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Verbeek

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[54] **DREDGE CUTTER HEAD**

[75] Inventor: **Adalbertus Raphael Maria Verbeek,** Heemstede, Netherlands

[73] Assignee: **Van Hattum en Blankevoort B.V.,** Beverwijk, Netherlands

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[51] **Int. Cl.** **E02f 3/92**

[58] **Field of Search** 37/67, 142

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Primary Examiner—Robert E. Pulfrey
Assistant Examiner—Clifford D. Crowder
Attorney, Agent, or Firm—Cushman, Darby & Cushman

[57] **ABSTRACT**

A cutter head construction for use in a cutter dredger, comprising a plurality of spiral-helical arms which on one end join together at a hub and on the other are connected by means of a supporting ring, to which arms are secured lateral ground working teeth each consisting towards their operative ends of a tooth crown extending from a tooth crown base, the representative tooth tips of which crowns, defined as the points halfway the tip or the middle of a cutting rib formed at the free end of the unworn tooth crown and the projection on the axis of the tooth crown of the centre of the wearing surface of the worn tooth crown, together define an imaginary enveloping plane in the form of a plane of revolution co-axial with said hub and said ring.

7 Claims, 3 Drawing Figures

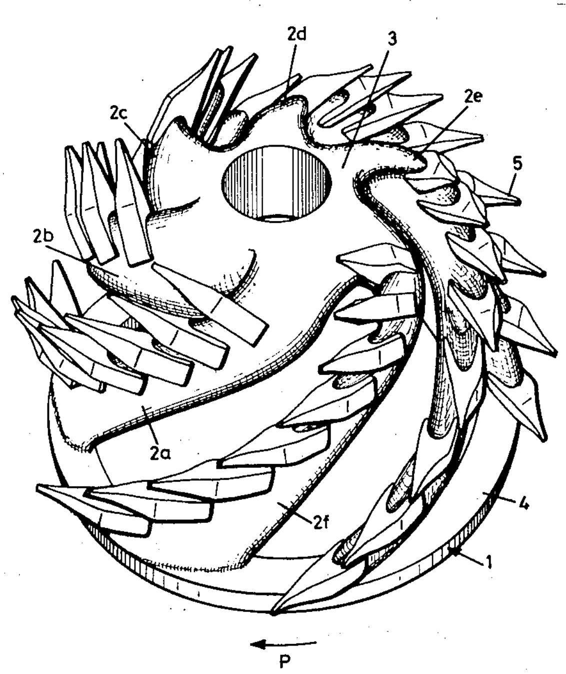


FIG. 1

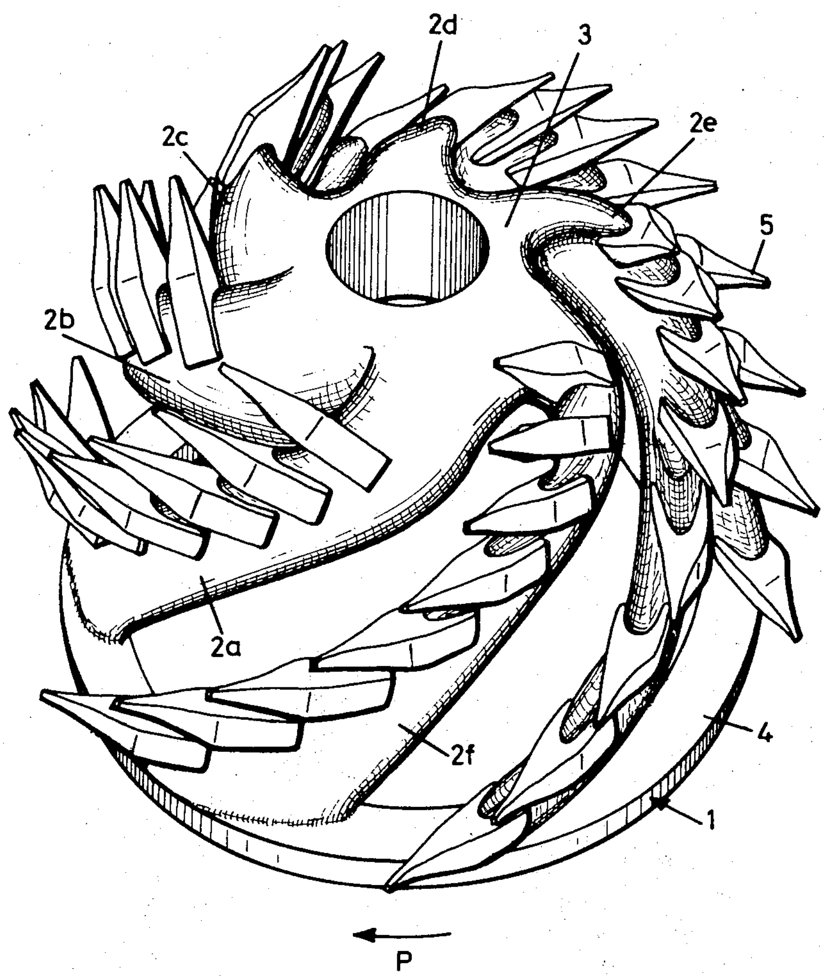


FIG. 2

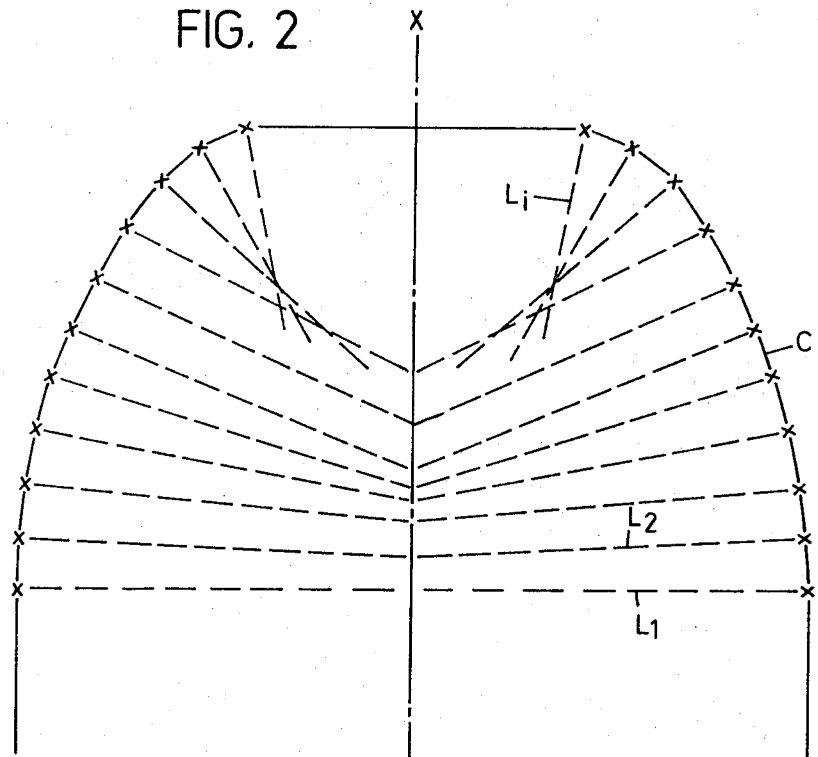
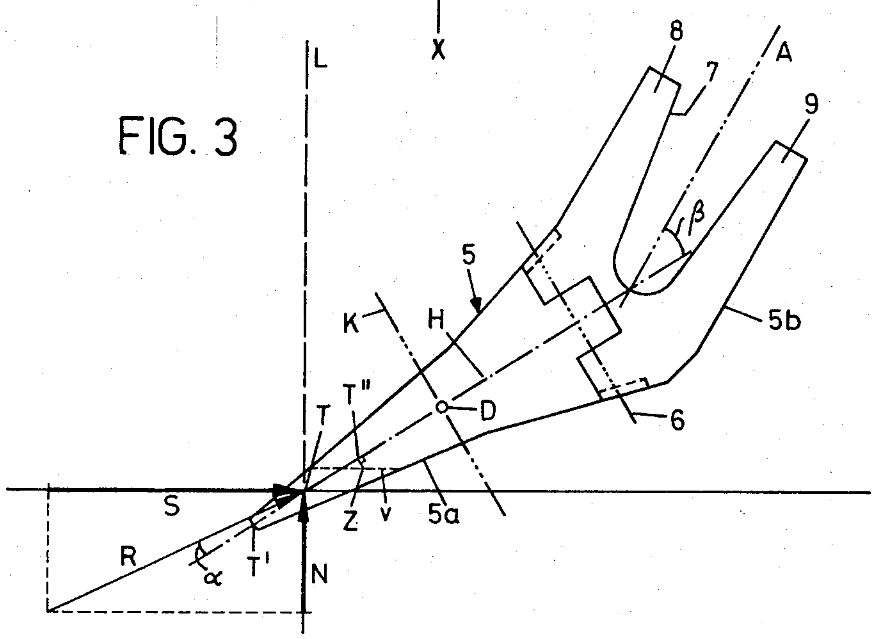


