LIP CONSTRUCTION FOR BUCKETWHEEL EXCAVATORS

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ABSTRACT

A lip for an excavating bucket has a row of sockets in each of which a respective excavating tooth is mounted, the center of the lip being relieved (i.e., offset with respect to the corners thereof) in two mutually perpendicular planes, such that the corner teeth do the initial excavating without interference from the center teeth, in both forward and lateral movements of the bucket. The combination of the shorter teeth used in the center of the lip plus the relief mentioned causes the corner teeth to engage the working face in advance of the other teeth, in both forward and lateral bucket movements.

4 Claims, 8 Drawing Figures
This invention is directed to improvements in the tooth-mounting lips of excavating buckets used in bucketwheel excavators.

In order to utilize tar sands as a raw material (for the extraction of valuable hydrocarbon products therefrom) in the most economic manner, tremendous quantities of the tar sands must be mined (per unit of time) and sent to the extraction plant for processing. For mining of the sands, bucketwheel excavators of large capacity may be employed; typically, such machines may have a nominal capacity of 5,000 tons of material per hour. In order to increase the total amount of tar sands mined during a period such a day, for example (taking into account necessary down time of the equipment for repair and replacement of worn teeth, as well as for other necessary maintenance), it is necessary to increase the work capacity of the bucketwheel as much as possible; one way in which this may be done is by reducing the power required to drive the wheel, during mining.

An object of this invention is to provide a novel toothed lip for bucketwheel excavators.

Another object is to provide a bucket lip configuration which markedly reduces the driving power required, as compared to prior configurations.

A further object is to provide a bucket lip construction which results in a greatly increased digging efficiency, as compared to known constructions.

In the mining of tar sands, one procedure which may be followed is to slue the buckets across the face of the work (i.e., to move them laterally or sideways across the working face), to thereby take a substantially horizontal "cut" of the sands.

Therefore, a still further object of this invention is to provide a bucket lip construction which is particularly suitable for the slue-mining of tar sands.

An additional object is to provide a bucket lip configuration which gives highly effective and efficient digging action when used for the slue-mining of tar sands.

The objects of this invention are accomplished, briefly, in the following manner: A tooth-mounting bucket lip has a variable profile, formed by the relieving of the center of the lip in both planes. The lip member is of generally U-shaped configuration, viewed head-on or looking into the bucket, and is skewed rearwardly at its two opposite ends. The end face of the member has therein a plurality of sockets for individually receiving the shanks of chisel-shaped excavating teeth, and the member is provided with means for removably securing the teeth in position in their respective sockets.

A detailed description of the invention follows, taken in conjunction with the accompanying drawings, wherein:

FIG. 1 is a fragmentary, diagrammatic side elevation, partly broken away, of a rotary excavator (bucketwheel) having buckets and excavating teeth attached;

FIG. 2 is a front elevational view of one of the buckets of FIG. 1, looking in the direction 2-2 of FIG. 1;

FIG. 3 is a side view of an excavating bucket lip according to this invention, prior to mounting thereof on a wheel;

FIG. 4 is an end-on view of the bucket lip of FIG. 3, in a direction looking onto the bucket; FIG. 5 is a plan or top view of the bucket of this invention;

FIG. 6 is an exploded view of a tooth retaining pin;

FIG. 7 is a fragmentary cross-section on a small scale, taken on line 7-7 of FIG. 4; and FIG. 8 is a fragmentary cross-section taken on line 8-8 of FIG. 5.

Referring now to the drawings, a portion of a typical rotary excavator or digger (bucketwheel) is indicated at 1. For excavating purposes, the wheel 1 is rotated in the direction 2 (counterclockwise in FIG. 1), and is arranged to advance toward the work 3 being mined or excavated, which work is disposed generally vertically with respect to the wheel 1. For mining, the wheel 1 may be moved laterally or sideways across the face of the work, in the direction of the arrows 4 (FIG. 2), in order to take a substantially horizontal "cut" of the work. This is to say, the bucketwheel 1 may be slued back and forth across the work.

