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Description

The invention relates to a surface drainage system. The invention is particularly concerned with a combined kerb and drainage block arrangement for use on highways, although the system does find more general application.

It is accepted that road kerb systems must fulfil a number of basic requirements which may be listed as follows:—

- a. a clear definition of the carriageway edge must be provided
- b. the carriageway edge must be strong enough to prevent deformation by road construction and by heavy vehicles throughout the design life of the road
- c. surface water from the carriageway must be controlled and drained therefrom
- d. the kerb should assist in preventing traffic leaving the carriageway in hazardous regions thereof
- e. the kerb must form a barrier to stop vegetation from spreading onto the carriageway
- f. the system must be sufficiently versatile to allow road resurfacing and kerb removal or lowering when new accesses are required
- g. the kerb should act as a datum for laying pavement courses
- h. the system must be capable of use in conjunction with and as a continuation of conventional kerb systems.

Although there have been many proposals for combined kerb and drainage systems none of these has met all the criteria listed above in a completely satisfactory manner. For example DE—U—7700385.1 discloses a surface drainage system comprising in combination open-ended channel section base members each having a base wall and two opposite side walls between which the lower part of the channel is defined, the base members being designed to be laid end-to-end in longitudinal alignment; and cover members laid above the base members and combining therewith to form an enclosed drainage channel, each cover member being of inverted channel section and having a top wall and two opposite side walls between the inner surfaces of which an open-ended upper part of the channel of constant cross-section is defined, and an opening through one of the side walls from the outer to the inner surface thereof. The cover member in this disclosure is made of plastics material rendering it unsuitable for highway use, but more importantly the configuration adopted for the cover member and the opening therein is such that the cover member would not withstand the loads experienced in a highway location, does not actively assist the rapid drainage of water, particularly in storm water conditions, and is prone to blocking. It also fails to meet requirements (f) and (h) set forth above. However, the

disclosure of this document is given as the prior art part of claim 1 herein.

In another example, DE—U—7200529.9 shows a combination of cover members and base members cooperating as aforesaid. Again, the configuration of the cover member and of the opening therein have the disadvantages associated with the system disclosed in DE—U—7700385.1.

The present invention seeks to solve the problem of providing a drainage system that does not suffer the aforesaid disadvantages and that meets all the requirements set forth above.

In accordance with the invention this objective is achieved by providing that each cover member, as seen in transverse cross-section, has side walls that are symmetrical about a plane bisecting the channel and intersecting the top wall and that diverge from the top to the bottom of the cover member to give to the cover member an overall substantially trapezoidal shape and to give to the upper part of the channel a concave shape that increases in width from the top to the open bottom of the upper part of the channel, and that the opening extends through said side wall at a downward inclination from the outer to the inner surface of said side wall, the lowermost part of the opening intersects the outer surface of the side wall at a height above the bottom of the cover member that is from 0.5 to 0.7 of the total height of the cover member, the whole of the opening intersects the inner surface of the side wall, and the transverse cross-sectional of the opening increases from the outer to the inner surface of the side wall.

The cross-sectional shape of the cover member gives it the necessary strength to withstand highway loadings. The positioning of the opening, its downward inclination, its increasing cross-section from the outer to the inner surface of the side wall and the increasing width of the channel from the top to the bottom thereof all combine actively to assist in the rapid drainage of water, even in storm water conditions, and in preventing blocking. Additionally, the cross-sectional shape leads to a system satisfying the other requirements mentioned.

Expanding on these and other advantages, when the system is used in a kerb and highway drainage context, the edge of the carriageway surface must terminate at a level not lower than the lowermost parts of the openings into the side walls of the cover members in order that surface water may drain from the carriageway into the drainage system. The spacing of the openings relative to the top of the cover member and the cross-section of the cover member lead to a number of significant advantages. The positioning of the openings allows there to be a significant depth of cover member between the opening and the base member, and thus a significant depth of carriageway material above the level of the upper edges of

the side walls of the base members. This allows versatility in that if drainage is required to run across the carriageway or across a road junction into the carriageway all that needs to be done is for cover members to be omitted in these areas and for the base members to be covered by cover plates over which carriageway material is laid. A significant thickness of material can be applied so that the road surface is not prone to breaking up in the region of the crossing. The depth of the cover members below the opening can be made such that the total depth of cover member is similar to or greater than the total depth of conventional kerbs so that the system can be laid as a simple continuation of conventional kerbing. The cross-section of the cover members provides them with significant strength for withstanding traffic loadings while also reducing the amount of material incorporated in the cover members, and thus reducing the weight thereof. The base members may be constructed in incremental depths to cater for accumulated drainage flow and generally speaking it is desirable for the cross-sectional area of the channel in any base member to be such as to accept the full design flow volume through the drainage channel formed by that base member and its associated cover member. The additional area within the cover member is then available for overload drainage conditions and is particularly effective in reducing the effects of turbulence when storm water enters the drainage system.

As well as straight base members and cover members as aforesaid a drainage system according to the invention will often include curved base members and junction base members and such base members will usually be covered not by cover members as aforesaid but by inspection or access covers, which may be of conventional form, so that blockages which may occur at bends and junctions can readily be cleared. The system will also usually include base members having an opening in the bottom wall thereof which may be connected to a gulley and/or outfall pipe.

The system will be better understood from the following description given in conjunction with the accompanying drawings, in which:—

Figures 1 to 3 are, respectively, a cross-section, side elevation and plan view of a cover member;

Figures 4 to 6 are, respectively, a cross-section, side elevation and plan view of a base member;

Figures 7 to 9 are, respectively, a cross-section, side elevation and plan view of a base junction member;

Figures 10 to 12 are, respectively, a cross-section, side elevation on line A—A and plan view of a curved base member;

Figures 13 and 14 are plan views of cover plates;

Figure 15 is a cross-section of a joint between adjacent cover plates;

Figure 16 is a cross-section of a cover member and base member in situ in a drainage system;

Figure 17 is a cross-section of a cover plate and base member in situ in a drainage system; and

Figure 18 shows a schematic plan view of part of a drainage system layout.