FIG. 3



DREDGE CUTTER HEAD

This invention relates to a cutter head construction for use in a cutter dredger, comprising a plurality of spiral-helical arms which on one end join together at a hub and on the other are connected by means of a supporting ring, to which arms are secured lateral ground working teeth each consisting towards their operative ends of a tooth crown extending from a tooth crown base, the representative tooth tips of which crowns, defined as the points halfway the tip or the middle of a cutting edge formed at the free end of the unworn tooth crown and the projection on the axis of the tooth crown of the centre of the wearing surface of the worn tooth crown, together define an imaginary enveloping plane in the form of a plane of revolution co-axial with said hub and said ring.

The tooth crowns preferably consist of a hard-wearing material. Generally the tooth crowns are separate members mounted at their base on so-called tooth holders so as to be readily replaceable. However, they may be formed integrally with such holder.

The tooth holders are often secured to the arms by means of sockets fitting seats recessed in the arms.

Earth movement operation under water in the case of very hard soil, such as rock and stone are often carried out by blasting and subsequently dredging the material thus loosened. In view of the many difficulties encountered in this cumbersome method, it is at present increasingly decided to work even such hard soils with cutter heads of cutter dredgers. The material loosened by the teeth can then be removed through the supporting ring.

Owing to this use with increasingly harder soils, the teeth are subject to excessive wear. The service life of the tooth crowns from their unworn condition to the condition in which they are worn, that is, no longer fit for use, is in practive sometimes as short as several hours.

The teeth or tooth crowns must then be replaced. In addition to wear, the use in harder soils often leads to breakage of teeth, resulting from the huge forces exercised on the teeth. As soon as one tooth is broken, the process of breakage escalates since the teeth in its immediate vicinity are loaded to a heavier extent.

In view of this the drill head must be regularly inspected during the drilling process and where necessary provided with new teeth or tooth crowns, which, however rapid it may be done, leads to interruption of work, so that, also as a result of the necessity of using expensive, hard wearing material, running costs are excessively high.

In order to at least try to have the teeth loaded in the most favourable way, it has been proposed in replacing a worn tooth crown to bend the new tooth or tooth crown before it is mounted in the direction in which the worn tooth crown was unilaterally worn away. This procedure, however, is very cumbersome and time-consuming, while the very hard-wearing properties of the material of the tooth crown render it highly unsuitable for such an operation.

