) for ensuring that the screen openings 15 are completely circular. The end portions 5,6 are instead purely tubular. Link elements of this design will form a grading screen design as shown schematically in Fig. 8, in which the screen openings are generally circular, but are not complete circles. While this may not provide the same grading accuracy as the screen of Fig. 1, it can still provide better grading accuracy than a square aperture screen.

[0025] Moreover, it will be appreciated that all of the above-described grading screen elements are also suitable for a grading screen which does not incorporate the feature of the ends of the crossbars 3 being bonded into two parallel endless drive transmission belts 4 as shown in Figs. 1 and 6. Instead, other drive means than endless belts may be used to drive the endless grading screen, with the ends of the crossbars 3 merely capped, bent or otherwise modified to ensure that the link elements 2 cannot slide off the crossbars.

[0026] The above-described grading screens are suitable not only for grading potatoes, but for also grading other crops or agricultural produce (e.g. fruit). The described grading screens may also be used for grading any other items, packages or products where generally circular grading screen apertures would produce good grading accuracy. Furthermore it will be appreciated that the grading screen of the invention may be incorporated in mobile agricultural machinery, such as a mobile harvester, for example, or may alternatively be permanently located in a warehouse, processing plant or packing facility or the like, wherever grading needs to be carried out.

[0027] A further embodiment of the invention is shown in Fig. 9. In the grading screen of Fig. 9, the connecting portions 9' of the link elements 2 are not waisted but are instead simply of thin tubular form, so that two pairs of opposed link elements define a screen opening 15' of rectangular format. Thus, the link elements are each generally I-shaped. I-shaped link elements are known from our International Application, publication no. Wo95/00260. However, in the grading screen of Fig. 9 the rectangular openings 15' are divided into smaller rectangular openings 15a, 15b by means of a multiplicity of rods 30 made of plastics material and which are threaded through the connecting portions 9 of the link elements 2, the rods 30 being perpendicular to the connecting portions 9' and in parallel alignment with the main crossbars 3 of the grading screen, each rod 30 being disposed between two adjacent crossbars 3. Each rod 30 extends across nearly the full width of the grading screen (between the drive belts 4) but, unlike the ends of the crossbars 3, the ends 31, 32 of the rods 30 are not bonded into (or otherwise connected to) the drive belts 4 of the grading screen: the rod ends 31, 32 are in fact free. As shown in Fig. 10, a portion 33 of the connecting

portion 9' of each link element 2, midway along the length of the connecting portion, is provided with a transverse bore 35 through which a respective one of the plastic rods 30 is threaded. This bore is smaller in diameter than the diameter of the bores 7, 8 in the tubular end portions 5, 6 of the link elements for the main crossbars 3. This is because it is possible to manufacture the plastic rods 30 with smaller diameter than the crossbars 3. As seen in Fig. 9, the result of incorporating the plastic rods 30 is that each rectangular opening 15 in the screen is subdivided into two equal halves 15a, 15b. This construction is useful where it is desired to grade smaller potatoes, and where the manufacture and/or durability of a grading screen with the desired smaller apertures, based only on the use of the conventional I-shaped link members (i.e. without the plastics rods 30), would not be practical. Of course, it will be appreciated that the rods 30 need not be made of plastics material. For example, metal or other suitable man-made materials, or a combination thereof, could be used although plastics offer the advantage of being relatively light-weight.

[0028] The above-described plastics rods 30 could, if desired, be similarly incorporated in any of the grading screens of Figs. 1, 6 and 8, so as to create smaller grid screen openings therein. In this case, the transverse bores 35 for the plastics rods 30 would be provided in the waist portions 12 of the connecting portions 9 of the link elements 2.