The basic system comprises in combination open-ended channel section base members together with cover members of inverted channel section. A typical cover member is shown in Figures 1 to 3 and is made to a standard size designed to withstand traffic loadings and shaped to match any required kerb face. The cover member, shown generally as 1, is in transverse cross-section of substantially trapezoidal overall shape and of inverted channel section, the channel being concave and increasing in width from the top to an open bottom thereof. The channel 2 is formed between opposite side walls 3 and 4 diverging downwardly from the top wall and symmetrical one with the other about a plane A—B bisecting the channel and intersecting the top wall. The lower edges 5 and 6 of the side walls are of interlocking formation designed to engage the base members. An opening 7 is provided at the longitudinal central region of the cover member and extends through the side wall 4 of the cover member. The lowermost part 9 of the opening where it intersects the outer surface of the side wall is located no closer to the bottom than to the top of the respective cover member, the height H_1 of the lowermost part 9 above the bottom of the cover member being from 0.5 to 0.7 of the total height H_2 of the cover member. The edge formed at the part 9 may be rounded off if desired. The whole of the opening intersects the inner surface of the side wall. The transverse cross-sectional shape of the opening is desirably somewhat oval as shown in Figure 2, with its longer dimension extending longitudinally of the cover member, although other shapes, may be used. An oval shape facilitates manufacture, reduces the degree of weakening of the surrounding material, reduces the length of unsupported carriageway lying across the lower part of the opening and provides an upwardly increasing width that facilitates rapid access into the system of deeper water experienced, for example, during storm conditions. The transverse cross-sectional area of the opening increases from the outer to the inner surface of the side wall, for example by a progressive flare as shown in Figures 1 to 3. This assists in allowing free passage of solid material into the channel and so reduces the risk of blockage.

For certain applications the member may be modified by having an opening in each of the opposite side walls 3 and 4. The axis of any opening through the side wall, e.g. axis A—A' in Figure 1, should, in preferred embodiments make an angle α to the plane A—B (which

plane will be vertical in normal use) of from 40° to 50°. Angles at the mid to the lower end of this range are preferable as the top wall of the member then has greater strength and inspection of the channel is facilitated, as is entry of storm water into the system. A 45° angle has been found to be particularly suitable.

A typical base member 11 is shown in Figures 4 to 6. A range of similar base members may be provided, all being generally similar in cross-section but having channels 12 of different depths d . In each case the channel 12 will be formed between symmetrical opposite side walls 13 and 14 having inwardly facing surfaces 15 and 16 respectively shaped to confront the outwardly facing surfaces of the lower edges 5 and 6 of the side walls of the cover member and so locate the cover member on the base member.

The profile of the channel 12 in the base member may be shaped to suit the anticipated flow velocities of water through the channel. Certain base members may be designed with the base of this channel sloping to form a transition member between base members having channels of different depth d .

Both the cover members and the base members are made from concrete and are designed to withstand the loadings imposed during highway construction and also the traffic loadings on the finished highway.

In addition to the cover members and base members described a drainage system according to the invention will generally include other members as hereinafter described.

Figures 7 to 9 show a typical base junction member which enables flows to be joined and/or diverted. The base junction member shown generally as 17 comprises a main channel 18 and in the direction perpendicular to this main channel the cross-section is generally similar to that of the base member as shown in Figure 4. The base junction member also includes a branch channel 19 which has a cross-section similar to that of the channel 18 and opening into that channel. A base member of this type can be modified to give flow diversion rather than a junction arrangement by filling in one end of the member with material such as concrete, terminating along a curved line such as 20.

Figures 10 to 12 show a curved base member 21 which may be incorporated in the system and which will be effective to divert the flow through an angle of 45°. Obviously curved members may also be made for flow diversion through other angles as required.

Any one of the base members shown in Figures 4 to 12 may be formed with a vertical outlet through its base so that it may be located over a sump to collect grit and debris, or located over an outfall pipe to allow water to flow from the system.

The base member may be used to carry flows under carriageways, footways, verges, kerbs

and other locations and in such cases the open top of the channel in the base member may be closed by a cover plate or cover block. A plan view of a typical cover plate 22 for a base member as shown in Figure 6 is shown in Figure 13, and a plan view of a cover plate 23 for the curved base member shown in Figure 12 is shown in Figure 14. The spaces between adjacent cover plates 24, 25 are desirably sealed by a jointing strip 26 as shown in Figure 15. Such cover plates are desirably of metal and are used where a run of base members are to pass under a carriageway or other heavy load bearing location. Where location under a verge or other lightly loaded area is required a cover block of concrete or other material moulded to seat on the upper edges 15 and 16 of the walls of the base member may be used. Alternatively, where a reduced height, but uncovered section of the system is required it is possible to use cover members similar to those shown in Figures 1 to 3, but of reduced height and with correspondingly smaller channels. Longitudinally tapered cover members could be used to join normal height members smoothly to those of reduced height.

In addition to the elements of the system so far described the system may include conventional surface water drainage components at certain locations. Thus, standard "side entry" kerb type gulley covers and frames or similar forms of inspection covers may be provided in place of cover members for inspection and maintenance purposes. These may be provided at junctions and outfalls as well as at bends in the system and at intervals on long lengths of the system. Where inspection covers are not provided over bends and junctions then it is desirable to use cover plates as shown in Figure 13 or 14 rather than the usual cover members. In certain locations the cover plate or cover member may be replaced by a standard drainage grating in order to collect surface water directly into the base member system. This facility of being combined with existing standard items adds increased versatility to the system.

Figure 16 shows a cross-section of a base member and a cover member in situ in a drainage system. A base block 27 preferably made of high quality pressed or vibrated concrete (and including reinforcement if necessary) is laid on a concrete or mortar bed 28 with a concrete backing 29. A number of such base members are laid end-to-end to form a continuous channel. Where the anticipated maximum flow of water increases then base members of increased depth may be used with transition base members inserted between base members of different depths, all base members generally being laid so that the upper surfaces 30 and 31 of the side walls of the base members are substantially coplanar. If greatly increased depth is required, or if cover members need to be significantly raised due to carriageway resurfacing

then vertical spacing members having appropriate interlocking formations on their upper and lower edges may be interposed between the side walls of the cover and base members.