In addition to the step of bending the tooth crown it has been attempted to provide possibilities of adaptation in the means for securing the teeth to the arms, so that the angular position of the tooth can be changed to a certain extent. It often turns out, however, that the direction in which the angular position of the tooth

crowns should be changed is impossible with the securing means provided, so that this arrangement fails to lead to the desired result.

It is an object of the present invention to provide an improved cutter head construction which leads to the most favourable loading of the teeth and hence to a considerably longer service life of the cutter head, and whereby the above and similar disadvantages of prior cutter head constructions are overcome.

The invention is based on a detailed understanding of what actually happens in the action of such cutter heads on the soil.

It is clear that the energy provided by the drive of the cutter head is transmitted via the tooth crowns to the soil and is used for cutting and breaking up the soil. The resultants of the forces generated apply to the tooth tips.

If the relatively slight movement of the teeth as a result of the shifting movements of the cutter dredger is neglected, the motion of the tip of a tooth crown is one in an orbit having its centre in the axis of rotation of the cutter head. The force component which effects the transmission of energy is directed tangentially to the orbit of the tooth tip concerned. This component is termed the cutting force (S).

In addition to this cutting force a so-called feed force is transmitted in the tooth tips. The feed force is perpendicular to the direction of the cutting force and hence lies in the so-called contour plane, that is the plane superficies containing the tooth tip concerned and the axis of rotation of the cutter head. This plane superficies intersects the enveloping plane, referred to hereinbefore, by the so-called cutter contour. Now, the feed force can be resolved into a main component and a side-component, respectively in the direction of the perpendicular to, and the tangent to, the cutter contour.

Careful observations of the way in which wear in cutter teeth progresses in many varied uses, in combination with the consideration that the soil material being worked by the cutter head will have to break up mainly in the direction through the tooth tip concerned at right angles to the enveloping plane, have lead to a concept which is of great importance to the present invention.

According to this concept the side-component of the feed force is negligibly small. In the following analysis, therefore, the main component of the feed force can be equalized to the feed force.

On the basis of this concept it can further be postulated that the resultant of the cutting force (S) and the feed force (N) will vary in direction according to the magnitude of these forces relative to each other, but will always lie within the plane superficies defined by the tangent to the orbit of the tooth concerned, on the one hand, and the perpendicular to the enveloping plane referred to herinbefore, or the cutter contour through said tooth tip, on the other, which superficies will hereinafter be termed the "nominal plane" belonging to the representative tooth tip concerned.

On the basis of the above-described concept, it is an object of the invention to position the teeth in such a manner and, if so desired, changing their position so that the tooth crowns are loaded in the most favourable way at all times.

To that effect it is proposed, according to the invention, in a cutter head construction as defined in the opening paragraph of this specification, that the axis of each tooth crown lies at least substantially within the nominal plane of the representative tooth tip concerned, which nominal plane is defined by the perpendicular from said tooth tip to said enveloping plane and the tangent to the orbit of said tip.

The moments in the tooth crown are thus limited to a moment in the plane containing the axis of the tooth crown.

To ensure in this arrangement that the stresses in the tooth crown resulting from these moments are as low as possible, it is a further elaboration of the principle of the invention, if — as is commonly the case — the tooth crowns have two mutually perpendicular planes of symmetry, the plane of symmetry containing the representative tooth tip, in which the moment of resistance of the tooth crown is maximal, substantially coincides with the nominal plane containing the tooth tip. As a result, the tooth crown has in cross-section its highest moment of resistance against the moments which, as appears from the foregoing, are active in said nominal plane.

In the above, reference is made to the representative tooth tips for determining the nominal planes in which the axes of the tooth crowns should be located.

This is theoretically the best solution. In fact this gives the best approach to the average situation between the condition of the fully unworn tooth crowns and that in which the tooth crowns are worn to the extent that the teeth have to be replaced.

Practice has shown that good results are also obtained if, instead of the representative tooth tips, the actual tooth tips are used as the starting point.