Claims

1. A grading screen (1) comprising a multiplicity of substantially parallel crossbars (3) and a multiplicity of link elements (2) bridging across pairs of successive crossbars so as to define an endless grading screen having a multiplicity of openings (15) defined therein, wherein each said link element comprises two integral end portions (5,6) of generally hollow tubular form via which the link element is hingedly connected to respective ones of a said pair of the crossbars, and an integral connecting portion (9) extending between said integral end portions, and the link elements are arranged on the crossbars in rows parallel to the crossbars, each crossbar having hingedly connected thereto in alternating relationship the link elements in two adjacent ones of said rows whereby each said opening in the grading screen is defined by two pairs of opposed link elements, and wherein the connecting portion of each said link element is substantially waisted (12) so that the openings in the grid screen are of generally circular form.
2. A grading screen according to claim 1, wherein the openings (15) in the grid screen are all of substantially uniform size and shape.

3. A grading screen according to claim 2, wherein the ratio of the largest diameter to the smallest diameter of each said screen opening is less than $\sqrt{2}$.
4. A grading screen according to claim 2, wherein the ratio of the largest diameter to the smallest diameter of each said screen opening is less than 1.4.
5. A grading screen according to claim 2, wherein the ratio of the largest diameter to the smallest diameter of each said screen opening is in the range of 1.0 to 1.2.
6. A grading screen according to claim 2, wherein the ratio of the largest diameter to the smallest diameter of each said screen opening is substantially equal to 1.0.
7. A grading screen according to claim 1 or claim 2, wherein said screen openings are circular.
8. A grading screen according to claim 1, wherein said connecting portions (9) of the link elements (2) each comprise at least one curvilinear edge, in plan view, defining at least a portion of the circumference of a circle.
9. A grading screen according to claim 1, wherein each connecting portion (9) comprises a plurality of linear edges arranged so that the openings (15) defined in the grading screen approximate a many-sided polygon.
10. A grading screen according to claim 9, wherein the openings (15) defined in the grading screen approximate a hexagon.
11. A grading screen according to any preceding claim, wherein each said connecting portion (9) tapers inwardly, in the plane of the grading screen, from each of its end regions where it is integrally joined to the end portions (5,6) of the link element.
12. A grading screen according to claim 11, wherein each said connecting portion (9) tapers inwardly from each of its end regions in curvilinear fashion whereby the screen openings are of substantially circular, or near-circular, form.
13. A grading screen according to claim 11, wherein each said connecting portion (9) tapers linearly in from each said end region, so that the connecting portion is of generally bow-tie shape, whereby the generally circular grading screen openings are of substantially hexagonal, or near-hexagonal, form.
14. A grading screen according to claim 1, wherein the cross-sectional diameter of each of the two generally hollow tubular end portions of each link element varies along the length of the axis of each end portion (5,6).
15. A grading screen according to claim 1, wherein a generally tubular outer surface of each end portion is radiused in order that the side profile of each said end portion defines a portion of the circumference of a circle.
16. A grading screen according to any preceding claim, further comprising two endless drive belts (4) into which opposite ends of the crossbars (3) are bonded.
17. A grading screen (1') comprising a multiplicity of substantially parallel crossbars (3) and a multiplicity of link elements (2') bridging across pairs of successive crossbars so as to define an endless grading screen having a multiplicity of openings defined therein, wherein each said link element comprises two integral end portions (5,6) of generally hollow tubular form via which the link element is hingedly connected to respective ones of a said pair of the crossbars, and an integral connecting portion (9') extending between said integral end portions, and the link elements are arranged on the crossbars in rows parallel to the crossbars, and wherein the grading screen further includes a multiplicity of rods (30) arranged substantially parallel to and in alternating relationship with said parallel crossbars (3) and which are threaded through complementary bores (35) provided therefor in the connecting portions of said link elements so as to sub-divide each said opening (15') defined in the grid screen, thereby creating smaller openings (15a, 15b) in the grading screen, and wherein the diameter of each said rod is less than the diameter of each said crossbar.
18. A grading screen according to any of claims 1 to 16, further including a multiplicity of rods (30) arranged substantially parallel to and in alternating relationship with said parallel crossbars (3) and which are threaded through complementary bores (35) provided therefor in the waisted portions (12) of said link elements so as to divide each said opening (15) defined by two opposed pairs of link elements substantially in half, thereby creating smaller openings (35) in the grading screen, and wherein the diameter of each said rod is less than the diameter of each said crossbar.
19. A grading screen (1') according to claim 17 or claim 18, wherein the grading screen further includes two endless drive belts (4) into which opposite ends of the crossbars (3) are bonded, and each said rod (30) spans substantially the full width of the grading screen, between the drive belts, with the ends

(31,32) of the rods being free.