A jointing compound may be used to seal the vertical joints between adjacent base members or those members may be constructed with ends to allow conventional "spigot and socket", "Ogee" or "flexible" type pipe joints. A long run of base members placed end-to-end may be replaced by a continuously extruded concrete block of similar profile in some locations. When laying the run of base blocks during carriageway construction it may be desirable temporarily to omit one base member at intervals in order to collect surface water from the adjacent carriageway construction bed.

Cover members 32 are then bedded onto the respective base members or spacing members using mortar or jointing compound 33 to the required alignment. The cover members may be provided with partial concrete backing 34 where anticipated traffic loadings indicate this to be desirable. Again, during carriageway construction occasional cover members may be temporarily omitted to facilitate drainage from the construction works. The base members and cover members should be fixed and bedded in position before carriageway construction materials are laid adjacent to them in order to cater for construction traffic loading. After construction the carriageway surface 35 is laid with the level of the carriageway edge being at or desirably slightly above the lowermost part 36 of the openings 37 into the cover members. A footway or verge 38 may then be laid to abut the opposite side of the cover member 32.

It will be seen from Figure 16 that small depths of road resurfacing may be laid without serious detriment to the efficiency of the drainage system. In extreme cases the cover members may be removed, the height built up with spacing members in the form of insert blocks or with in situ concrete or mortar on the upper edges of the walls of the base members and the lower members replaced to accommodate full road resurfacing without affecting the base member invert levels. Also, where it is necessary to have adjacent footway surfaces below the top of the cover member, those cover members may be constructed with additional inlets in the back wall to accept surface water directly from the footways. Alternatively occasional ones of a run of standard cover members may be turned through 180° so that the inlet may face the footway rather than the carriageway.

When flows of water are to be diverted underneath carriageways or other elements the cover members are omitted and the cross-section may then be as shown in Figure 17. As shown in this Figure, base members 39 are bedded into and surrounded with concrete 40 and the open top of the channel in the base member is covered by a plate 41 bedded onto

mortar or a jointing compound 42. The plates may be of galvanised steel or other similar material of thickness to suit the respective anticipated traffic loadings. Sealing strips such as shown in Figure 15 may be fixed to the joints between adjacent plates before the plates are covered with concrete and/or with road construction materials 43.

Figure 18 shows parts of a drainage system layout along one edge of a carriageway 44. Reading from the top of the Figure a conventional kerb 45 extends alongside the carriageway and is backed by concrete in the normal manner. Part of a drainage system according to the invention crosses the carriageway by means of a run of base members such as 46 set in a concrete surround 47, each base member being provided with a cover plate as shown in Figure 17. At the end of this cross run a curved base member 48 is incorporated and joins the member 46 to a junction base member 49, one end of which is filled with in situ concrete 50 to form a bend. Adjacent to the junction base member 49 there extends a run of base members 51, both the junction member 49 and the base members 51 being set in a concrete foundation and backing 52 in the manner shown in Figure 16. Alternatively, the junction member 49 could be omitted and the run 46 joined to the run 51 by a curved member such as 48 of appropriate orientation. The curved base member 48 is covered by a curved cover plate as shown in Figure 14 while the junction base member 49 is covered by a kerb type gulley cover. The base members 51 are fitted with cover members as shown in Figure 16. At the end of the run of base members 51 is a further junction base member 53 receiving the flow from a further set of base members 54 crossing beneath the carriageway and terminating in a curved base member 55. Again the base members 54 are covered by cover plates, the curved base member 55 has a curved cover plate as shown in Figure 14 and the junction member 53 is covered by a kerb type gulley cover. A further run of base members 56 and cover members as shown in Figure 16 then extends to a final base member 57 in the bottom of which is formed an aperture 58 connected to a sump and outfall pipe 59. The base member 57 is again covered by a kerb type gulley cover and from it can extend conventional kerbing 60 aligned to continue the carriageway kerbing.

It will be understood that Figure 18 is merely exemplary, but it does illustrate the manner in which drainage systems according to the invention may be designed to suit any location.

The drainage system of the invention varies from other specialised combined kerb and drainage systems in that the profiles of the base members and cover members have been designed to cater for conveying the maximum quantity of surface water flow in addition to catering for loadings imposed by heavy traffic,

with resulting economy in the size and weight of the members. It is preferred that the cross-sectional area of the channel in the base member at any one location is designed to carry the maximum anticipated flow, so leaving the whole of the channel area within the cover members available to cope with exceptional overloads or with turbulent inflow during storm water conditions.

Usually the longitudinal fall of the channel formed by the system will be similar to that of the carriageway along which it is installed although in particular circumstances slightly differing falls may be constructed.

The drainage system is capable of being used as extensions to existing kerbs, of crossing under carriageways, footways, verges, vehicle crossings and other obstructions, and of allowing for junctions and changes in direction of flow. Furthermore, it is designed with sufficient surface water inlet area so as not to become blocked by grit or debris. In addition to these advantages it can easily be maintained, can be used in conjunction with many conventional drainage fittings, and can readily be added to conventional kerb and drainage systems.

Claims

1. A surface drainage system comprising in combination open-ended channel section base members (27) each having a base wall and two opposite side walls (13, 14) between which the lower part of the channel is defined, the base members being designed to be laid end-to-end in longitudinal alignment; and cover members (32) laid above the base members and combining therewith to form an enclosed drainage channel, each cover member being of inverted channel section and having a top wall (10) and two opposite side walls (3, 4) between the inner surfaces of which an open-ended upper part of the channel of constant cross-section is defined, and an opening (7) through one of the side walls (4) from the outer to the inner surface thereof, characterised in that each cover member, as seen in transverse cross-section, has side walls (3, 4) that are symmetrical about a plane (A—B) bisecting the channel and intersecting the top wall and that diverge from the top to the bottom of the cover member to give to the cover member an overall substantially trapezoidal shape and to give to the upper part of the channel a concave shape that increases in width from the top to the open bottom of the upper part of the channel, and that the opening (7) extends through said side wall at a downward inclination from the outer to the inner surface of said side wall, the lowermost part of the opening intersects the outer surface of the side wall at a height above the bottom of the cover member that is from 0.5 to 0.7 of the total height of the cover member, the whole of the opening intersects the inner surface of the side wall, and the transverse cross-section of the

opening increases from the outer to the inner surface of the side wall.