The bucketwheel 1 has mounted thereon peripherally disposed spaced apart excavating buckets 5. These buckets each have a chain-type wall 6 and a lip denoted generally by numeral 7, to be described in detail hereinafter. Mounted on the front edge of lip 7 are spaced apart excavating teeth generally indicated at 8. At each end of the generally U-shaped lip 7, there is a respective integral tongue-like plate 9 by means of which the ends of the lip are rigidly secured to respective opposite faces of the wheel 1. The wall 6 (see FIG. 2) is formed of a plurality of closely-spaced, parallel lengths of link chain, one end of each length of chain being secured to the rear edge of lip 7 and the other end of each length of chain being secured to a cross-member 10 which extends between the pair of tongue plates 9.

Refer now more particularly to FIGS. 3-5. The lip 7 is a thick, heavy member (sufficiently rigid to resist the substantial stresses applied thereto during excavating operations) of generally U-shaped configuration viewed end-on from the work-engaging side of the lip, as in FIG. 4. As an indication of size, the horizontal dimension at the top of FIG. 4, across the tongues 9 and between the outer edges thereof, may be about five feet. The lip member 7 mounts a plurality of excavating teeth 8, as will be detailed hereinafter, and is symmetrical about a central plane of symmetry indicated by numeral 11 in FIGS. 4 and 5. The forward edge face 13 of lip 7 (which is the face closest to the observer in FIG. 4) is provided with a plurality (thirteen in number) of transversely spaced sockets 12, for receiving the shank portions of respective excavating teeth 8, which sockets are distributed over the base and legs of the "U" previously mentioned and which extend more or less longitudinally of the lip (which would mean in a more or less vertical direction in FIG. 5). The sockets 12 all have exactly the same size and shape, so for convenience only some of them (those devoid of teeth, generally at the right-hand side of line 11 in FIG. 4) are illustrated in detail.

The forward edge face 13 of lip member 7 is skewed rearwardly at its two opposite ends, essentially beginning at the corners of the "U" previously mentioned, as may be seen in FIGS. 3 and 5. This provides an approximately U-shaped outer configuration when viewed at 90° to the end-on direction, that is, when viewed as in FIG. 5, which may be considered a plan or top view, looking down at the lip from above.
Refer now particularly to FIG. 5. The five central teeth 8a–8e (of the group of 13 teeth generally denoted by numeral 8) all have the same length, these teeth being shorter than the other eight teeth of the group. The central plane of symmetry passes through the center of tooth 8c. According to one aspect of this invention, the center of the lip 7 is relieved in both planes, thereby to provide a variable profile lip (or variable profile bucket). In order to provide this relief in one plane (to wit, in the forward-rearward direction of the lip), the central portion of the forward edge 13 of lip member 7 is stepped rearwardly from both ends of such central portion to the middle thereof. Consider the central portion of the lip 7 to be that portion occupied by teeth 8a–8e, which teeth extend parallel to each other and the center lines of which are parallel to the central plane of symmetry 11.

The lip forward edge portion 13a for tooth 8a (which forward edge portion establishes the position of the chisel edge of tooth 8a) is rearwardly displaced (about 1 inch, for example) with respect to the lip forward edge portion 13f for tooth 8f, which latter is the tooth immediately adjacent to tooth 8a, toward the corner of the “U,” and in one of the eight longer teeth. The lip forward edge portion 13b for tooth 8b is rearwardly displaced (1 inch, for example) with respect to the lip forward edge portion 13c for tooth 8c which is rearwardly displaced (1 inch, for example) with respect to the lip forward edge portion 13d.

The lip member 7 being symmetrical about the central plane 11, the lip forward edge portion 13d for tooth 8d is coplanar with lip edge portion 13b (so 13a and 13d are horizontally aligned in FIG. 5). The lip forward edge portion 13e for tooth 8e is coplanar with lip edge portion 13a.