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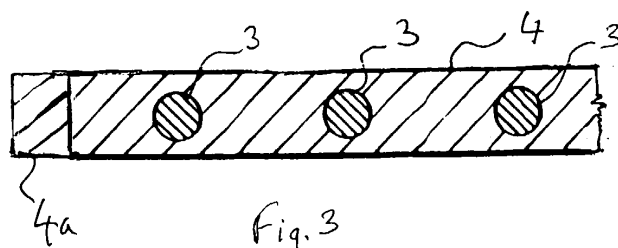
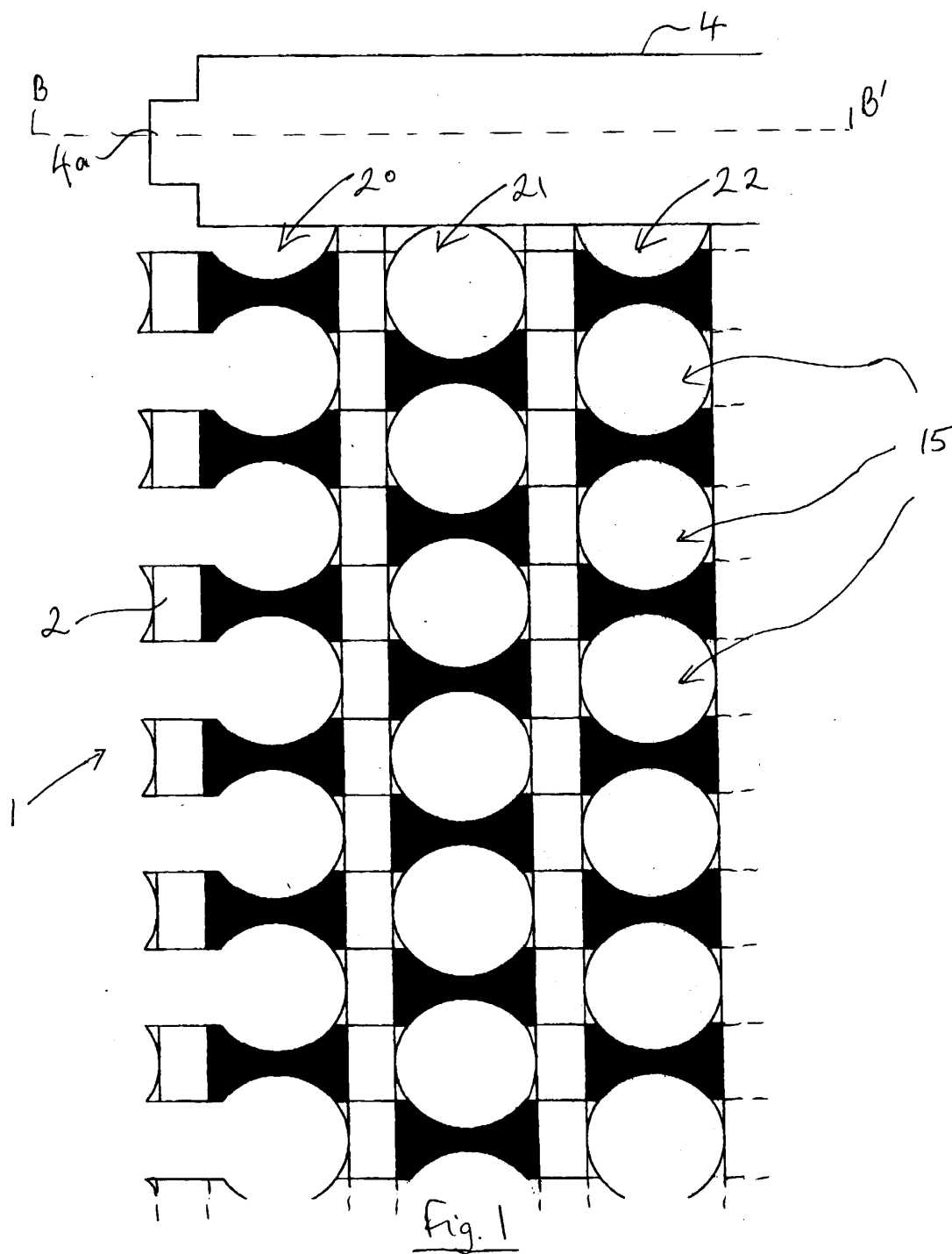
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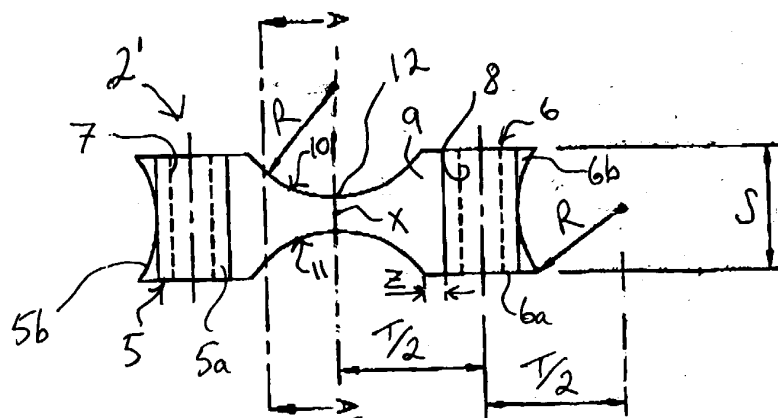