2. A surface drainage system according to claim 1 characterised in that the axis (A—A') of the opening (7) makes an angle (α) to the plane of symmetry (A—B) of from 40° to 50°.

3. A surface drainage system according to claim 1 or claim 2 characterised in that the cross-section of the opening (7) transverse to the axis (A—A') thereof is oval in shape, with its longer dimension extending longitudinally of the cover member.

4. A surface drainage system according to any one of the preceding claims characterised in that there is a single opening (7) located at the longitudinally central region of the cover member.

Patentansprüche

1. Flächen-Drainage-System bestehend aus einer Kombination von an den Enden offenen, je eine Kanalsektion bildenden Basis-Bauteilen (27), von denen jedes eine Bodenwand und zwei einander gegenüberliegende Seitenwände (13, 14) aufweist, durch die das untere Teil des Kanals definiert ist, und die derart ausgebildet sind, daß sie Ende an Ende in Längsrichtung aneinandergereiht verlegbar sind, und von auf die Basis-Bauteile auflegbaren Abdeck-Bauteilen (32), die gemeinsam mit jenen einen eingeschlossenen Drainage-Kanal bilden, wobei jedes Abdeck-Bauteil (32) ein invertiertes Kanalprofil aufweist mit einer oberen Wand (10) und zwei einander gegenüberliegenden Seitenwänden (3, 4), deren Innenwandungen das an den Enden offene obere Teil des Kanals konstanten Querschnitts definieren, mit einer von der Außenzur Innenfläche sich erstreckenden Öffnung (7) in einer der Seitenwände (4), dadurch gekennzeichnet, daß jedes Abdeck-Bauteil, im Querschnitt gesehen, Seitenwände (3, 4) besitzt, die symmetrisch zu einer den Kanal halbierenden und die obere Wand unterteilenden Ebene (A—B) liegen und die von oben nach unten divergieren, um dem Abdeck-Bauteil eine im wesentlichen trapezförmige Form sowie um den oberen Teil des Kanals eine konkave Form zu geben, die in ihrer Weite von oben nach unten bis zur offenen Bodenfläche des oberen Kanalteils zunimmt, daß die durch die Seitenwand sich erstreckende Öffnung (7) von der äußeren zur inneren Fläche nach abwärts geneigt ist, und daß der unterste Teil der Öffnung die äußere Fläche der Seitenwand in einer Höhe von der Bodenfläche des Abdeck-Bauteils durchsetzt, die 0,5 bis 0,7 der Gesamthöhe des Abdeck-Bauteils beträgt, wobei die Öffnung in voller Größe die innere Fläche der Seitenwand durchsetzt und in ihrem Querschnitt sich von der äußeren zur inneren Fläche der Seitenwand vergrößert.

2. Flächen-Drainage-System nach Anspruch 1, dadurch gekennzeichnet, daß die Achse (A—A') der Öffnungen (7) zur Symmetrie-Ebene

(A—B) um einen Winkel von 40° bis 50° geneigt ist.

3. Flächen-Drainage-System nach den Ansprüchen 1 oder 2, dadurch gekennzeichnet, daß der Querschnitt der Öffnungen (7) quer zur Achse (A—A') eine ovale Form aufweist, deren längere Ausdehnung in Längsrichtung des Abdeck-Bauteils sich erstreckt.

4. Flächen-Drainage-System nach einem der vorhergehenden Ansprüche, gekennzeichnet durch eine einzige im längsgerichteten zentralen Bereich des Abdeck-Bauteils angeordnete Öffnung (7).

Revendications

1. Système d'écoulement des eaux de surface comprenant en combinaison des éléments de base de section de canal à extrémité ouverte (27) comportant chacun une paroi inférieure et deux parois latérales opposées (13, 14) entre lesquelles est définie la partie inférieure du canal, les éléments de base étant agencés pour être posés bout-à-bout selon un alignement longitudinal; et des éléments de recouvrement (32) posés au-dessus des éléments de base et étant combinés avec ceux-ci pour former un canal d'écoulement des eaux clos, chaque élément de recouvrement ayant une section de canal inversée et comportant une paroi supérieure (10) et deux parois latérales opposées (3, 4) entre les surfaces intérieures desquelles est définie une partie supérieure à extrémité ouverte du canal de section transversale constante, et une ouverture (7) formée dans une des parois latérales (4) de la surface extérieure jusqu'à la surface intérieure de celle-ci, caractérisé en ce que chaque élément de recouvrement, vu en coupe transversale, comporte des parois latérales (3, 4) qui sont

symétriques par rapport à un plan (A—B) divisant en deux parties égales le canal et coupant la paroi supérieure et qui divergent du haut au bas de l'élément de recouvrement pour donner à l'élément de recouvrement une forme d'ensemble essentiellement trapézoïdale et pour donner à la partie supérieure du canal une forme concave qui augmente en largeur du haut au bas ouvert de la partie supérieure du canal, et en ce que l'ouverture (7) s'étend dans ladite paroi latérale en étant inclinée vers le bas de la surface extérieure jusqu'à la surface intérieure de cette paroi latérale, la partie la plus basse de l'ouverture coupant la surface extérieure de la paroi latérale à une hauteur au-dessus du bas de l'élément de recouvrement qui est de 0,5 à 0,7 fois la hauteur totale de l'élément de recouvrement, l'ensemble de l'ouverture coupant la surface intérieure de la paroi latérale, et la section transversale de l'ouverture augmentant de la surface extérieure à la surface intérieure de la paroi latérale.

2. Système d'écoulement des eaux de surface selon la revendication 1, caractérisé en ce que l'axe (A—A') de l'ouverture (7) fait un angle (α) avec le plan de symétrie (A—B) compris entre 40° et 50°.