The stepping of the lip 7 in the forward-rearward direction, just described, provides a regular progression, of the forward, chisel edges of the teeth 8a–8e, from each end of this group of five teeth to the central plane of symmetry; thus, the forward edge of tooth 8b is stepped rearwardly from the outer edge of tooth 8a, and the forward edge of tooth 8c is stepped rearwardly from the outer edge of tooth 8b. Similarly, the forward edge of tooth 8d is stepped rearwardly from the outer edge of tooth 8c, and the forward edge of tooth 8e is stepped rearwardly from the outer edge of tooth 8d. Also, it may be noted that the forward edge of tooth 8a is located a considerable distance rearwardly with respect to the outer edge of tooth 8f, and also with respect to the outer edge of corner tooth 8h. At the opposite side of the lip, the forward edge of tooth 8e is located a considerable distance rearwardly with respect to the outer edge of tooth 8g, which latter is the tooth immediately adjacent to tooth 8e, toward the corner of the “U,” and is one of the eight longer teeth. The forward edge of tooth 8e is also located a considerable distance rearwardly with respect to the outer edge of corner tooth 8i.

Refer now particularly to FIG. 4. In order to provide relief of the center of the lip member 7 in the other plane (to wit, in the outward-inward direction of the lip), the central portion of the forward edge 13 of the lip, viewed end-on, is stepped inwardly (i.e., upwardly in FIG. 4 with respect to a reference plane indicated by line 14), with respect to the ends of the central portion, from both ends of such central portion to the middle thereof. It may be noted here that the line 14 in FIG. 4 (to which the corner teeth 8h and 8i, see FIG. 5, are tangent) might also represent the substantially vertical face of the work, during the digging or excavating operation (compare FIG. 1).

The center of the socket for tooth 8a is displaced inwardly (with respect to reference plane 14, which would mean upwardly in FIG. 4) a distance of about %4-inch relative to the center of the socket for tooth 8f. The center of the socket for tooth 8b is displaced inwardly a distance of about %4-inch relative to the center of the socket for tooth 8a. The center of the socket for tooth 8c, the central tooth, is displaced inwardly a distance of about %4-inch relative to the center of the socket for tooth 8b.

Since the lip member 7 is symmetrical about the plane 11, the center of the socket 12 for tooth 8d is displaced outwardly (which is to say downwardly in FIG. 4) a distance of about %4-inch relative to the center of the socket for tooth 8c; the center of the socket 12 for tooth 8e is displaced outwardly a distance of about %4-inch relative to the center of the socket 12 for tooth 8d; the center of the socket 12 for tooth 8g is displaced outwardly a distance of about %4-inch relative to the center of the socket 12 for tooth 8e.

The construction just described provides relief of the center of lip member 7 in the outward-inward direction of the lip. It may be noted that all of the center teeth 8a–8e are located inwardly with respect to reference plane 14, to which the corner teeth 8h and 8i are tangent. The center teeth 8a–8e are also spaced above (in FIG. 4) the teeth 8f and 8g.

As previously described, the center of the lip member 7 (at the locations of teeth 8a–8e) is relieved in both planes. Due to this construction, the corner teeth (8f–8i, as well as others yet to be described) do the initial digging, without interference from the central section, in both forward and side (or lateral) movements of the bucket lip. In fact, most of the actual digging is accomplished by the corner teeth, the center teeth 8a–8e serving mainly merely to convey the excavated material rearwardly, into the bucket 5. Because the corners do the initial digging, without interference from the central section of the lip, the power required to drive the wheel 1 is substantially reduced, thus increasing the total work capacity (in tons per hour of material mined).

As previously stated, the center lines of all of the central teeth 8a–8e extend parallel to the central plane of symmetry 11, which means that the lip edge portions 13a–13e all lie at right angles to this symmetry plane (or line).

The lip edge portions 13f (for tooth 8f) and 13g (for tooth 8g) are canted slightly with respect to edge portions 13a, etc., such that the angle ω (FIG. 5) is about 7°, which means that the chisel edges of teeth 8f and 8g form angles of 7° with the horizontally-extending reference plane 14 in FIG. 4. The edge of tooth 8f extends upwardly from left to right at 7°, whereas the edge of the corresponding tooth 8g extends upwardly from right to left at 7° (in FIG. 4).