The invention accordingly includes within its scope the forms in which the conditions referred to above are met, but with reference to the actual tooth tips, or the centres of the actual cutting edge, rather than the representative tooth tips.

When the teeth are provided with a cutting edge, it is a preferred feature of the present invention that such cutting edge is at least substantially perpendicular to said nominal plane. In this way the most favourable "bit" action is exerted on the soil by the cutting edge, and especially, such action is maintained as the tooth tip wears off.

Since the direction of the resultant of the cutting force and the feed force is mainly determined by the rate of rotation of the cutter head, the hardness of the material and the extent to which the cutter head is pressed against the soil by the cutter dredger, it is possible, in each and every particular case, to aim at minimizing moments occuring in the tooth crowns, on the basis of experience gained under comparable conditions. For this purpose it must be possible for the tooth crowns to be set at the most favourable angular position. To this effect it is possible from case to case to use teeth having a broken axis still extending in the nominal plane. In this way the cutter can be suited to particular circumstances by just replacing the teeth, with a broken or straight axis, by corresponding teeth having an axis broken at a different angle.

When the teeth are each mounted by means of a socket on the seat of an arm of the cutter head, the position and form of the socket and the seat are preferably such that the socket and the seat are symmetrical relatively to an axis of symmetry lying at least substantially within the nominal plane of the representative tooth tip concerned. When said axis of symmetry is broken relatively to the axis of the tooth crown, there is a further possibility of adjustment of the angular position of the tooth crown when using one and the same type of tooth in reversing the socket on the associated seat through 180°. When separate tooth crowns are used their angular position can also be made as favourable as possible by using different kinds of tooth crowns the axis of which, though extending substantially within the nominal plane, are broken at different angles relatively to the axis of symmetry of the means for connecting and fastening the tooth crowns and holders.

According to the invention such connecting construction of a tooth crown and holder is formed so as to be symmetrical relatively to an axis of symmetry lying at least substantially within the nominal plane of the representative tooth tip concerned. When said axis of symmetry extends at an angle to the axis of the tooth crown, there is a further possibility of adjusting the angular position of the tooth crown while using one and the same kind of tooth crown in reversing the tooth crown through 180° on the connecting construction.

The reduction in breakage, achieved by the features proposed according to the present invention leads to a considerable increase in operating efficiency of the tooth and a substantial decrease of the cost of material.

A further important advantage of the invention cutter head construction consists in that, owing to the favourable orientation of the tooth crowns, achieved by the invention, relative to the direction from which wearing action is exercised on the tooth crowns, the location of the limited surface area where the wear of the tooth crowns will be concentrated when the cutter head is in use, is known a priori.

Owing to the localization of the surface area of the tooth crowns that is subjected to the heaviest conditions of wear, it is worthwhile, and has become economically justified to provide the tooth crowns at that limited surface area with a hard-wearing liner. Such liners may consist of, for example, soldered tungsten carbide plating, or tungsten carbide pellets soldered into a layer of relatively softer material, such as steel, iron, copper. It is also possible to provide the tooth crowns with extra hard electrodes at these areas by electrical means. In cutter head constructions not formed in accordance with the concept of the present invention, the relative uncertainty as to the wearing behaviour would make such tooth crown liners much more expensive, because for them to have any effect would require such liners to be applied in a much larger surface area. Therefore, the provision of a hard-wearing liner is particularly effective and remunerating in a cutter head of the present invention.

The invention will be further described with reference to the accompanying diagrammatic drawings, which illustrate, merely by way of example, one embodiment of a cutter head construction according to the invention, and are illustrative of the terms used hereinbefore.

In said drawings,

FIG. 1 is a perspective view of a cutter head construction according to the invention;

FIG. 2 is a showing, in a so-called contour plane, of the cutter contour with appurtenant perpendiculars through the points of intersection of the orbits of the representative tooth tips;

FIG. **3** is a showing, in the nominal plane, of the forces occurring therein and the relative position of a tooth, consisting of a tooth crown and a tooth holder.