3. Système d'écoulement des eaux de surface selon l'une quelconque des revendications 1 et 2, caractérisé en ce que la section transversale de l'ouverture (7) par rapport à son axe (A—A') a une forme ovale, sa plus grande dimension s'étendant dans la direction longitudinale de l'élément de recouvrement.

4. Système d'écoulement des eaux de surface selon l'une quelconque des revendications 1 à 3, caractérisé en ce qu'une seule ouverture (7) est située dans la région centrale longitudinale de l'élément de recouvrement.

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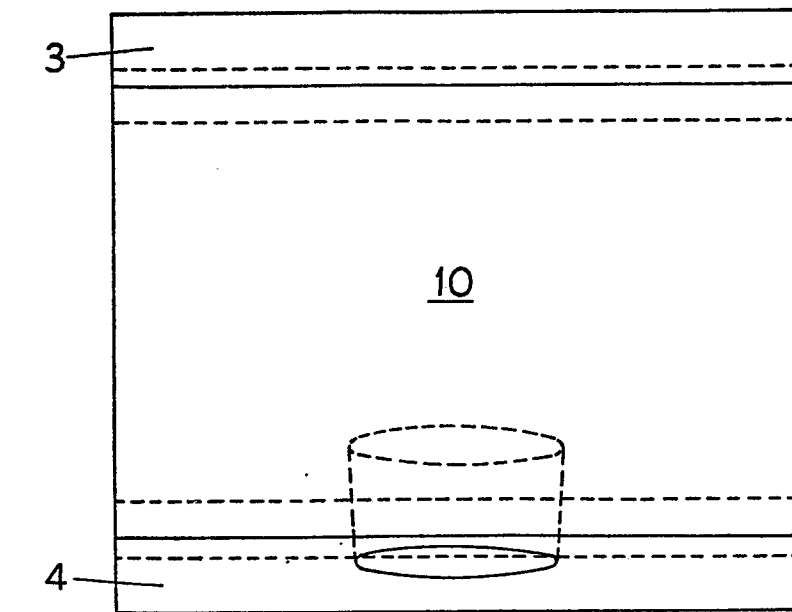
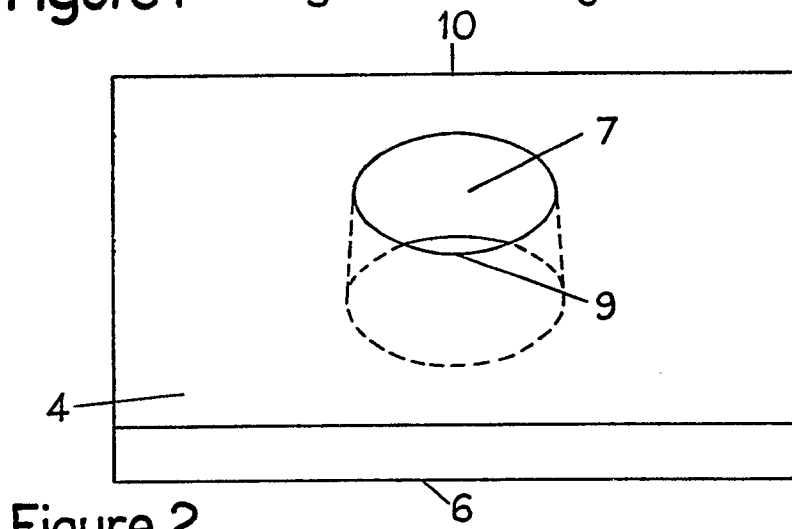
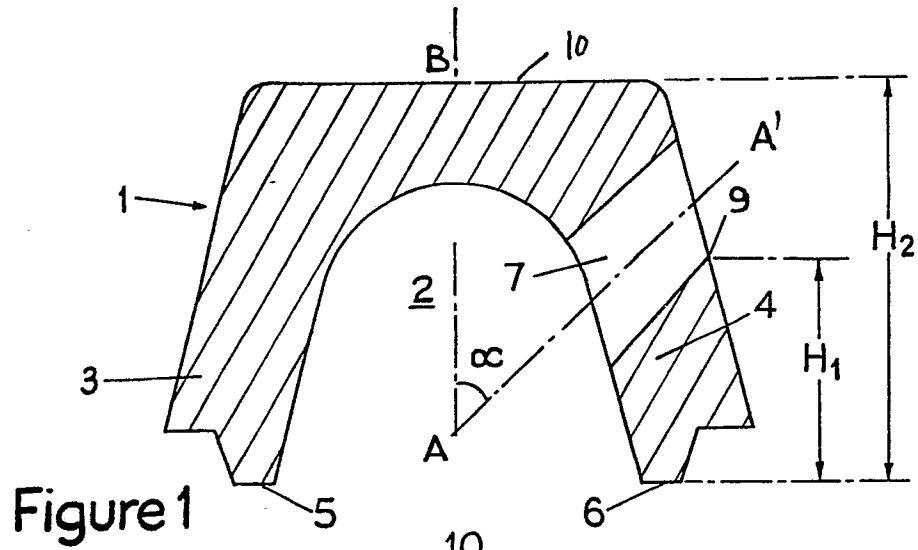
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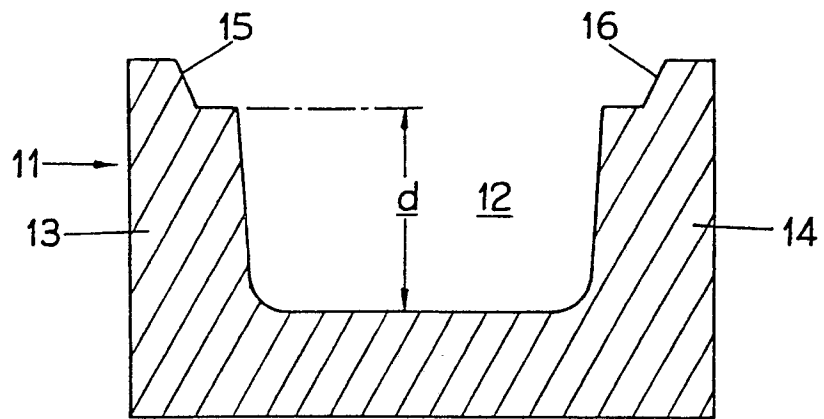