Fig. 2(a)

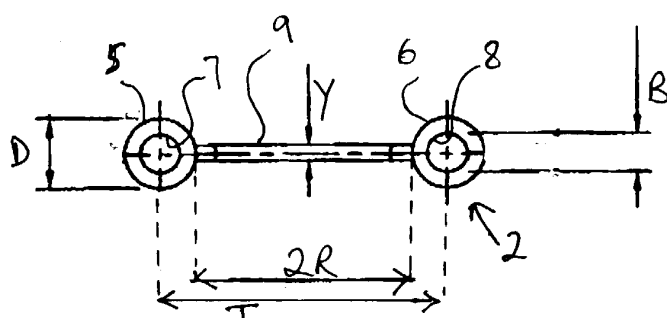


Fig. 2(b)

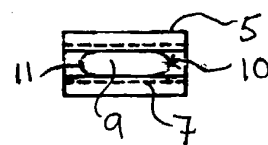
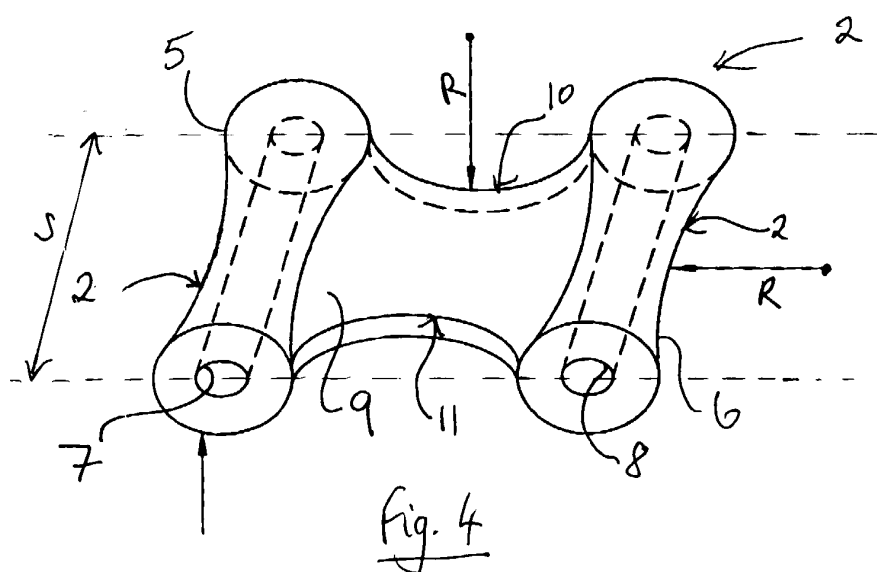