The lip edge portions 13h (for the corner tooth 8h) and 13i (for the corner tooth 8i) are located forwardly (speaking with reference to FIG. 5) of the lip edge portions 13f and 13g, respectively, such that the corner teeth 8h and 8i will, in general, engage the work first,
the remaining teeth (upon either forward or lateral movement of the bucket lip) before any of the remaining teeth (upon either forward or lateral movement of the bucket lip).

The angle which the (substantially planar) lip edge portions 13a and 13i make with the central plane of symmetry 11 (or, more specifically, the angle \( \alpha \)) formed between the chisel edges of the corner teeth 8h and 8i and the face-of-the-work line or reference plane 14, FIG. 4) has been determined to be rather critical, for minimizing driving power and maximizing tooth life. This acute angle \( \alpha \) between the chisel edges of the corner teeth 8h-8i and the work face 14 should lie in the range of about 32° to about 38°, preferably about 35°. Of course, because of the symmetry previously mentioned, the corner teeth 8h and 8i would be like mirror images of each other, the edge of tooth 8h extending downwardly from left to right at the angle \( \alpha \) (in FIG. 4), and the edge of tooth 8i extending upwardly from left to right at the angle \( \alpha \).

As previously stated, the forward edge 13 of lip member 7 is skewed rearwardly at its two opposite ends, which means that the lip edge portions 13j (for the tooth 8j) and 13k (for the tooth 8k) are located rearwardly (speaking with reference to FIG. 5; see also FIG. 3) of the lip edge portions 13h and 13i, respectively. In addition, these lip edge portions 13j and 13k are so disposed that the angle \( \beta \) formed between the chisel edges of the teeth 8j and 8k and the face-of-the-work line 14 is greater than the angle \( \alpha \).

The angle \( \beta \) is preferably about 60°. The edge of tooth 8j extends downwardly from left to right at the angle \( \beta \) (in FIG. 4), while the edge of tooth 8k extends upwardly from left to right at the angle \( \beta \).

The lip edge portions 13l (for the extreme end tooth 8l) and 13m (for the extreme end tooth 8m) are located rearwardly (speaking with reference to FIG. 5; see also FIG. 3) of the lip edge portions 13j and 13k, respectively. In addition, these lip edge portions 13l and 13m are so disposed that the angle formed between the chisel edges of the teeth 8l and 8m and the face-of-the-work line 14 is greater than the angle \( \beta \).

The angle \( \gamma \) between the chisel edges of these teeth and a perpendicular to the line 14 is about 8°, which means that the angle formed between the chisel edges of teeth 8l and 8m and the face-of-the-work line 14 would be about 85°. Again, the edge of tooth 8l extends downwardly from left to right at about 85° (in FIG. 4), while the edge of tooth 8m extends upwardly from left to right at about 85°.

Each of the lip edge portions 13a-13m is substantially planar, in and of itself, as previously mentioned, and each has, at the approximate center of such edge portion, a respective socket 12 for a corresponding one of the teeth 8a-8m. The sockets 12 all extend generally inward of the lip member 7, and the longitudinal axis or center line of each socket is perpendicular to the plane of its respective lip edge portion. The Shank portions of all of the teeth 8a-8m are of elliptical or oval transverse cross-section (see for instance FIG. 8), and the sockets 12 have a matching elliptical or oval configuration, to receive the individual tooth shanks. This shape prevents any substantial rotation of the teeth in their socket; however, the tooth sockets 12 are cored (or reamed) to allow a small amount (say 2°) of rotational clearance or freedom.

The shanks of all the teeth 8a-8m are exactly alike, and the distal portions of the teeth are all chisel-shaped, but the distal portions of the central teeth 8a-8e are considerably shorter than are those of the remaining teeth 8f-8m. The outer teeth 8f-8m are preferably fabricated to have the form illustrated in my copending application, Ser. No. 255,960, filed May 18, 1972, however, as previously mentioned, the shanks of all the teeth 8a-8m are exactly alike.