Figure 4

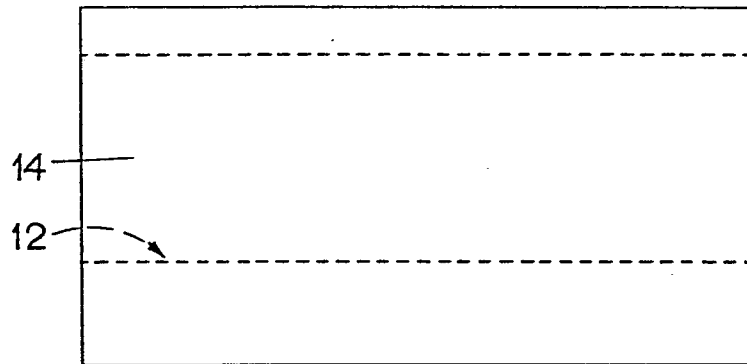


Figure 5

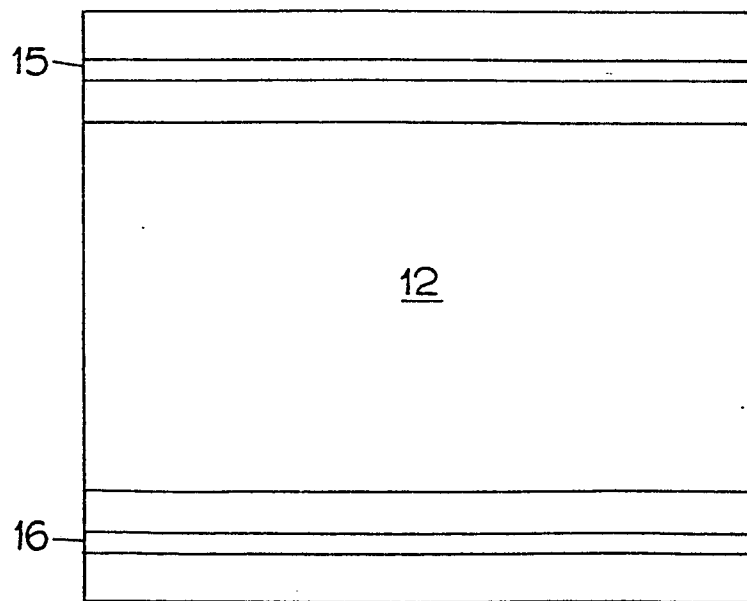


Figure 6

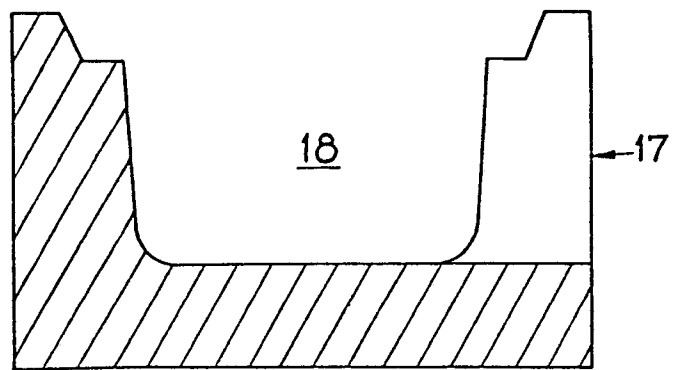


Figure 7

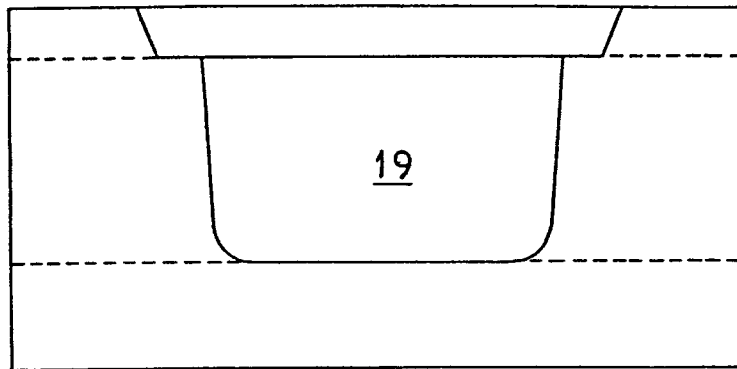


Figure 8

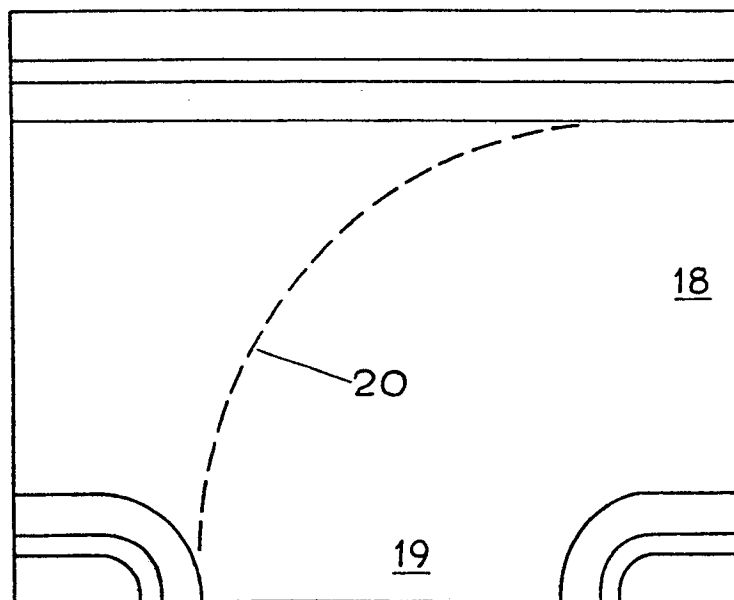


Figure 9

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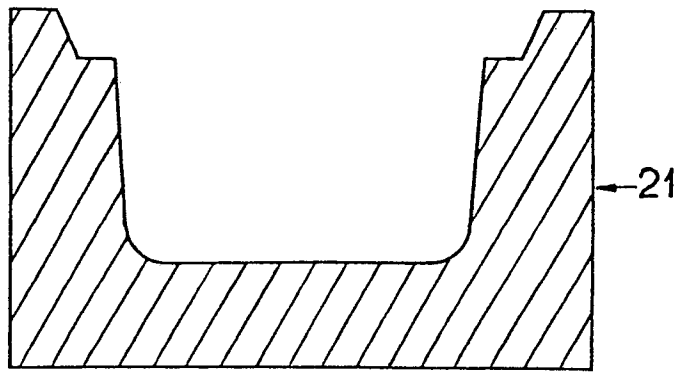