Fig. 2(c)



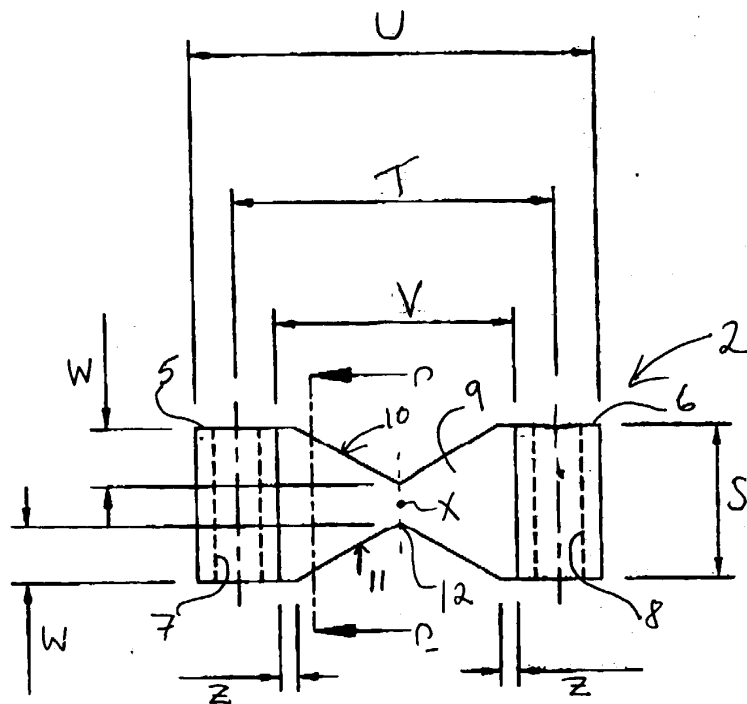


Fig. 5(a)

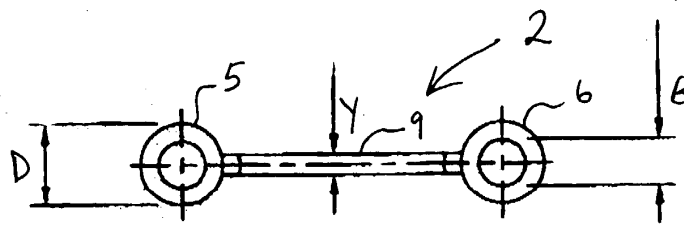


Fig. 5(b)

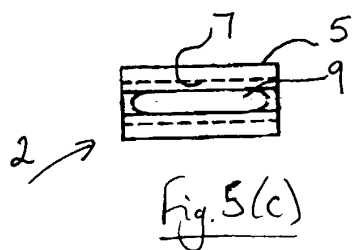


Fig. 5(c)