Referring to the drawings, there is shown a cutter head construction, generally indicated by **1**, for a cutter dredger. The head consists essentially of a plurality of spiral-helical arms **2***a*–**2***f* which join together at the free end of the cutter head construction in a hub **3** and at the other end are interconnected by a ring **4**.

The contemplated direction of rotation of the cutter head is indicated by arrow *p* in FIG. **1**.

As appears from FIG. **1**, the preferred form is that in which the helical configuration of the arms of the cutter head "screws in" in a direction opposite to the direction of rotation of the cutter head.

In fact it has been found that the conventional construction of the arms, in which the helix screws in in the direction of rotation of the cutter head, results in structural difficulties as regards the position of the teeth required according to the invention, namely, in effectively securing the tooth holders to the arms.

Extending laterally of arms **2***a*–**2***f* are ground working teeth **5**, shown as integral members in FIG. **1**, but as will be described in more detail hereinafter, essentially consisting of a tooth crown **5***a* and a tooth holder **5***b*. These two parts are complementary and are locked together by a locking pin **6**, shown in FIG. **3** by its axis by dashes alternating with four dots.

In the foregoing description the term "representative tooth tip" has been introduced.

By this term is meant the point lying on the axis of the tooth crown halfway between the tip of the unworn tooth crown, on the one hand, and the projection of the middle, or actually the centre of gravity of the wearing surface of the worn tooth crown on said axis, on the other. In the case of a tooth which rather than a tip has a cutting edge at its free end, the middle of the cutting edge should be substituted for the unworn tooth tip in this definition.

In FIG. **3**, the unworn tooth tip is designated T' and the representative tooth tip T''. T'' in that figure indicates the projection of the centre of gravity Z of the wearing surface *v*, shown dotted, on the axis H of the tooth crown.

FIG. **2** shows, in a so-called contour plane, which contains the axis of rotation X—X of the cutter head construction — which axis of rotation accordingly coincides with the axis of hub **3** and ring **4** — the curve of intersection C of that plane with the imaginary enveloping plane of all representative tooth tips. The points of intersection of the orbits of the representative tooth tips with said plane during the rotary movement of the cutter head are indicated in FIG. **2** by crosses. The dash lines $L_1 - L_i$ in FIG. **2** are the perpendiculars to line C in the contour plane of the representative tooth tips at the moment when these pass the contour plane.

In FIG. **3** the perpendicular L, belonging to tooth tip T, to the enveloping plane is shown as a dash line. The line lies in the plane of drawing of FIG. **3**. The line extending in the direction of arrow S in FIG. **3** represents the tangent to the orbit of the representative tooth tip T. The arrow at S represents the cutting force acting in the direction of that tangent.

Arrow N indicates the feed force, which is directed according to the perpendicular to the enveloping plane containing the representative tooth tip T.

Arrow R indicates the resultant of the feed force N and the cutting force S, which resultant must be taken up by tooth **5**. As appears from FIG. **3**, the direction of resultant R does not fully coincide with the axis H of the tooth crown, so that resultant R applies a moment to the tooth crown, the magnitude of which is partly determined by angle α in FIG. **3**. In FIG. **3** further is shown, at letter K, halfway between the representative tooth tip T and the base zone of tooth crown **5***a*, approximately corresponding to the axis of locking pin **6**, is a cross-sectional plane perpendicular to axis H of the tooth crown, which plane is called the perpendicular plane of the crown. The point of intersection of line K in FIG. 3 with axis H of the tooth crown is the point of intersection of the so-called main axis of the crown cross-section at the perpendicular plane of the crown. The point of intersection of line K in FIG. **3** with the axis H of the tooth crown is the point of intersection of the so-called main axis D of the cross-section of the crown at its perpendicular plane. Main axis D is the axis of the cross-section of tooth crown **5***a* at K around which the moment of resistance of the tooth crown against bending is maximal.