Figure 10

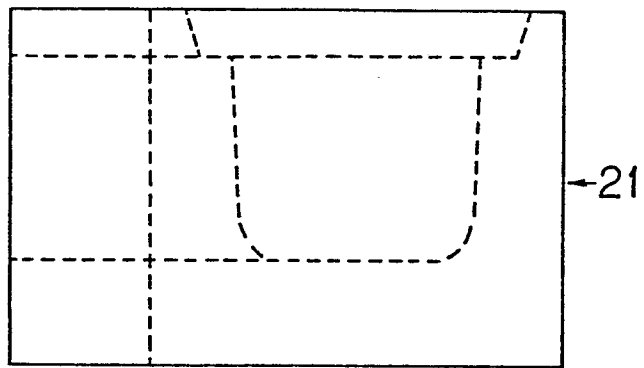


Figure 11

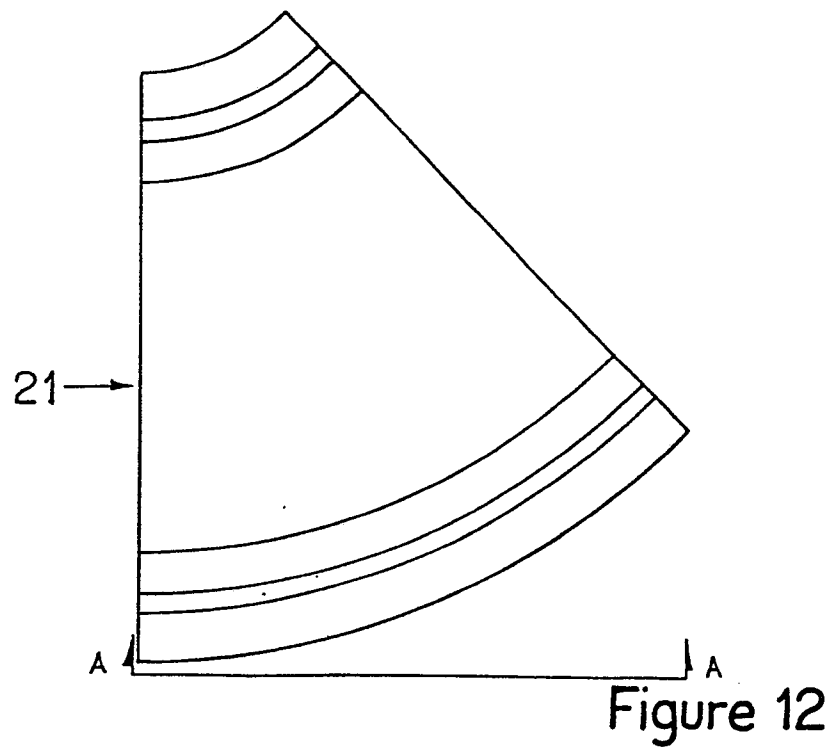


Figure 12

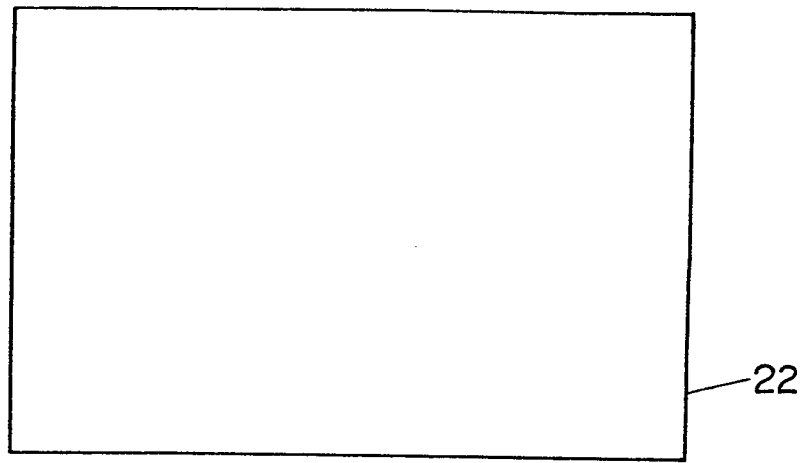


Figure 13

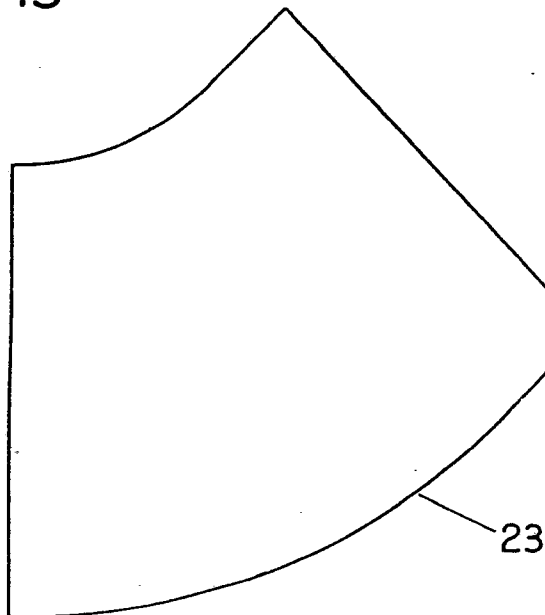