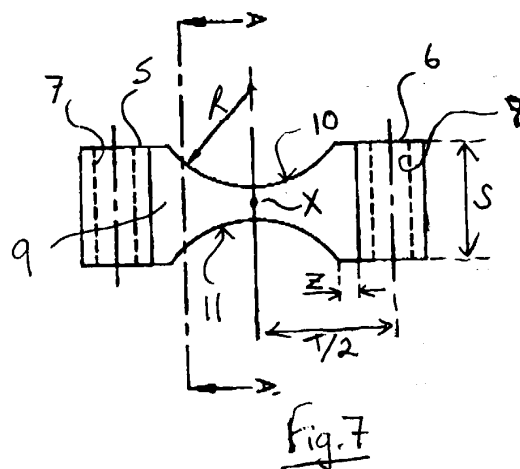


Fig. 7

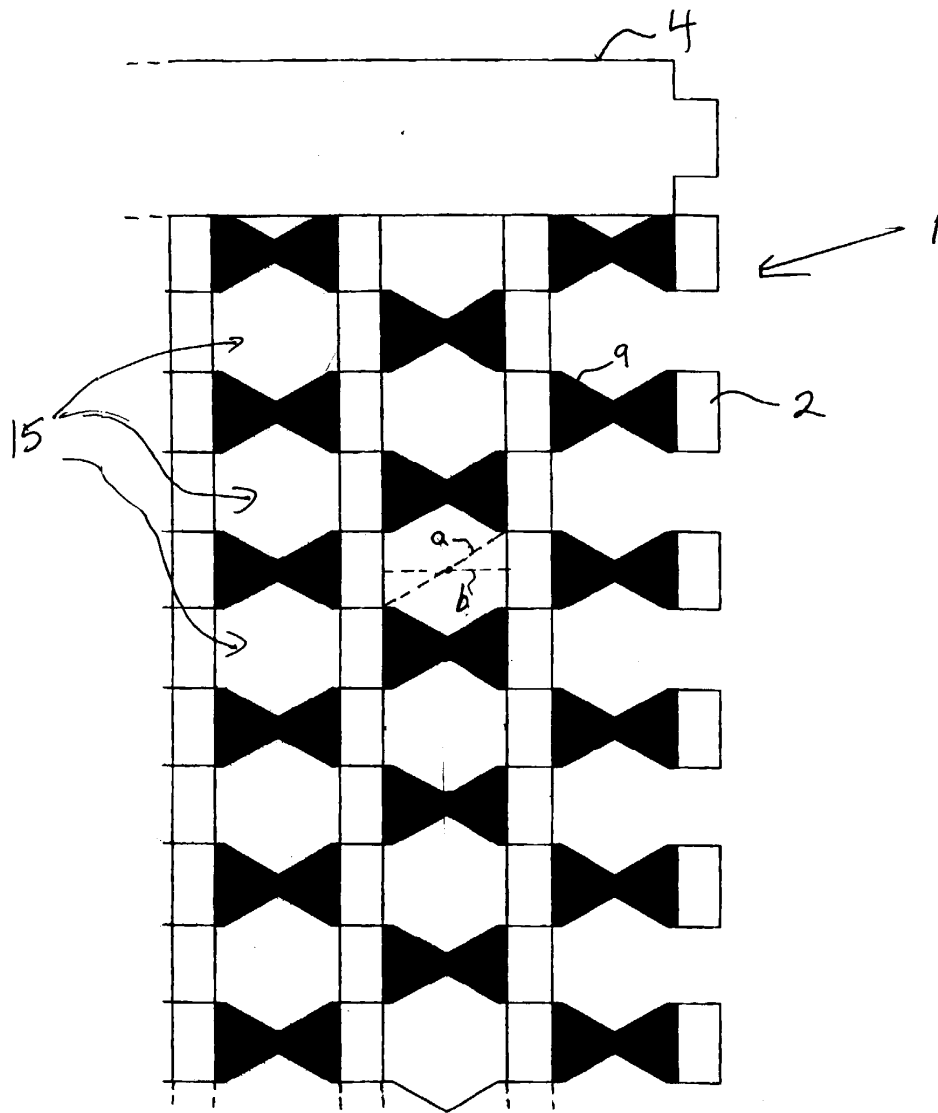


Fig. 6

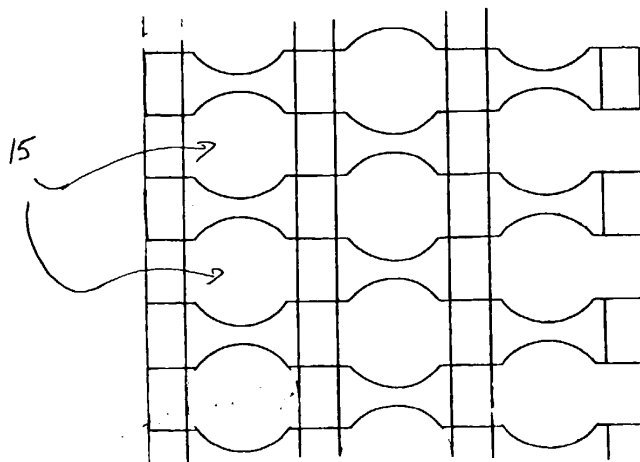