Owing to the fact that it is arranged for said main axis to be perpendicular to the nominal plane, the stresses in the tooth crown resulting from load R are limited. In other words, if the cross-section of the tooth crown at K is, for example, rectangular, the longer side of the rectangle will be parallel to the plane of drawing. When teeth having a cutting edge are used, it can be ensured that these edges are always at right angles to the nominal plane concerned.

Tooth holder **5***b* comprises a tooth socket **7**, which is defined by the boundary face, substantially perpendicular to the nominal plane, of a recess formed between two legs **8** and **9** of the tooth holder, which as shown in FIG. **1** straddle an arm of the cutter head complementary to a recessed seat of such arm.

A designates an axis of symmetry of tooth socket **7**, lying in the nominal plane.

In FIG. **3**, the axes of tooth crown H and tooth socket A are directed to enclose an angle β. If various kinds of teeth of different angles β are available, the direction of the tooth crown axis can be adjusted to load conditions by an appropriate selection of the kind of tooth. It is also possible that one kind of tooth affords adjustment to two cases of load conditions. This can be realized by reversing the tooth socket through 180° on the arm. The direction of the axis of the tooth crown is then turned through an angle 2β. In the tooth construction of FIG. **3** the axis of symmetry of the connection between the tooth crown and the tooth holder extends in the direction of the axis of the tooth crown.

If, however, the construction is such that these two axes enclose an angle between them, the use of various kinds of tooth crowns having such angles in different magnitudes, provides a further possibility of adjustment to load conditions.

It is then in addition possible to effect such adjustment with one kind of crown by a reversal through 180°.

Naturally the position of the representative tooth tip is changed by such adjustments, and hence the associated nominal plane. Practice has shown, however, that the extent of such change is such that the requirements of the invention, as defined in the appendant claims, are still substantially satisfied.

We claim:

1. A cutter head construction for use in a cutter dredger, comprising a plurality of spiral-helical arms which on one end join together at a hub and on the other are connected by means of a supporting ring, to which arms are secured lateral ground working teeth each consisting towards their operative ends of a tooth crown extending from a tooth crown base, the tips or the middles of the cutting edge of the tooth crowns together defining an imaginary enveloping plane in the form of a plane of revolution co-axial with said hub and said ring, characterized in that the axis of each tooth crown lies within the nominal plane of the tooth crown concerned, which nominal plane is defined by the perpendicular from said tooth tip or the middle of the cutting edge to said enveloping plane and the tangent to the orbit of said tip or middle.

2. A cutter head construction according to claim **1**, and provided with teeth having cutting ribs, and wherein each cutting rib is substantially perpendicular to its associated nominal plane.

3. A cutter head construction according to claim **1**, wherein each tooth is secured to the seat of an arm by means of a socket, such seat and such socket being symmetrical relatively to an axis of symmetry lying at least substantially within the nominal plane of the representative tooth tip concerned.

4. A cutter head construction according to claim **1**, wherein each individual tooth crown is secured to a tooth holder of the tooth by connecting and fastening means, said connecting and fastening means being symmetrical relatively to an axis of symmetry lying at least substantially within the nominal plane of the representative tooth tip concerned.

5. A cutter head construction according to claim **1**, wherein the tooth crowns are locally provided with a hard-wearing layer.

6. A cutter head construction according to claim **1**, in which the tooth crowns are set in position by rotation around their axes in such a way that the main axis, which lies in the cross-section of each tooth crown, half-way the length of the crown and perpendicular to the axis of that crown and around which the moment of resistance is maximal, is perpendicular to said nominal plane.

7. A cutter head construction according to claim **1**, in which the point of connection of each arm at the supporting ring is in advance, in direction of rotation, of the point of connection at the hub of the cutter head.

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