Refer now more particularly to FIGS. 7 and 8. Each tooth shank, such as shank 15 of the tooth 8c which is illustrated, has a generally elliptical (or oval) transverse cross-section (see FIG. 8), and is tapered from one end to the other, to provide a driving fit in its respective socket 12 of matching taper and elliptical cross-section. It will be recalled, in connection with FIGS. 4 and 5, that a separate, individual socket 12 is provided in lip 7 for each respective excavating tooth 8.

The distal ends or distal portions of all of the teeth are generally chisel-shaped, and the tooth width at the inner end of the distal portion exceeds the maximum outer dimension of the shank, thereby to provide a shoulder 16 (which may be beveled from both outer edges toward the center; see FIG. 7) at the juncture of the shank portion 15 and the distal portion of the tooth. As the tooth shank 15 is driven into its socket 12, the shoulder 16 comes into engagement with the corresponding lip forward edge portion such as 13c, to limit the insertion of the tooth and to properly position the tooth (and particularly the forward, chisel edge thereof) with respect to lip 7.

A face layer of a hard, wear resistant material (for example, a form of tungsten carbide), denoted generally by numeral 17, is provided (by means of an electrodeposition process, for example) on the upper (in FIGS. 4 and 5) face of each of the end teeth (longer teeth) 8f-8m; this upper face is the one which approaches the work first. This hard-facing is applied over a tooth length denoted by numeral 18 (FIG. 5); this length may be about 3½ inches.

A similar face layer of hard, wear resistant material, denoted generally by numeral 19, is provided on the upper face of each of the shorter center teeth 8a-8e. In the case of these center teeth, the hard-facing is applied over the entire distal portions of the teeth (a length of about 6 inches). Again, the hard-facing is applied to the face which approaches the work first.

To form the shorter center teeth 8a-8e, a long tooth such as 8f-8m could be cut off about at the inner end of the length dimension 18, and then a hard facing 19 could be electrodeposited on one side, over the entire remaining length of the distal portion of the tooth.

Since the hard facings just described are deposited on only one face of each of the teeth 8a-8m, a keying means is provided, to make certain that the excavating teeth are properly installed in the bucket lip (i.e., such that the hard facings face in the same direction as does the interior of the buckets). An integral, outwardly-extending keying projection or spine 20 is formed on the outer end of each tooth shank 15, adjacent the shoulder 16; this spine is on the same side of the tooth as is the hard facing 19 (or 17, as the case may be, all the tooth shanks being exactly alike). Matching keying slots 21 (see FIGS. 4, 5, and 7) are formed in the lip 7, one in the outer end of each respective socket 12, at the upper side thereof (speaking with reference to FIGS. 4 and 5). The keying elements 20-21 described make it impossible for any of the teeth 8 to be inserted into sockets 12 in an upside-down or inverted position.
In order to secure each of the teeth 8 in position in its respective socket 12, a pair of oppositely-disposed semi-cylindrical grooves 22 are formed in each tooth shank 15, one at each of the two opposite sides thereof, these grooves extending from top to bottom of the shank in directions parallel to the minor axis of the elliptical shank (see FIGS. 7 and 8). A mounting or retaining pin hole 23, which extends entirely through the lip member 7 in a direction at 90° to the center line of the corresponding socket, is provided adjacent the inner end of each respective one of the sockets 12, on one side or the other of the socket center line, these holes 23 being so located that, when a tooth is inserted into its socket and pushed all the way "home," one of the grooves 22 will come into alignment with a respective pin hole 23.

A composite mounting or retaining pin 24, of the type illustrated in FIG. 6, can then be inserted into the hole 23 and driven down through the tooth groove 22, thereby to retain the tooth in position in lip 7 by engagement of the pin with the side walls of the groove. When it is desired to remove a worn tooth for replacement, the pin 23 can be driven out of groove 22 and out of the lower end (in FIG. 8) of hole 23.