Fig. 8

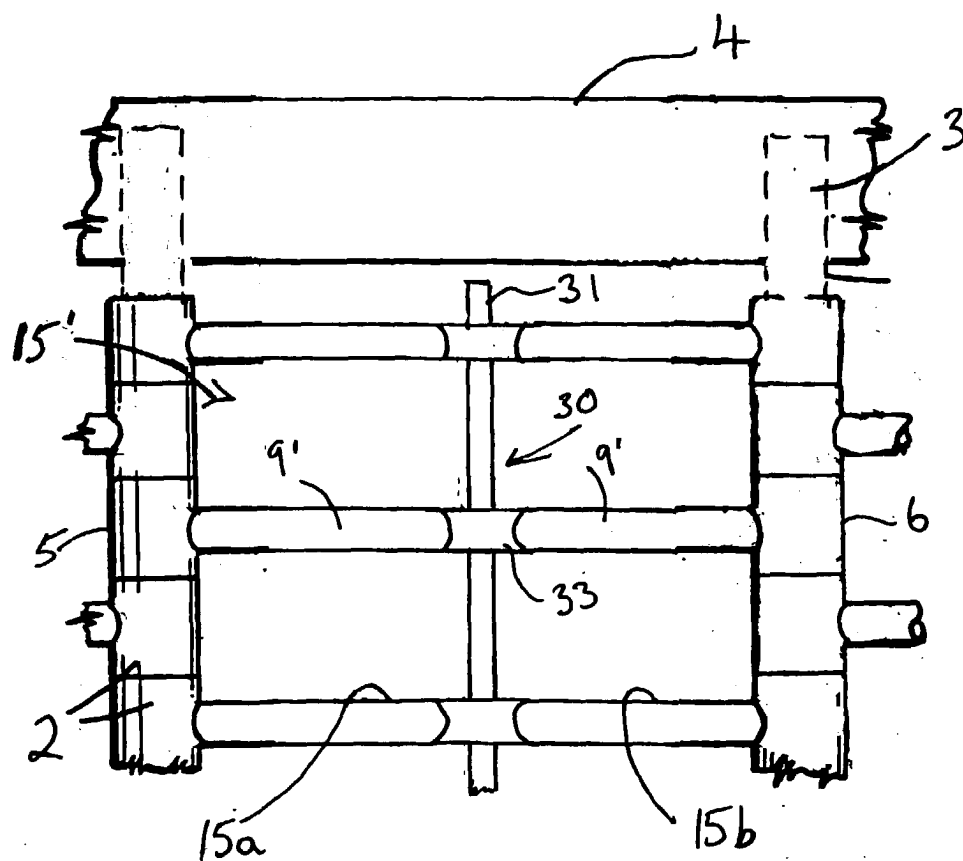


fig. 9

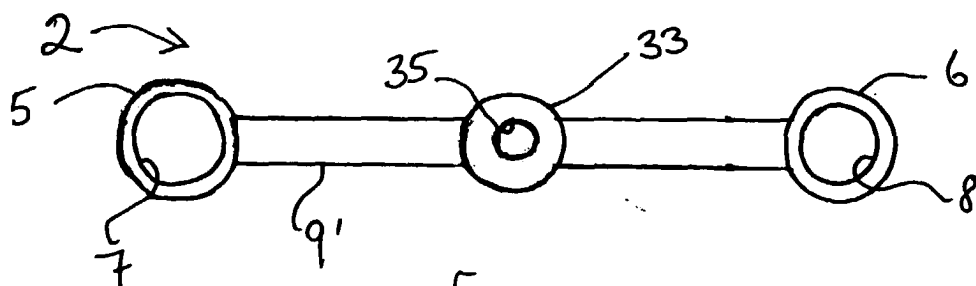


fig. 10