Figure 14

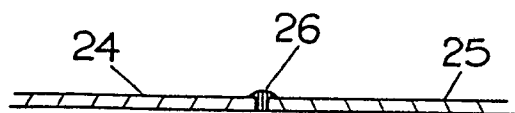


Figure 15

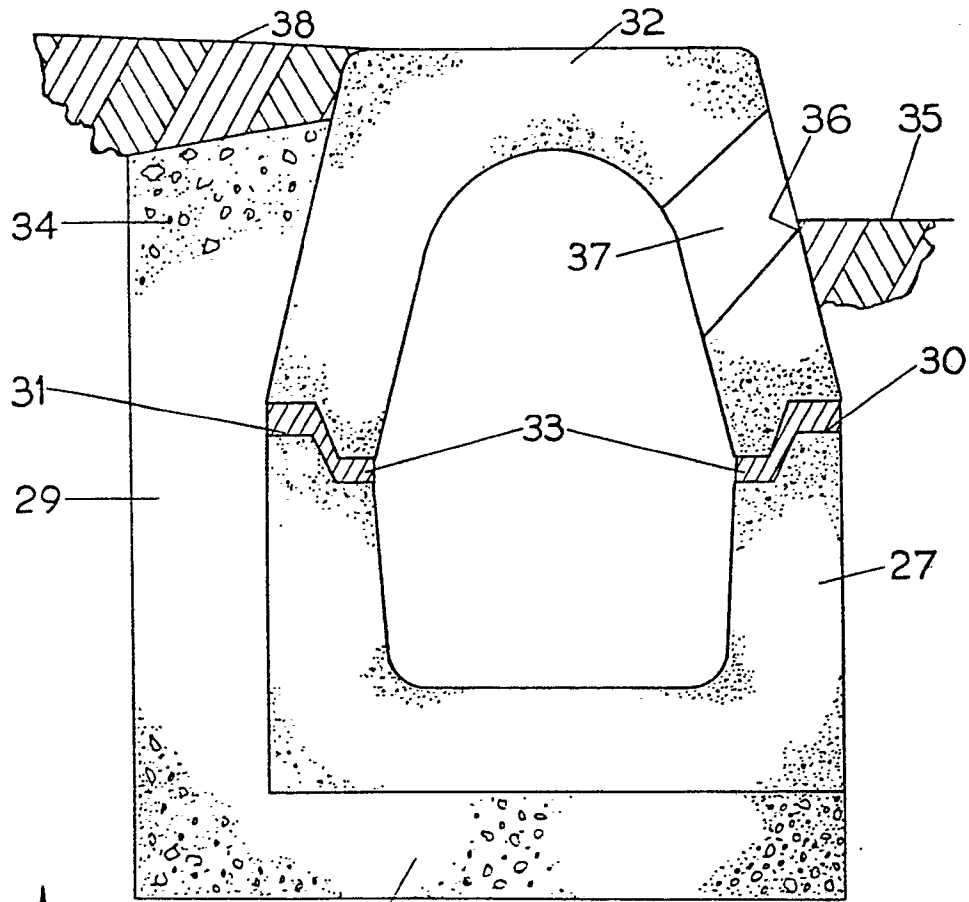


Figure 16

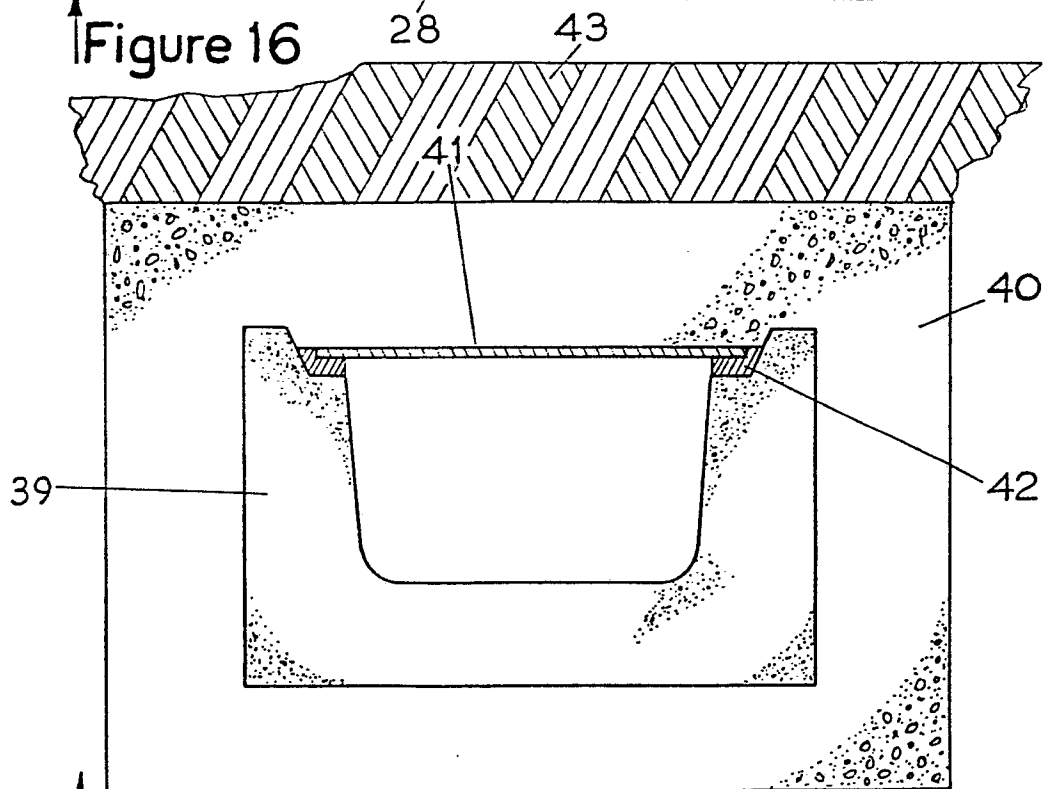


Figure 17

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