The mounting pin 24 may comprise two solid semi-cylindrical members 25 and 26 made of steel, between which is sandwiched a pad member 27 made of a suitable elastic or resilient material such as Neoprene. The resilience of the pad 27 provides a composite pin which has a driving fit within hole 23; it can be driven into and out of engagement with tooth groove 22 by the application of a suitable driving force.

A rectangular tooth knock-out hole 28, which extends entirely through the lip member 7 in a direction at 90° to the center line of the corresponding socket, is provided at the inner end of each respective one of the sockets 12, offset slightly with respect to the socket center line (see FIG. 8), these holes 28 being of such dimension that, when a tooth is in "working" position in its socket, the inner end face of the shank 15 will be visible (and accessible) through hole 28, as illustrated in FIG. 7. Hence, after the retaining or mounting pin 24 has been removed from engagement with any particular tooth, a wedge-shaped tool may be inserted into the corresponding knock-out hole 28, against the inner end face of the tooth shank, and then driven downwardly to eject the tooth from its socket 12, or to at least loosen it so that it can be then removed manually from the socket. In this connection, it will be appreciated that the insertion of the teeth such as 8c into their sockets 12 is effected by moving the teeth toward the left in FIG. 7, and removal from the sockets, by moving the teeth toward the right in this same figure.

The invention claimed is:

1. A lip for excavating buckets comprising a rigid mounting member of generally U-shaped configuration, but wherein the base of the "U" is substantially straight, viewed end-on from the work-engaging side of said lip, said member having in its forward edge face a group of transversely spaced and generally longitudinally-extending sockets distributed over the base and legs of the "U" for receiving the shank portions of respective excavating teeth; excavating teeth mounted individually in said sockets, the tips of the teeth in the central portion of the member being stepped rearwardly, viewed at 90° to the end-on direction, relative to the corners of the aforesaid "U," and the rearward stepping of the central portion of the forward edge of said member, with respect to the ends of said central portion, is symmetrical about the center line of symmetry of said member and is in the form of a regular progression from each end of said central portion to such center line of symmetry.

2. A lip for excavating buckets comprising a rigid mounting member of generally U-shaped configuration, but wherein the base of the "U" is substantially straight, viewed end-on from the work-engaging side of said lip, said member having in its forward edge face a group of transversely spaced and generally longitudinally-extending sockets distributed over the base and legs of the "U" for receiving the shank portions of respective excavating teeth; excavating teeth mounted individually in said sockets, the tips of the teeth in the central portion of the member being stepped rearwardly, viewed at 90° to the end-on direction, relative to the corners of the aforesaid "U," and the rearward stepping of the central portion of the forward edge of said member, with respect to the ends of said central portion, is symmetrical about the center line of symmetry of said member and is in the form of a regular progression from each end of said central portion to such center line of symmetry.

3. A lip for excavating buckets comprising a rigid mounting member of generally U-shaped configuration viewed end-on from the work-engaging side of the lip, said member having in its forward edge face a group of transversely spaced and generally longitudinally-extending sockets distributed over the base and legs of the "U" for receiving the shank portions of respective excavating teeth; excavating teeth mounted individually in said sockets, the tips of the teeth in the central portion of the member being stepped rearwardly, viewed at 90° to the end-on direction, relative to the corners of the aforesaid "U," and the rearward stepping of the central portion of the forward edge of said member, with respect to the ends of said central portion, is symmetrical about the center line of symmetry of said member and is in the form of a regular progression from each end of said central portion to such center line of symmetry.

4. An excavating bucket comprising a rigid mounting member of generally U-shaped configuration viewed end-on from the work-engaging side of the bucket, said member having in its forward edge face a group of transversely spaced and generally longitudinally-extending sockets distributed over the base and legs of the "U" for receiving the shank portions of respective excavating teeth; excavating teeth mounted individually in said sockets, the tips of the teeth in the central portion of the member being stepped rearwardly, viewed at 90° to the end-on direction, relative to the corners of the aforesaid "U," and the rearward stepping of the central portion of the forward edge of said member, with respect to the ends of said central portion, is symmetrical about the center line of symmetry of said member and is in the form of a regular progression from each end of said central portion to such center line of symmetry.